July 23
2018

JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

100% Issue for Construction

JHU APL Building 14 Systems Integration 3

PROJECT MANUAL

Volume 2 – Divisions 20-26
Divisions 31-41

Laurel, MD

HDR

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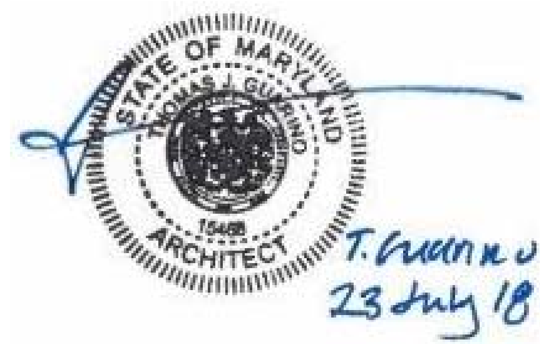
Structural



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DIVISION 20

MECHANICAL GENERAL REQUIREMENTS

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SECTION 20 05 00
SPECIAL MECHANICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Special Mechanical Requirements, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

C. Drawings Use and Interpretation:
1. Drawings are diagrammatic and indicate general arrangement of systems and equipment, except when specifically dimensioned or detailed.
2. For exact locations of building elements, refer to dimensioned architectural/structural drawings.
3. Field measurements take precedence over dimensioned drawings.
4. Piping and ductwork plans are intended to indicate size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement.
5. Field verify locations and arrangement of existing systems and equipment.

D. Installation of Systems and Equipment:
1. Installation is subject to clarification as indicated in reviewed Shop Drawings and Field Coordination Drawings.
   a. Generally, lay out piping requiring gravity drainage first; then lay out large pipe mains, ductwork and electrical conduit.
   b. This procedure is intended to promote orderly installation, but not to establish trade precedence.
   c. Dimensions indicated are limiting dimensions.
   d. Do not use equipment exceeding dimensions indicated on detail drawings or arrangements that reduce required clearances or exceed specified maximum dimensions.
   e. In mechanical equipment room aisles, maintain clear head room between floor and underside of ducts, pipes, and equipment to allow for future replacing of equipment and major components (e.g., coils, fans, heat exchangers, pumps).

E. Description of Systems:
1. Provide materials resulting, upon completion, in functioning systems in compliance with performance requirements specified, and modifications resulting from reviewed Shop and Field Coordination Drawings.

1.2 QUALITY ASSURANCE

A. Perform work in accordance with following codes:
1. State and local building, plumbing and mechanical codes.
2. American Gas Association.
3. National Electrical Code.
4. National Fire Protection Association.
5. Authorities Having Jurisdiction (AHJ).

B. Use only prime quality, new materials, apparatus and equipment.

1.3 SUBMITTALS

A. Shop Drawings:
1. Structural steel support drawings and calculations signed and sealed by Specialty Structural Engineer.

1.4 PROTECTION

A. Provide covering and shielding for equipment provided to protect from damage.

B. Repair, restore and replace damaged items.

C. Protect nameplates on motors, pumps and similar equipment.

D. Protect plumbing fixtures and brass or chromium plated trim, valves and piping from damage.

E. Keep dirt and debris out of pipes and ducts by capping or plugging open ends.
   1. Keep plug or cap in place until final connections are made.

1.5 JOB CONDITIONS

A. Avoid interference and interruption of existing utilities and services.
   1. Schedule work which will cause interference or interruption in advance with Owner, Construction Manager, Architect, authorities having jurisdiction, and affected contractors.

B. Keep roads clear of materials and debris.

C. Examine Contract Documents to determine how other work will affect execution of mechanical work.

D. Examine site and become familiar with existing local conditions affecting work.

E. Determine and verify locations of existing utilities on or near site.

F. Make arrangements for and pay for necessary permits, licenses, and inspections.

G. Air Quality Permits: Contractor shall be responsible for obtaining EPA air quality permits. Coordinate permitting process with Owner.

H. Record drawings:
   1. Keep a complete set of mechanical drawings in job site office for indicating actual installation of mechanical systems and equipment.
   2. Use this set of drawings for no other purpose.
   3. Where material, equipment, or system components are installed differently from that indicated, indicate such differences clearly and neatly.
   4. At project completion, submit record set of drawings in accordance with Division 01.

I. Operation and Maintenance Data:
   1. See Division 01.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Motors:
   1. Base:
      a. Reliance Electric.
   2. Optional:
      a. Baldor.
      b. Century Electronics; E-Plus.
      c. General Electric; Energy Saver.
      d. Westinghouse Motor.

B. Shaft grounding ring for motors:
   1. Base:
      a. Aegis.

2.2 ACCESS DOORS, PANELS, AND FRAMES

A. Access Doors, Panels and Frames:
   1. See Section 08 31 16.
   2. Where not indicated on Drawings, provide access panels and/or doors at walls, and inaccessible ceilings to permit access to equipment, devices and piping requiring service, adjustment, or inspection.
   3. Size:
      a. As required to allow access, inspection, service, and removal of items served.
      b. Minimum 18 IN x 18 IN.

2.3 EQUIPMENT GUARDS

A. Equipment guards:
   1. Use suitable structural frames with minimum 12 GA, 3/4 IN galvanized mesh, or expanded metal mesh.
   2. Attach to equipment by removable clips and bolts with wing nuts, or other approved connectors.
   3. At belts, provide opening for measuring RPMs.
   4. Provide at belts, couplings, moving machinery and equipment in accordance with OSHA.
   5. Design for easy access to belts and other items requiring replacement.

2.4 MOTORS AND CONTROLS

A. Motors:
   1. Provide motors indicated in Mechanical Specification Divisions.
   2. Ball or roller bearing type, premium efficiency type.
   3. Starting and running characteristics consistent with torque and speed requirements of driven machine.
   4. Motor efficiency:
      a. NEMA Standard MG-1, part 31.
      b. Indicate full load efficiency on each nameplate.
   5. Rated in accordance with NEMA performance standards to carry full nameplate load continuously at maximum temperature rise of 40 DEGC above ambient with service factor of 1.15.
   6. Motor powers as scheduled.
   7. Do not allow power requirements of driven machine to exceed nominal nameplate rating of motor furnished.
   8. Do not include service factor when selecting motor power.
   9. Motors 1/2 HP and over: 460/3/60.
   10. Motors less than 1/2 HP: 115/1/60.
   11. Provide for items which require electric drive.

B. Motors for use with variable frequency drives (VFDs):
   1. Provide with following to prevent bearing current damage:
      a. Shaft grounding ring:
         1) Discharges shaft currents to ground through use of frictionless conductive microfibers surrounding motor shaft.
         2) Maintenance required: none.
         3) Design to last for service life of motor.
         4) RPM limitation: none.
         5) Manufacturer: Aegis SGR.

C. Motor controls and wiring for controls:
   1. Provide complete installation of controls and wiring for controls for Mechanical Specification Divisions packaged/pre-wired equipment.
      a. Include line voltage controls, low voltage controls, control switches, starters, disconnects, conduit, and wiring.
      b. Locate disconnects on outside of equipment enclosures or guards.

2. Starters, disconnects, conduit, and wiring furnished under Mechanical Specification Divisions shall comply with applicable Electrical Specification Divisions.
3. Where equipment is specified with packaged/pre-wired controls, but is furnished instead with loosely shipped components that require field wiring, coordinate complete installation and assume costs.

2.5 RAIN HOODS AND COUNTER FLASHINGS

A. Rain hoods and counter flashings not exposed to view:
   1. Stainless steel: Minimum 20 GA.
   2. Sheet copper: Minimum 24 OZ/SF.

B. Rain hoods and counter flashings exposed to view:
   1. Material specified in Section 07 62 00.

2.6 PENETRATIONS

A. Maintain fire and smoke ratings where mechanical items penetrate fire and fire/smoke rated building elements.

2.7 STRUCTURAL STEEL FOR SUPPORTS

A. Assume engineering responsibility for design of steel supports.

B. Engineer Qualifications: Comply with Section 01 71 21, Specialty Engineering Requirements

C. Design units and connections to satisfy requirements of applicable Building Codes.

D. Design units and connections capable of withstanding the following design loads as shown on structural drawings within limits and under conditions indicated:
   1. Include effect from adjacent attached construction.
   2. Wind pressure, and/or earthquake lateral forces.
   3. Live Loads.
   4. Dead load of unit plus superimposed loads.

E. Structural Steel for Supports:
   1. Comply with ASTM A36.
   2. Galvanize members installed in fan plenums or areas of high humidity or condensation, and outside.
   3. Furnish other members with shop coat of rust inhibiting primer.
   4. Shop fabricate for field assembly using bolts.
   5. Minimize field welding.
   6. Retouch primer after field welding.

PART 3 - EXECUTION

3.1 GENERAL

A. When changes in location of work are required, obtain approval of Architect before making change.
   1. Make changes at no extra cost.

B. Provide necessary offsets and crossovers in piping and ductwork, whether indicated or not.

C. Install piping and ductwork parallel to walls and vertically plumb.

D. Do not change indicated sizes without approval of Architect.

E. Electrical equipment:
   1. Maintain space above electrical equipment rooms and closets clear of ductwork and piping.
   2. Maintain space above panelboards, switchboards, motor control centers, or motor control panels clear of ductwork and piping.

F. In elevator machine rooms, install no piping except floor drains and fire protection piping that specifically serves the room.

G. Roof penetrations:
   1. Make penetrations through roofs prior to installation of roofing.
   2. For penetrations required after installation of roofing:
      a. In built up roofing (BUR), provide curbs, cants and counter flashings.
      b. In elastic sheet roofing (ESR), arrange and pay for flashing work by authorized roofer; provide counter flashings.
   3. Repair and replace roof construction which is damaged by this work in manner which will not nullify roof warranty.

3.2 LOCATING SERVICEABLE DEVICES

A. Install devices, that may require adjustment or service maintenance, in accessible locations or provide flush-mounted access doors.
   1. Such devices include but are not limited to equipment, valves, filters, motors, drives, compressors, unions, traps, strainers, thermometers, gauges, switches, measurement devices, coils, detectors, dampers, sensors, monitors, backflow prevention devices, drains, floor sinks, cleanouts, test stations, signal devices, sprinkler heads, air vents, expansion joints, and system drains.
   2. Arrange piping, conduit, ducts, and related work to facilitate maintenance.
   3. Relocate items which interfere with access.

3.3 CUTTING AND PATCHING

A. Requesting openings in advance.
   1. Coordinate locations with work of other sections.

B. Avoid cutting, where possible, by setting sleeves or frames.

C. Before cutting of structural elements, obtain written approval of Structural Engineer.
   1. Use only approved methods.
   2. Neatly cut holes as approved by structural engineer to admit work.
   3. Do not weaken walls or floors; locate holes in concrete to avoid structural members.

D. Perform cutting, fitting, repairing, patching and finishing of work to permit installation of mechanical work.

E. Locate openings and sleeves to permit neat installation of piping, ductwork and equipment.

F. Do not remove or damage fireproofing materials.
   1. Install hangers, inserts, supports, and anchors prior to installation of fireproofing.
   2. Repair or replace fireproofing removed or damaged.

G. Remove and replace existing ceilings for mechanical work in existing areas.

H. See Section 01 73 29.

3.4 EXCAVATING AND BACKFILLING

A. See Section 31 23 33.

3.5 INSTALLATION OF EQUIPMENT

A. Install equipment in accordance with manufacturer's recommendations and as specified.

B. Provide necessary anchoring devices and supports.
   1. Use structural supports suitable for equipment, or as indicated.
   2. Check loadings and dimensions of equipment with shop drawings.
   3. Do not cut building structural members.
   4. Provide equipment supports even though not detailed on architectural and structural drawings.

C. Coordinate fit of equipment support with layouts indicated.
   1. Where substitute equipment is used, revise indicated supports to fit.

D. Arrange for necessary openings to allow entry of equipment.
   1. Where equipment cannot be installed as structure is being erected, provide and arrange for building in of boxes, sleeves or other devices to allow later installation.

E. Install rain hoods and metal counter flashings as indicated, and to make penetrations of mechanical work through walls and roofs water and weathertight.
   1. Furnish clamps, waterproofing material and labor.
   2. Where metal flashings are applied over concrete, paint concrete with 1/8 IN of mastic cement first.
   3. Set flashing in mastic cement, watertight.

F. Provide concrete foundations (isolation pads) or housekeeping pads for mechanical equipment as follows unless indicated otherwise:
   1. Install 4 IN high concrete housekeeping pads. Outside dimension of pad shall be at least 4 IN larger in all directions than base of equipment or 9 IN from center of anchor, whichever is greater.
   2. Use 3,000 PSI concrete.
   3. Reinforce with No.4 bars, 12 IN OC each way, with short No.4 dowels into floor at 24 IN OC each way .
   4. Chamfer top edges 3/4 IN.
   5. Make faces smooth.
   6. Set anchor bolts for equipment.

3.6 INSTALLATION OF EQUIPMENT FURNISHED BY OWNER OR OTHER DIVISIONS

A. Receive, uncrate and set in place mechanical equipment furnished by Owner or other Divisions.

B. Remove, relocate and reinstall existing mechanical equipment to be reused.

C. Provide rough-in and final connections to equipment requiring mechanical services.
   1. See schedules.
   2. Obtain rough-in data from inspection of same for existing equipment.
   3. Obtain rough-in data from final shop drawings for equipment furnished by Owner or other divisions.

D. Install loosely shipped fittings, valves, and other items furnished as integral part of equipment.

3.7 PAINTING

A. See Section 09 91 13 and Section 09 91 23.

3.8 FIELD QUALITY CONTROL

A. Perform indicated tests to demonstrate workmanship, operation, and performance.
   1. Conduct tests in presence of Architect and, if required, inspectors of agencies having jurisdiction.
   2. Arrange date of tests in advance with Architect, manufacturer and installer.
   3. Give inspectors minimum of 24 HRS notice.
   4. Furnish or arrange for use of electrical energy, steam, water or gas required for tests.
   5. Furnish materials required for test.

B. Repair or replace equipment and systems found inoperative or defective and retest.
   1. If equipment or system fails retest, replace it with products conforming to Contract Documents.
   2. Continue remedial measures and retests until satisfactory results are obtained.

C. Test equipment and systems for each item, unless otherwise recommended by manufacturer.
   1. Tests specified in Section 20 08 00, Testing and Balancing need not be duplicated under other sections.

3.9 ADJUST AND CLEAN

A. Inspect equipment and put in satisfactory working order.

B. Clean exposed and concealed items: See Section 01 74 23 Cleaning.
   1. Clean air surfaces of coils, fans (including fan wheels and motors), air handler plenums and air filter frames.
   2. Clean floor drains, cleanouts, and plumbing fixtures.
   3. Clean specialties such as strainers and equipment surfaces such as pumps, motors, boilers, chillers, etc.
   4. Clean piping of tags, debris and other construction materials before insulating or painting.
   5. Clean debris including dirt and sand out of ductwork.

3.10 PUTTING SYSTEMS IN OPERATION - START UP

A. Prior to substantial completion and building occupancy, at time agreed to by Owner and Architect, put systems into satisfactory operation.
   1. At first heating or cooling season following substantial completion, put systems not yet operated under their seasonal loads into satisfactory operation.

B. Operate systems in satisfactory working order for period of 10 working days.
   1. After the 10 days, clean debris including dirt and sand out of ductwork.

END OF SECTION

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SECTION 20 05 19
PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Piping Specialties, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Comply with applicable UL, ANSI and ASTM Standards.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Layout of piping showing expansion joints and manufacturer recommended locations for pipe anchor and guide locations.
   2. Include axial, lateral, and vertical stresses at anchors as calculated by expansion joint manufacturer. Stresses shall be compliant with ASME B31.1 requirements.

B. Product Data:
   1. Pressure gauges.
   2. System Drains.
   3. Thermometer wells and test gauge connections.
   4. Thermometers.
   5. Wye strainers for hydronic systems.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Pressure gauges:
   1. Base:
      a. Weiss Instruments.
   2. Optional:
      a. Trerice, HO.
      b. Marsh Instrument.
      c. US Gauge.
      d. Weiss Instruments.
      e. Weksler Instruments.
      f. Weston and Ernst.
      g. Winters.

B. Thermometers and Pressure Gauges:
   1. Base:
      a. Weiss Instruments.
   2. Optional:
      a. Marsh Instrument.
      b. Marshalltown Instrument.
      c. Palmer Instruments.
      d. Taylor Environmental Instruments.
      e. Trerice, HO.

f. Weiss Instruments.
g. Weksler Instruments.
h. Weston and Ernst.
i. Ashcroft.
j. Winters.

C. Wye strainers:
1. Base:
a. Armstrong International
2. Optional:
a. Armstrong International.
b. Spirax Sarco.
c. Keckley, OC.
d. Metraflex.
e. Mueller Steam Specialty.
f. Spence Engineering.
g. Victaulic of America.

2.2 PRESSURE GAUGES

A. Pressure gauges:
1. Water systems operating above 150 DEGF:
a. Case and twist ring: 4-1/2 IN diameter, anodized aluminum.
b. Socket: brass.
c. Bourdon tube: Phosphor bronze.
d. Movement: Bushed Brass Rotary.
e. Dial: White aluminum, black markings.
f. Pointer: Black or red anodized aluminum, slotted adjustable.
g. Window: Glass.
a. Siphon and gauge cock (low pressure steam): brass.
b. Siphon and needle valve (medium and high pressure steam): brass..
c. Accuracy: 1.0 PCT full scale, ASME B40.1 Grade 1A.
d. Range: Operating pressure to occur in middle half (25 % to 75 PCT) of the full scale range of the fluid being measured.
e. Connections: 1/4 IN or 1/2 IN NPT.
2. Compressed air systems and water systems operating below 150 DEGF
a. Case and Ring: 4 IN diameter, liquid filled, type 304 stainless steel case with polished stainless steel bayonet ring.
b. Fill liquid: Glycerin.
c. Socket: Brass with push-in restrictor.
d. Bourdon tube: Phosphor Bronze.
e. Movement: Brass rotary type with bushings.
f. Dial: White aluminum with black markings.
g. Pointer: Black or red anodized aluminum, adjustable.
h. Window: Clear acrylic.
i. Snubber and gauge cock: Chrome plated brass.
j. Accuracy: 1.0 PCT full scale, ASME B40.1 Grade 1A.
k. Range:
1) Refer to pressure range schedule except as follows:
a) Pump suction gauges for open piping systems where elevation difference between pump center line and liquid level of open system is less than 50 FT: Compound type, indicating at least 30 IN Hg to 30 PSIG.
b) Diesel fuel pump suction: Compound type, indicating to 210kPa 30 IN Hg to 30 PSIG.
l. Connections: 1/4 IN or 1/2 IN NPT.

3. Pressure gauge range schedule:

	Range PSIG	Fig. Interval PSIG	Inter. Gradu-ations PSIG	Bldg. Height Stories
Chilled/condenser water	0-60	5	1	to 4
Chilled/condenser water	0-100	10	1	over 4
Heating hot water	0-100	10	1	to 4
Heating hot water	0-160	20	2	over 4
Fire	0-400	50	5	
Distilled water	0-60	5	1	
Compressed air	0-160	20	2	
Domestic hot water	0-200	20	2	
Domestic cold water	0-200	20	2	
Diesel Fuel Pump Discharge	0-100	10	1	

2.3 SYSTEM DRAINS

A. Valved drains (nonpotable water):
   1. Piping 2 IN and smaller:
      a. 1/2 IN V-13, or V-14 with male hose-thread outlet and brass cap.
   2. Piping 2-1/2 IN and larger:
      a. 1-1/2 IN V-13 or V-14 ball valve with 1-1/2 IN fire hose adapter and cap.

B. Valved drains (potable water):
      a. 1/2 IN V-13 with plugged outlet.

C. On nonpotable systems, label system drains as nonpotable.

D. Valve standards: See section 20 05 23.

2.4 THERMOMETER WELLS (SOCKETS) AND TEST GAUGE CONNECTIONS

A. Temperature sensing wells (sockets) and test gauge connections:
   1. Brass or stainless steel.
   2. Provide extension necks for insulated piping.

2.5 THERMOMETERS

A. BiMetal Thermometers:
   1. Case: Type 304 Stainless Steel.
   2. Window: Shatterproof glass or acrylic.
   3. Stem assembly: Stainless steel all welded construction and 1/2 IN NPT connection.
   4. Element fluid: Silicone.
   5. Dial: Heavy gauge aluminum, white finish, black or red graduation lines and numerals.
   6. Accuracy: 1 PCT of scale range.

B. Liquid filled thermometers:
   1. Case: Industrial type molded polyester or die cast aluminum.
   2. Window: Shatterproof glass or acrylic.
   3. Liquid: Blue reading, non-mercury.
   4. Scale: 9 IN scale minimum, black lines and numbers.
   5. Accuracy: 1 PCT of scale range.
   6. Angle adjustment: variable with angle adjusting screw.

C. Digital Thermometers:
   1. Case: High-impact ABS.
   2. Display: m 1/2 IN LCD digits.
   3. Sensor: Glass passivated thermistor.
   4. Ambient Operating conditions:-30 DEGF to 140 DEGF.

5. Accuracy 1 PCT of reading or 1 DEGF.
6. Resolution: .1 DEGF between–20 DEGF and 200 DEGF.
7. Recalibration: Through case potentiometer adjustment.
8. Lux rating: 10 Lux (one foot candle).
9. Update span: 10 seconds.
10. Range: -50 DEGF to 300 DEGF. Switchable from Metric to English scale.
11. Ambient temperature error: Zero.
12. Maximum ambient humidity: 100 PCT.
13. Power: Solar.

D. Thermometers range schedule:

	Range degF	Division degF
Domestic hot water	32-180	2
Domestic cold water	32-100	1
Heating hot water	50-300	2
Compressed air	50-300	2
Blow down	50-400	5
Diesel Fuel	50-400	5
Chilled water at coils	32-130	1
Chilled water at pumps and chiller	32-100	1
Condenser water	32-100	1

2.6 WYE STRAINERS FOR HYDRONIC SYSTEMS

A. Wye strainers.
1. Screwed or flanged.
2. Body:
   a. 2 IN and smaller:
      1) Cast bronze, ASTM B62, screwed ends.
   b. 2-1/2 IN and larger:
      1) Cast iron, flanged ends.
      2) Coating: Rust inhibiting.
3. Working pressure, non shock: 150 PSIG.
4. Screens:
   a. Water: Bronze, monel or stainless steel.
      1) 2 IN and less: 3/64 IN perforations.
      2) 2-1/2 IN and larger: 1/8 IN perforations.

PART 3 - EXECUTION

3.1 GENERAL

A. Install piping specialties according to manufacturer instructions and as specified.

3.2 PRESSURE GAUGES

A. Install filter type pressure snubbers at pumps and chillers.

B. Install brass tee handle cock and 1/4 IN hard tempered tubing from gauge to pipe connection.

C. Install additional brass tee handle cock at gauge for panel mounted gauge.

D. Calibrate and zero gauges at job site.

3.3 SYSTEM DRAINS

A. At low points of piping systems, provide valved drains to allow complete drainage of each system.

B. Neither terminate nor run drains over electrical equipment.

3.4 THERMOMETER WELLS AND TEST GAUGE CONNECTIONS

A. Provide test thermometer well adjacent to each point where a temperature sensing device is required by control specifications and where piping schematics indicate thermometers.

B. Placement and sizing:
   1. For 4 IN piping and larger, place tee in piping to create perpendicular flow-to-stem measurement.
      a. Size stem length based on pipe size as indicated below:
         1) 4 and 5 IN pipe: 3-1/2 IN stem.
         2) 6 and 8 IN pipe: 6 IN stem.
         3) 10 and 12 IN pipe: 9 IN stem.
         4) 14 IN pipe and larger: 12 IN stem.
   2. For piping smaller than 4 IN , place oversize piping well and tee in 90-degree piping turn to create parallel flow-to-stem measurement.
      a. Stem length: 12 IN.
      b. Piping well length: 14 IN.
      c. Size piping well and tee based on pipe size as indicated below:
         1) 1/2 and 3/4 IN pipe: 1-1/4 IN well and tee.
         2) 1 IN pipe: 1-1/2 IN well and tee.
         3) 1-1/4 and 1-1/2 IN pipe: 2 IN well and tee.
         4) 2 IN pipe: 2-1/2 IN well and tee.
         5) 2-1/2 and 3 IN pipe: 4 IN well and tee.

3.5 THERMOMETERS

A. Where temperature control requires a temperature transmitter, a thermometer is not required in same location unless specifically required in equipment specifications.

B. Where 2 or more pumps are headered, provide one thermometer in suction header and one in discharge header.

3.6 WYE STRAINERS

A. Provide wye strainers as indicated in piping-system sections.

B. Connections to suit piping system.

C. Provide blow-down valves:
   1. Strainers 6 IN and larger: 1-1/2 IN blow-down valve.
      a. Pipe blow down to drain.
   2. Strainers 2 to 5 IN: 1 IN blow-down valve with 3/4 IN hose end connection and brass cap.
   3. Strainers 1-1/2 IN and smaller: 1/2 IN blow-down valve with 3/4 IN hose end connection and brass cap.

END OF SECTION

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SECTION 20 05 23
MANUAL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Manual Valves, as indicated, in accordance with provisions of Contract Documents.

B. Definitions:
   1. Class: ANSI Class.
   2. SWP: Steam Working Pressure.
   3. WOG: Water/Oil/Gas non-shock working pressure.
   4. WWP: Cold water non-shock working pressure.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. This specification lists a variety of valves that may be applicable to the project. Not all valves listed are applicable to the project, refer to appropriate specs sections for project applicability.

B. Boiler system valves: ASME Boiler Code Specifications.

C. Fire protection valves: UL listed, NFPA and FM approved.

D. Valves used in flammable liquid or flammable gas systems: UL listed for applicable service.

E. Valves for Potable Water: Shall comply with provisions called for by the Safe Drinking Water Act as amended by S3874 (the "Lead Free Law) or any subsequent amendments or addendums thereto.

F. Valve bodies, shells and seats: Designed, manufactured, and tested in accordance with the following:
   1. Pressure testing of steel valves: MSS SP-61.
   2. Butterfly valves: MSS SP-67.
   3. Cast iron gate valves, flanged and threaded ends: MSS SP-70.
   4. Cast iron swing check valves, flanged and threaded ends: MSS SP-71.
   5. Cast iron plug valves, flanged and threaded ends: MSS SP-78.
   6. Bronze gate, globe, angle and check valves: MSS SP-80.
   7. Valve pressure testing methods: MSS SP-82.
   8. Cast iron globe and angle valves, flanged and threaded ends: MSS SP-85.
   9. Diaphragm type valves: MSS SP-88.
   10. Resilient seated eccentric cast iron plug valves: MSS SP-108.
   11. Ball valves--threaded, socket-welding, solder joint, grooved, and flared ends: MSS SP-110.

G. Standard Specification for Composition of Bronze or Ounce Metal Castings: ASTM-B62.

H. Standard Specification for Steam or Valve Bronze Castings: ASTM-B61.

I. Iron body valves:
   1. Pressure containing parts: ASTM-A126, Grade-B.
      a. Standard Specification for Gray Iron Castings for valves, flanges and pipe fittings: ASTM-A126, Grade B.
   2. Face to face and end to end dimensions: ANSI/ASME-B16.10.
   3. Use domestic manufactured valves as defined by Buy American Act.

J. Valve stems: ASTM-B371, Alloy C69400; ASTM-B371, Alloy C65100H04 (rolled silicon brass); or other material equally resistant to dezincification.

K. Indicate following information on valves:
   1. Stamped or cast into body:
      a. Manufacturer's name or trademark.
      b. Pressure rating as Class, SWP, WOG, or WWP.
      c. "UL-FM" for UL-FM valves.
   2. Permanently attached to body:
      a. Valve's country of origin.

1.3 SUBMITTALS

A. Product Data:
   1. Valves.
      a. In addition to submittal requirements of Section 01 33 00, submittal shall include the following:
         1) For submittals with model numbers not listed in this section, include published cross reference sheet. Indicate association between submitted model number and the listed model number on the cross reference sheet.
         2) For each valve submitted indicate in which specification section(s) and in which system(s) the valve will be used.
      b. When valve assembly includes components other than the base valve body and handle (e.g., operator, valve box), include data on entire valve assembly.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Angle valves:
   1. Base:
      a. Nibco.
      b. Stockham .
   2. Optional:
      a. Crane Valves.
      b. Hammond Valve.
      c. Jenkins Valves.
      d. Lunken.
      e. Milwaukee Valve.
      f. Powell.
      g. Walworth.

B. Ball valves:
   1. Base:
      a. Milwaukee Valve.
      b. Nibco.
   2. Optional:
      a. Apollo.
      b. Crane Valves.
      c. Hammond Valve.
      d. Jamesbury.
      e. Jenkins Valves.
      f. Stockham.

C. Butterfly valves:
   1. Base:
      a. DeZurik.
      b. Milwaukee Valve.
      c. Stockham.
      d. Victaulic of America.

2. Optional:
    a. CenterLine Inds.
    b. Crane Valves.
    c. Jamesbury.
    d. Hammond Valve.
    e. Keystone Valve.
    f. Lunken.
    g. Mueller Steam Specialty.
    h. Nibco.
    i. Powell.
    j. Walworth.

D. High Performance Butterfly Valves:
1. Base:
    a. Dezurik.
2. Optional:
    a. Bray Controls.
    b. Neles (Jamesbury).

E. Check valves:
1. Base:
    a. Apco Valve & Primer.
    b. Nibco.
    c. Stockham Valves & Fittings.
2. Optional:
    a. Crane Valves.
    b. Hammond Valve.
    c. Kennedy Valve.
    d. Milwaukee Valve.
    e. Mueller Steam Specialty.
    f. Powell.
    g. Victaulic of America.
    h. Viking.
    i. Walworth.
    j. Waterous.

F. Gate Valves:
1. Base:
    a. Mueller Steam Specialty.
    b. Nibco.
    c. Stockham.
2. Optional:
    a. Crane Valves.
    b. Hammond Valve.
    c. Jenkins Valves.
    d. Kennedy Valve.
    e. Milwaukee Valve.
    f. Mueller Steam Specialty.
    g. Powell.
    h. Walworth.

G. Globe valves:
1. Base:
    a. Stockham.
2. Optional:
    a. Crane Valves.
    b. Hammond Valve.

c. Jenkins Valves.
d. Lunken.
e. Milwaukee Valve.
f. Nibco.
g. Powell.
h. Walworth.

H. Plug valves:
1. Base:
a. DeZurik.
b. Resun Valves.
2. Optional:
a. Milliken.
b. Mueller Steam Specialty.
c. Rockwell International.
d. Victaulic of America.

I. Valve boxes and stop boxes:
1. Base:
a. Tyler Pipe.
b. Western.
2. Optional:
a. Neenah Foundry.
b. Vulcan.
c. Local foundry.

J. Balancing valves (globe style):
1. Base:
a. Tour and Andersson.
2. Optional:
a. Armstrong.
b. Wheatley.
c. Mepco.

2.2 MATERIALS

A. Ball valves:
1. Port size: Standard.
2. Ball and stem material: 316 Stainless Steel unless noted otherwise in specific valve description.
3. Blow-out proof stems.
4. Reinforced Teflon (PTFE) (PTFE) seats.
5. Teflon (PTFE) (PTFE) seals.
6. Adjustable packing.
7. 3-piece valves:
a. May be standard port.
b. Repairable in line.

B. Butterfly valves:
1. Ninety degree operation.
2. Bubble-tight shut off, suitable for bi-directional dead-end service at rated pressure without use of downstream flange.
3. 2 IN extended neck.
4. Lugs, where specified, shall be drilled and tapped.
5. Operators:
a. 2-1/2 to 4 IN: Position lock handle.
b. 5 IN and larger: gear operator with 4-arm or wheel handle.

6. Bronze:
    a. Viton seals.
    b. Pressure rating: Refer to valve listings under Part 2.3.

C. High performance butterfly valves:
1. Ninety degree operation.
2. Bi-directional, drip-tight shut off at full pressure rating.
3. 2 IN extended neck.
4. Lugs shall be drilled and tapped.
5. Operator: gear type with 4-arm or wheel handle.
6. Body: carbon steel.
7. Disc: stainless steel.
8. Seat: RTFE.
9. Stem: stainless steel; blow-out proof.
10. Taper pins: compression type; stainless steel.
11. ANSI Class: 150.
12. Applicable fire test standard: API-607.

D. Chain operators:
1. Provide operators for valves located in mechanical spaces 8 FT or higher above floor.
2. Chain lever or chain sprocket operator with sufficient chain to reach within 5 FT of floor.
3. Remote operator accessories by same manufacturer as valve.
4. Do not provide for Fire Protection valves.

E. End styles, general:
1. Compatible with piping systems served.
2. Flanged valves:
    a. Class 125 cast iron: Flat flanges.
    b. Class 250 cast iron: Raised flanges.
    c. Ductile iron: Raised flanges.
3. Valves with solder ends for use in brazed piping systems shall be constructed for brazing.

F. Extended necks and stems:
1. For valves specified with extended necks or stems, provide design that isolates moving valve parts from insulation.
2. For valves specified with extended necks or stems and memory stops, provide design that allows access to memory stop without disturbing insulation.

G. Packing shall not contain asbestos.

H. Plug valves:
1. Eccentric plugs:
    a. Non-lubricated valves with resilient seats shall be suitable for 250 DEGF service.
    b. Rubber seated eccentric plugs: Bolted stem seals shall permit replacement of packing without removing valve from line or removing parts other than operator.

2.3 VALVES

A. General:
1. Example model numbers may indicate a general series, or may be abbreviated. They may not reflect all features described. Provide valves with described features.
2. Specified requirements are minimums. Valves that meet or exceed specifications may be submitted.
3. Where valves are installed in piping systems using ring seal crimped pipe joining systems acceptable manufactures who manufacture valves designed for connection to ring seal crimped systems are acceptable. Refer to specification sections 22 10 16 Plumbing Piping and 23 21 13 Hydronic Piping Systems for acceptable applications of Ring Seal Crimped piping systems.

B. V-1: Gate valve, Class 125, bronze body, screwed bonnet, non-rising stem, solid wedge disc, solder. Example: Stockham B-112.

C. V-2: Gate valve, Class 150, bronze body, union bonnet, rising stem, solid wedge disc, threaded. Example: Stockham B-120.

D. V-3: Gate valve, Class 125, cast iron body, bronze trim, bolted bonnet, rising stem, OS&Y, solid wedge disc, flanged. Example: Stockham G-623.

E. V-4: Gate valve, same as V-2 except Class 200. Example: Stockham B-135.

F. V-5: Gate valve, same as V-3 except Class 250. Example: Stockham F-667.

G. V-6: Globe valve, Class 150, bronze body, union bonnet, renewable Teflon (PTFE) disc, solder. Example: Stockham B-24T.

H. V-7: Globe valve, same as V-6 except threaded. Example: Stockham B-22T.

I. V-8: Globe valve, Class 125, cast iron body, bronze trim, bolted bonnet, OS&Y, renewable seat and bronze disc, flanged. Example: Stockham G-512.

J. V-9: Globe valve, Class 200, bronze body, union bonnet, renewable plug type seat and disc, threaded. Example: Stockham B-62.

K. V-10: Globe valve, same as V-8 except Class 250. Example: Stockham F-532.

L. V-11: Ball valve, 150 PSI SWP, 400 PSI WOG bronze body, adjustable memory stop, 3-piece construction, extended stem, solder. Example: Milwaukee UPBA-350S.

M. V-12: Ball valve, same as V-11 except threaded. Example: Milwaukee UPBA-300S.

N. V-13: Ball valve, 150 PSI SWP, 400 PSI WOG bronze body, 2-piece construction, extended stem, solder. Example: Milwaukee BA-450S.

O. V-14: Ball valve, same as V-13 except threaded. Example: Milwaukee BA-400S.

P. V-15: Ball valve, 150 PSI SWP, 600 PSI WOG, 29 IN Hg vacuum service, full port, bronze body, 3-piece construction, chrome plated brass ball, Teflon seats, cleaned and capped for oxygen service, lockable or non-lockable as specified, color coded handle to match gas service, braze. Example: Milwaukee BA-350.

Q. V-16: Ball valve, 150 PSI SWP, 600 PSI WOG, 250 PSI UL listed for flammable liquids and LP gas, bronze body, 2-piece construction, full or standard port, bronze ball, non-lubricated, threaded. Example: Nibco T-580-70-UL & T-585-70-UL.

R. V-17: Angle valve, Class 125, bronze body, screwed bonnet, bronze disc, threaded. Example: Stockham B-216.

S. V-18: Angle valve, Class 125, cast iron body, bolted bonnet, bronze trim, renewable seat and disc, flanged. Example: Nibco F-818-B.

T. V-19: Angle valve, Class 200, bronze body, union bonnet, bronze disc, threaded. Example: Stockham B-237.

U. V-20: Angle valve, Class 250, cast iron body, bronze trim, flanged. Example: Stockham F-541.

V. V-21: Angle valve, automatic stop-check, Class 250, cast iron body, bolted bonnet, renewable disc and seat, flanged. Example: Stockham F-541.

W. V-22: Check valve, in-line pattern, spring-operated double doors, Class 250, cast iron body, renewable bronze doors and Viton-A seal, Inconel springs, stainless steel trim, flat faced wafer. Example: Stockham WG-976.

X. V-23: Check valve, Y-pattern, horizontal swing, Class 150, bronze body, threaded cap, renewable Teflon (PTFE) disc and seat, threaded. Example: Nibco T-433-Y.

Y. V-24: Check valve, Y-pattern, horizontal swing, Class 125, bronze body, threaded cap, renewable bronze disc and seat, solder. Example: Nibco S-413-Y-LF.

Z. V-25: Check valve, same as V-23 except Class 125. Example: Nibco T-413-Y-LF.

AA. V-26: Check valve, in-line pattern, spring-operated disc, Class 125, bronze body, renewable Teflon (PTFE) disc and seat, 316 stainless-steel spring, threaded. Example: Nibco T-480-Y.

BB. V-27: Check valve, T-pattern, horizontal lift, Class 150, bronze body, union bonnet, renewable Teflon (PTFE) disc and seat, threaded. Example: Stockham B-322-T.

CC. V-28: Check valve, T-pattern, horizontal swing, Class 125, cast iron body, bolted bonnet, bronze trim, renewable bronze or cast iron disc and seat, flanged. Example: Stockham G-931.

DD. V-29: Check valve, in-line pattern, spring-operated double doors, Class 125 (cast iron body) or Class 150 (steel body), Buna-N or EPDM seal, aluminum bronze or stainless steel doors, 316 stainless steel spring; grooved, threaded, flanged, wafer, or lugged at locations other than equipment; grooved, flanged or lugged if between equipment and its isolation valve. Example: APCO L9000.

EE. V-30: Check valve, silent, in-line pattern, spring-operated disc, Class 125, cast iron body, renewable bronze disc and seat, stainless steel spring, flat faced wafer. Example: Nibco W-910-B.

FF. V-31: Check valve, same as V-23 except Class 200. Example: Nibco T-473-Y.

GG. V-32: Check valve, same as V-28 except Class 250. Example: Stockham F-947.

HH. V-33: Butterfly valve, 200 PSI WWP; 27 IN Hg vacuum; cast or ductile iron body; EPT (EPDM) sleeve; stainless steel stem; aluminum-bronze or stainless steel disc; lugged. Example: Stockham L#-7#2.

II. V-34: Butterfly valve, same as V-33 except wafer. Example: Stockham L#-5#2.

JJ. V-35: Butterfly valve, 200 PSI WWP for 12 IN and smaller, 175 PSI WWP for 14 IN and larger; 27 IN Hg vacuum for all sizes; cast or ductile iron body; EPT (EPDM) seat; stainless steel stem; replaceable forged brass, aluminum-bronze, stainless steel, or EPDM coated ductile iron disc; grooved. Example: Victaulic 300/709.

KK. V-36: Eccentric plug valve, 175 PSI WOG, cast-iron body, bronze or nickel-plated cast-iron plug, Isobutene-Isoprene steam and plug seals, high-temperature plug face, capped drip tap on seat end of valve, memory stop, lever handle, threaded. Example: DeZurik 499S.

LL. V-37: Eccentric plug valve, 175 PSI WWP for 12 IN and smaller, 150 PSI WWP for 14 IN and larger, cast-iron body, Viton filled TFE U-ring seal, Isobutene-Isoprene plug face, memory stop; lever handle for sizes 2-1/2 to 4 IN; gear operator with handwheel actuator for sizes 6 IN and larger; flanged. Example: DeZurik 118F.

MM. V-38: Eccentric plug valve, same as V-36 except flanged, or grooved. Example: DeZurik 499.

NN. V-39: Ball valve, same as V-13 and V-14 except include adjustable memory stop. Example: Milwaukee BA-100S and BA-150S.

OO. V-40: Butterfly valve, 200 PSI WWP, bronze body, adjustable memory stop with visual disc position range of 90 DEG, stainless steel disc and stem, Viton seal, threaded. Example: Milwaukee BB2-100.

PP. V-41: Plug valve, lubricated, 200 PSI WOG, semi-steel, bottom or bolted-top entry, UL listed for application, lubricant compatible with application, short pattern flanged. Example: Resun R-1431.

QQ. V-42: Not used.

RR. V-47, Gate valve with valve box:
1. Gate valve, AWWA-C500, 200 PSI WWP for 12 IN and smaller, 150 PSI for 14 IN and larger, iron body, bronze mounted, bronze or cast-iron double disc, non-rising stem, parallel seat, mechanical joint. Example: Stockham G-743.
2. Valve box: coated cast-iron, 5-1/4 IN shaft, screw type, 3-piece, drop-in lid with cast-in marking indicating service. Example: Tyler 6860.

SS. V-48, Butterfly valve with valve box:
1. Butterfly valve, AWWA-C504, Class 150, iron body, stainless steel seat, aluminum-bronze or cast iron disc, natural rubber or Buna-N seat, mechanical joint or flanged. Example: DeZurik BAW.
2. Valve box: coated cast-iron, 5-1/4 IN shaft, screw type, 3-piece, drop-in lid with cast-in marking indicating service. Example: Tyler 6860.

TT. V-49: Gate valve, UL-FM, 175 PSI WWP, bronze body, union or screwed bonnet, solid wedge disc, OS&Y, threaded. Example: Nibco T-104-O.

UU. V-50: Gate valve, UL-FM, 175 PSI WWP, cast iron body, bolted bonnet, resilient or solid wedge, OS&Y, flanged. Example: Stockham G-634.

VV. V-51: Butterfly valve, UL-FM, 175 PSI WWP, ductile iron body, O-Ring seals, aluminum-bronze or ductile-iron disc, stainless steel stem, Buna-N seal, manual geared operator with visual position indicator, lugged. Example: Stockham LD-72UF.

WW. V-52: Gate valve, UL-FM, AWWA C-509, 175 PSI WWP, cast iron body, resilient wedge, non-rise stem, indicator post flange, MJ or flanged. Example: Stockham G-600/601/602.

XX. V-53: Check valve, T-pattern, horizontal swing, UL-FM, 175 PSI WWP, cast iron body, bolted bonnet, bronze trim, renewable bronze or cast-iron disc and seat, flanged. Example: Stockham G-939.

YY. V-54: Check valve, in-line, spring-operated single or double door(s), UL-FM, 200 PSI WWP, cast iron body, renewable bronze door and rubber or EPDM seat, stainless steel spring, wafer or grooved. Example: Stockham WG-990.

ZZ. V-55: Butterfly valve, UL listed, 175 PSI WWP, bronze body, stainless steel stem and disc, Viton seal, threaded. Example: Milwaukee BB2-100.

AAA. V-56: Butterfly valve, same as V-40 except include extended neck, solder. Example: Milwaukee BB2-350.

BBB. V-57: Butterfly valve, same as V-40 except include extended neck, threaded. Example: Milwaukee BB2-100.

CCC. V-58: Not used.

DDD. V-59: Butterfly valve, same as V-55 with tamper switch. Example: Milwaukee BB2-100.

EEE. V-60: Plug valve, lubricated, 125 PSI WOG semi-steel, bottom or bolted-top entry, UL listed for application, lubricant compatible with application, threaded. Example: Resun R-1430.

FFF. V-61: Butterfly valve, UL-FM, 175 PSI WWP, coated cast or ductile iron body, aluminum bronze or ductile iron disk with EPDM coating, manual geared operator with visual position indicator, grooved. Example: Victaulic 708.

GGG. V-62: Butterfly valve, 300 PSI WOG, 27 IN vacuum, brass body, aluminum bronze disk, extended neck, grooved. Example: Victaulic 608N.

HHH. V-63: High performance butterfly valve, Class 150, carbon steel body, RTFE seat, stainless steel shaft, stainless steel disc, TFE packing, wafer. Example: Dezurik BHP.

III. V-64: Globe-style balancing valve, Y-pattern design, rated for 300 PSI WWP and 250 DEGF, cast copper alloy construction, dual pressure/temperature read-out ports, calibrated handwheel with minimum (4) 360 degree adjustment turns and hidden tamper-proof memory stop, threaded or sweat connections and suitable for positive shut-off. Example: Tour and Andersson STAD/STAS.

JJJ. V-65: Globe style balancing valve, Y-pattern design, rated for 250 PSI WWP and 250 DEGF, cast iron body fitted with copper alloy components, dual pressure/temperature read-out ports, calibrated handwheel with minimum (5) 360 degree adjustment turns and hidden tamper-proof memory stop, Class 125 flanged or grooved connections, and suitable for positive shut-off. Example: Tour and Andersson STAF/STAG.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to individual sections for specific valve installation requirements.

B. Keep valves clear of pull spaces.

C. Install valves in accessible locations for operation, removal, inspection, and repair of valves and equipment.

D. Install gate and globe valves with stem in vertical upright to horizontal position.

E. Install butterfly valves with stem in horizontal position.

F. Install diaphragm valves to be self draining.

G. Support valves individually to relieve pipe stress and allow equipment removal.

H. Follow manufacturer's recommendation for disassembly of valves for end joining method employed.

I. Provide globe valve in bypass around control valves. Coordinate with Controls Contractor.

J. Provide shut off valve on each side of control valve. Coordinate with Controls Contractor.

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SECTION 20 05 29
PENETRATIONS AND SUPPORTS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Penetrations and Supports, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
   1. Penetrations.
   2. Pipe hangers and supports.
   3. Pipe and equipment anchors.

C. Definitions:
   1. UCSS: Universal Channel Strut System.

D. Completely coordinate with work of other trades.

E. Concrete Anchoring:
   1. Cracked concrete is the baseline condition for the design of cast-in-place and post-installed anchors in alignment with both ACI 318 and International Building Code.

1.2 QUALITY ASSURANCE

A. Pipe hanger standards:
   1. Manufacturers Standardization Society (MSS) SP-58 Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation.
   2. ASME/ANSI B31.1 Code for Pressure Piping
   3. ACI 318: Building Code Requirements for Reinforced Concrete

1.3 SUBMITTALS

A. Shop Drawings:
   1. For pipe larger than 16 IN, show layout of hanger locations and method of support from structure.
   2. Layout for all required structural penetrations shown on structural framing plan or structural wall elevation. When working with existing construction include size and location of all existing penetrations on the drawing.
   3. Pipe Anchors:
      a. Detailed drawings, signed and sealed by a Specialty Structural Engineer.

B. Product Data:
   1. Pipe hangers:
      a. Identify each hanger according to systems, pipe sizes, and orientations on which it will be used.
   2. Concrete Anchors:
      a. Document Manufacturer approval or listing for cracked concrete application
         1) Drop-In Anchors are NOT cracked concrete rated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Pipe hangers:
   1. Base:
      a. PHD Manufacturing.

2. Optional:
    a. Anvil International.
    b. Cooper B-Line.
    c. Tolco Inc.
    d. Erico International.

B. Concrete inserts, pre-pour:
1. Base:
    a. Hilti.
2. Optional:
    a. Simpson.
    b. Powers Fasteners.
    c. Tolco.
    d. B-line.

C. Concrete inserts, post-pour:
1. Base:
    a. Hilti.
2. Optional:
    a. Simpson.
    b. Powers Fasteners.

D. Factory-fabricated supports for insulated pipe:
1. Base:
    a. Pipe Shields.
2. Optional:
    a. B-Line Systems.
    b. Power Piping.

E. Pipe and equipment anchors:
1. Base:
    a. Shop fabricated.
2. Optional:
    a. Field fabricated.

F. Factory-fabricated pipe supports at plumbing fixtures:
1. Base:
    a. Sioux Chief Manufacturing.
2. Optional:
    a. B-Line Systems.
    b. Holdrite.
    c. Sumner.

G. Universal channel strut system:
1. Base:
    a. Unistrut (Tyco Electrical and Metal Products).
2. Optional:
    a. Erico International.
    b. Cooper B-Line.
    c. Tolco, Inc.

H. Insulation Saddles:
1. Base:
    a. PHD Manufacturing.
2. Optional:
    a. Buckaroos, Inc.

I. Elastomeric Pipe Insulation Saddles:
   1. Base:
      a. Armacell engineered foams.

2.2 PENETRATIONS

A. Penetrations - General:
   1. For concrete walls, floors, roofs, foundations, footings and grade beams, provide openings sufficiently sized to allow free movement of piping with insulation continuous through sleeve.
   2. Create openings by placing sleeves prior to pouring of concrete in accordance with requirements indicated on structural drawings.
   3. Core drilling or cutting will not be permitted without prior written approval by structural engineer.
   4. Opening diameters:
      a. Minimum 3 IN.
      b. Bare pipe: Minimum 1 IN larger than outside diameter of pipe.
      c. Insulated pipe: Minimum 1-1/2 IN larger than outside diameter of insulation.
      d. Diameter suitable for construction tolerances and to receive sealant.
   5. Openings for future work: Same as this work.
   6. Coordinate detailing of roof, foundation wall, and slab-on-grade penetrations with roofing, waterproofing, and vapor retarder installers. Protect continuity of roofing, waterproofing, and vapor retarder systems.

B. Pipe entrance wall sleeve and anchoring:
   1. Provide steel, heavy wall welded or seamless pipe sleeve full circle continuously welded water stop plate.
   2. Provide sleeve full length of wall thickness and protect with a primer coat.
   3. Structurally secure pipe to withstand water hammer force.
      a. Extend exterior piping material into building a minimum of 12 IN.
      b. Provide a mechanical joint on interior end of pipe and mechanical tie in back to adjoining structural, exterior, wall.
   4. Provide "Link-Seal" on pipe at exterior side of sleeve.

C. Water dams:
   1. Construct water dams to meet either of the following criteria:
      a. Steel pipe with flange water dam:
         1) Construct water dam by welding together Schedule 40 steel pipe and steel flange to be water tight.
         2) Cut flange from flat steel of same thickness as pipe wall. Flange ring width shall be 1 IN minimum.
         3) Inside diameter of dam shall be approximately 1 IN larger than outside diameter of piping or its insulation, whichever is larger.
         4) Install top of water dam to be 4 IN above the finished floor.
         5) Permanently anchor dam flange to the floor, and seal the flange-to-floor joint water tight.
      b. Steel water dam:
         1) Construct dam by inserting end of Schedule 40 steel pipe or sheet steel fully into a groove approximately 1/2 IN deep.
         2) Seal the joint between dam and floor water tight.

D. Sealants:
   1. Seal annular space around piping.
   2. Maintain fire and smoke ratings at pipe penetrations of fire and fire/smoke rated building elements.
   3. For non-rated floors and walls see Section 07 92 16.

4. For exterior and foundation walls: Use synthetic rubber seals, "Link-Seal" water proof material or system.
   a. Optional sealing of pipe with oakum stop and caulk on exterior side is acceptable.
5. Seal water dams to floor in accordance with Section 07 92 13.

2.3 PIPE HANGERS

A. Pipe hangers - General:
   1. MSS SP-58 for materials, design, manufacture, selection, application, and installation requirements.
   2. ACI 319 for attachment requirements to concrete.
   3. Hangers and channels, angles, and supporting steel: Galvanized unless indicated otherwise.
   4. Pipes running parallel may be supported on trapezes.
   5. Hanger rods of continuous thread type: Galvanize after threads are cut.
   6. Galvanize structural steel, angles, rods, channels, and hardware located in boiler, mechanical, and fan rooms and on roofs.
   7. Where grooved couplings are used, place hanger within 2 FT each side of fittings or refer to manufacturer's pipe support and anchorage guide.
   8. Screw threads on hangers and fittings: Conform to Class 2A and 2B of ANSI/ASME-B1.1.

B. Structural considerations:
   1. Steel or concrete roof/floor system including slabs or roof deck shall be in place and complete before installation of mechanical piping system.
   2. Space hangers so maximum individual hanger load will not exceed values listed in paragraph "Pipe hanger loading".
   3. Do not attach hangers to steel roof deck.
   4. Do not attach hangers larger than 1/2 IN diameter to bottom of concrete filled floor or roof deck.
   5. Individual hanger loads exceeding 1000 LBS attached to the same deck span shall not be spaced closer than 5 FT on center.
   6. The sum of all hangers supported by a slab span in a 5 FT by 5 FT area shall not exceed 1000 LBS.
   7. Attach hangers to beams whenever possible.

C. Pipe hanger spacing:
   1. Locate hangers at each change of direction.
   2. Space hangers at or within following maximum limits:

Pipe Diameter	Standard Steel		Copper	
	Fluid	Vapor	Fluid	Vapor
1/2 - 1 IN	7 FT	8 FT	5 FT	6 FT
1-1/4 - 2 IN	7 FT	9 FT	7 FT	9 FT
2-1/2 - 3 IN	11 FT	14 FT	9 FT	13 FT
3-1/2 - 4 IN	13 FT	16 FT	11 FT	15 FT
5 - 6 IN	16 FT	19 FT	13 FT	18 FT
8 - 14 IN	16 FT	24 FT	16 FT	23 FT
16 IN	12 FT	24 FT	--	--

   3. For pipe larger than 16 IN diameter, see mechanical drawing for location of hanger supports.
      a. If not shown on plans, provide shop drawings for approval showing location of hangers and method of support from structure.
   4. Fire protection piping: See Section 21 10 00.
   5. For cast iron pressure piping, space maximum 12 FT OC.
      a. Provide minimum of one hanger per pipe section close to joint on barrel and at change of direction and branch connections.

6. For cast iron soil piping, space maximum 10 FT OC.
   a. Provide minimum of one hanger per pipe section close to joint on barrel and at change of direction and branch connections.
7. For piping materials not covered in this spec, space hangers according to manufacturer's recommendations.

D. Pipe hanger rod loading:
1. Total hanger rod load (including piping, insulation, and fluid) not exceeding following limits:

Nominal Rod Diameter	Maximum Load
3/8 IN	560 LB
1/2 IN	890 LB
5/8 IN	1460 LB
3/4 IN	2030 LB

2. Do not exceed manufacturer's recommended maximum safe load if smaller than above.

E. Pipe hangers for uninsulated pipe:
1. Independent hangers: MSS SP-58 type 1, 3, 4, 5, 7, 9, 10, 11, 12, 24, 41, 43, 44, 45, or 46.
   a. Types 7 and 10: Not allowed on pipe sizes greater than 6 IN.
2. Hangers used with trapezes:
   a. MSS SP-58 type 24 or 26.
   b. Hanger designed as part of UCSS.
3. Hangers supporting bare copper pipe:
   a. Copper plated or electro-galvanized hangers. Provide factory-applied felt or plastic padding to eliminate contact between support and copper pipe.

F. Pipe hangers for insulated pipe:
1. Hangers shall support piping from outside diameter of insulation.
2. Independent hangers: MSS SP-58 type 1, 3, 7, 9, 10, 41, 43, 44, 45, or 46.
   a. Types 7 and 10: Not allowed on pipe sizes greater than 6 IN.
3. Hangers used with trapezes:
   a. Pipe sizes 2 IN and smaller: MSS SP-58 type 26.
   b. Pipe sizes 2-1/2 IN and larger:
      1) MSS SP-58 type 24 or 26.
      2) Hanger designed as part of UCSS.
4. Pipe sizes 2 IN and smaller: Use hanger with insulation protection shield: MSS SP-58 type 40.
5. Pipe sizes 2-1/2 IN and larger: Use hanger with factory-fabricated support:
   a. 100 PSI, waterproofed calcium silicate fully encased in sheet metal shield.
      1) Pipe supported on rod hangers: Pipe Shields Models A1000, A2000, A3000, A4000 and A9000.
      2) Pipe supported on flat surfaces: Pipe Shields Models A1000, A2000, A5000, A6000 and A7000.
      3) Pipe supported on pipe rolls: Pipe Shields Models A3000, A4000, A5000, A6000 and A8000.
   b. Extend insulation inserts 1 IN beyond shields on chilled water lines.
6. For piping systems insulated with Elastomeric pipe insulation, composite Elastomeric and high density insert may be used:
   a. Jacket: 30 mils stainless steel.
   b. Basis: Armacell Armafix NPH pipe hanger inserts.
   c. Coordinate with section 20 07 00 Pipe, Duct and Equipment Insulation for applicability.

G. Pipe hangers in other situations: See MSS-SP-58.

H. Trapezes:
1. Suspend trapezes from concrete inserts, approved structural clips or beam clamps.

2. Construct trapezes of galvanized angle iron, UCSS channels, or other structural shapes with flat surfaces for point of support.
3. See pipe hanger paragraphs for hanger types allowed with trapezes.

I. Vertical pipe supports and guides:
1. Support vertical pipe runs in pipe chases from the top and every other floor down.
2. Provide pipe guides for lateral movement on alternating floors of pipe supports.

J. Concrete inserts:
1. Pre-pour concrete inserts:
a. Continuous-slot or individual concrete inserts for use with hangers for piping and equipment exposed in labs and classrooms, and as required.
b. Provide inserts in time for installation in concrete.
c. Continuous-slot inserts:
1) B-Line Figure B22I, B32I, B42I or B52I.
d. Individual inserts:
1) Grinnell Figure 282, or 281.
2) Do not exceed manufacturer's recommended load on insert.
2. Post-pour concrete inserts:
a. Approved for cracked concrete applications. Drop-In Anchors SHALL NOT be used.
b. At concrete slabs on steel deck, install anchor in top of deck flute.
c. Minimum embedment depth and base material thickness per anchor size shall be according to the following schedule:

Anchor Size IN	Minimum Base Material Thickness IN	Minimum Embedment Depth IN
1/4	3	1
3/8	3-1/8	1-9/16
1/2	4	2
5/8	5-1/8	2-9/16
3/4	6-3/8	3-3/16

K. Beam clamps:
1. Pipe size 3 IN and smaller:
a. MSS SP-58 types 19 or 23.
2. Pipe sizes larger than 3 IN but smaller than 8 IN:
a. Malleable-iron beam clamp: MSS SP-58 type 30.
b. Iron beam clamp: B-Line B3055 or equal.
3. Pipe sizes 8 IN and larger:
a. Forged steel beam clamps: MSS SP-58 type 28 or type 29.
b. Steel Beam clamps: B-Line B3291 through B3298 or equal.

2.4 PIPE RACKS

A. Assume engineering responsibility for design of steel rack.

B. Engineer Qualifications: Comply with section 01 71 21 Specialty Engineering Requirements

C. Design racks and connections to satisfy requirements of applicable Building Codes.
1. Installation shall reflect the design intent of the drawings with respect to:
a. General pipe arrangement.
b. Pipe spacing.
c. Pipe clearances for access.
d. Rack structural arrangement.
e. Expansion anchor forces, when indicated.

D. Hangers attached to pipe racks: Same as for systems hung from building structural systems.

2.5 PIPE AND EQUIPMENT ANCHORS

A. Pipe Anchors:
   1. Approved for cracked concrete applications.
   2. Provide as indicated and required to permit complete installation of system.
   3. Do not anchor piping to plaster or gypsum wallboard partition walls.
   4. Provide anchoring devices at locations indicated.
   5. General arrangement subject to review and approval of the Structural Engineer of Record.
   6. Assume engineering responsibility for design of pipe anchors and connection of anchor to structure.
   7. Engineer Qualifications: Comply with section 01 71 21 Specialty Engineering Requirements
   8. Design anchors to satisfy requirements of applicable Building Codes.
   9. Design for stresses determined by expansion joint manufacturer. Adjust stresses at structure connection point for distance between anchor and structure connection point.
      a. See section 20 05 19.

B. Anchors:
   1. Angle iron and rods with turnbuckles, unless detailed otherwise.

C. Anchors for ductwork, equipment and piping hanger rods:
   1. Post-pour concrete inserts:
      a. Approved for cracked concrete applications. Drop-In anchors SHALL NOT be used.
      b. Hard-metal, self-drilling tapped for threaded rods and designed not to depend on lead or wood for holding power.

2.6 PIPE SUPPORTS AT PLUMBING FIXTURES

A. Pipe supports at plumbing fixtures:
   1. Fire-treated dimensional lumber. See Section 06 10 53.
   2. Factory-fabricated metal brackets.
      a. Plastic grommets/inserts factory fabricated for specific pipe diameters and materials.
   3. Factory-fabricated PVC pipe supports and pipe fasteners.
      a. Fastening method: Stainless-steel bands and screws.
      b. PVC: Fire retardant.

PART 3 - EXECUTION

3.1 GENERAL

A. Install components as indicated and in accordance with manufacturer's instructions and recommendations.

3.2 PENETRATIONS

A. Coordinate locations of openings in structural systems with Architect.

B. Maintain fire and smoke ratings at pipe penetrations of fire and fire/smoke rated building elements.

C. Set sleeves plumb or level, in proper position, tightly fitted into work.

D. Provide water dams around pipes penetrating the floor in wet areas such as the following:
   1. Mechanical room.
   2. Boiler rooms.

3.3 PIPE SUPPORTS AT PLUMBING FIXTURES

A. Pipe supports at plumbing fixtures:
   1. General: Fasten piping to supports within 8 IN of final fixture connection point (valve).
   2. Fire-treated wood: See Section 06 10 53.

3. Factory-fabricated brackets:
   a. Fasten brackets to studs with screws.
   b. Galvanized brackets:
      1) Fasten piping to brackets with plastic grommets/inserts.
   c. Copper-clad brackets:
      1) Use only with copper piping.
      2) Isolate copper-clad brackets from metal studs with insulating tape, felt, or rubber pads.
      3) Fasten piping to brackets by soldering or by using plastic grommets/inserts.
4. Factory-fabricated PVC supports:
   a. Fasten brackets to waste piping, fixture carriers, or studs.

END OF SECTION

SECTION 20 05 33
ELECTRICAL HEAT TRACING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Electrical Heat Tracing System, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
   1. Electrical heat tracing system for exterior piping.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Standards:
   1. National Electrical Code.
   2. ANSI/IEEE-515 Recommended Practice for the Testing, Design and Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.

1.3 SUBMITTALS

A. Shop Drawings:
   1. System layout drawings.

B. Product Data.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Electrical Heat Tracing System:
   1. Base:
      a. Thermon.
   2. Optional:
      a. Tyco.
      b. Raychem.

2.2 MATERIALS

A. Electrical heat tracing system: UL listed heat tracing system including heaters, components and controls.
   1. Provide as indicated.

B. Heater: Low temperature, self-limiting cable.
   1. Two 16 AWG nickel plated copper bus wires embedded in parallel in a self-regulating polymer core.
      a. Power output varies to respond to temperature along its length.
         1) Provide heater with a radiation cross-linked modified polyolefin dielectric jacket.

C. Applications:
   1. Exterior piping:
      a. Output rating: 8 watts/foot at 50 DEGF pipe temperature with 2 IN pipe insulation and -20 DEGF.
         1) Pipe sizes 10 IN and under: One pass.
         2) Pipe sizes 12 IN to 18 IN: Two passes.

b. Electrical Requirements:
   1) Voltage: 208-277.
   2) Maximum cable length based upon 0 DEGF start-up temperature:
      a) 20 amp circuit: 284 FT.
      b) 30 amp circuit: 427 FT.
      c) 40 amp circuit: 479 FT.
c. Controls: Thermostat control, ambient sensing.
   1) Provide an ambient sensing thermostat to enable heat tracing through contactor when outdoor air temperature approaches freezing conditions.
d. Provide power connections, recommended pipe attachment accessories, end seals, splices and tee kits.
e. Manufacturer: Thermon FLX.

PART 3 - EXECUTION

3.1 INSTALLATION OF HEAT TRACING SYSTEM

A. Apply heater linearly on pipe after piping has been successfully pressure tested.

B. Install complete system in accordance with manufacturer's instructions.

C. After installation, subject heat tracing system to testing using a 2500 VDC megger prior to connection to power.
   1. Minimum resistance should be 20 megohms regardless of length.
   2. For piping, the heat tracing system shall be tested both before and after installing thermal insulation.

END OF SECTION

SECTION 20 05 50
MECHANICAL SOUND AND VIBRATION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Mechanical Sound and Vibration Control, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
1. Vibration isolators.
2. Bases.
3. Piping connections.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Comply with ASHRAE, ASTM and AASHO standards.

1.3 SUBMITTALS

A. Shop Drawings:
1. Submit drawings for each piece of isolated equipment.
2. Include drawings of spring isolators with equipment submittal. Include the following information:
   a. Spring diameter.
   b. Deflection.
   c. Compressed spring height.
   d. Solid spring height.
   e. Point location of each isolator.
   f. Calculated load at each point.
   g. Field static deflection.
   h. Calculated horizontal loading and bolt requirements.
   i. Indicate base clearance of 1 IN.
   j. Installation instructions and drawings.

B. Product Data:
1. Vibration isolators, bases, and piping connections for equipment: Include with equipment submittal.
2. Vibration isolators, bases, and piping connections for applications other than equipment.
   a. Indicate specific applications with submittal.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Mechanical Sound and Vibration Control:
1. Base:
   a. Mason Industries.
2. Optional:
   a. Vibration Mountings and Controls.
   b. Vibration Eliminator.
   c. Korfund Dynamics.
   d. Amber/Booth.
   e. California Dynamics.

f. Vibro-Acoustics.
g. Kinetics Noise Control.

2.2 MATERIALS

A. Provide piping and equipment isolation systems as specified.

B. Select vibration isolators in accordance with weight distribution to produce reasonably uniform deflection.

C. Provide vibration isolation equipment including isolators, bases, and piping connections from a single manufacturer of vibration isolation equipment.

D. Coat vibration isolation systems exposed to moisture and an outdoor environment as follows:
1. Hot dip galvanize steel parts.
2. Coat springs with neoprene.
3. Cadmium plate hardware.

2.3 VIBRATION ISOLATORS

A. Neoprene Isolators:
1. Type 1 isolator:
   a. Similar to ASHRAE Type 1 isolator.
   b. Neoprene wafer pads.
   c. Durometer or hardness shall suite application.
   d. Square waffle pattern on 1/2 IN centers.
   e. Waffle pad thickness: 3/4 IN.
   f. Provide steel backing plate where recommended by manufacturer.
   g. For non-bolted applications, provide adhesive on both sides of isolator.
2. Type 2 isolator:
   a. Similar to ASHRAE Type 2 isolator.
   b. Molded neoprene, double-deflection.
   c. Provide color coded neoprene-stock elements for easy identification of rated load capacity.
   d. Completely imbed steel top plate and base plate in neoprene elements.
   e. Where neither isolator nor equipment manufacturer recommends bolting, provide friction pads both top and bottom.
   f. Where either isolator or equipment manufacturer recommends bolting, provide bolt holes in base plate and tapped holes in top plate.
3. Type 2 isolator for suspended supports:
   a. Molded neoprene, double-deflection.
   b. Similar to ASHRAE Type 2 isolation hanger.
   c. Provide color coded neoprene-stock elements for easy identification of rated load capacity.
      1) Provide integral extension bushing on element where it contacts hanger frame to prevent metal to metal contact between frame and hanger rod.
   d. Provide hanger for direct attachment to flat iron duct straps.

B. Spring Isolators:
1. Type 3 isolator:
   a. Similar to ASHRAE Type 3 spring isolator.
   b. Free standing and laterally stable without housings, snubbers or guides.
   c. Provide 1/4 IN thick neoprene acoustical friction pads between baseplate and structure.
   d. Provide leveling bolts for rigid attachment to equipment.
   e. Spring diameter: Not less than 0.8 of compressed height of spring at rated load.
   f. Spring shall have minimum additional travel to solid equal to 50 PCT of rated deflection.
2. Type 3 isolator for suspended supports:
   a. Similar to ASHRAE Type 3 spring hanger.

b. Provide Steel spring and neoprene cup element in series inside bottom of hanger frame.
    1) Provide steel washer in cup to properly distribute load on neoprene and prevent its extrusion.
c. Provide integral extension bushing on neoprene element where it contacts hanger frame to prevent metal to metal contact between frame and hanger rod.
d. Minimum additional spring travel to solid: 50 PCT of rated deflection.
e. Spring diameter and hanger frame's lower hole size shall be large enough to permit hanger rod to swing through a 30 degree arc before contacting hole and short circuiting spring.

3. Type 3N isolator for suspended supports:
    a. Similar to ASHRAE Type 3 spring hanger.
    b. Provide Steel spring and molded neoprene element in series inside bottom of hanger frame.
        1) Provide steel washer in cup to properly distribute load on neoprene and prevent its extrusion.
    c. Provide color coded neoprene-stock elements for easy identification of rated load capacity inside top of hanger frame.
    d. Provide integral extension bushing on neoprene elements where they contact hanger frame to prevent metal to metal contact between frame and hanger rod.
    e. Minimum additional spring travel to solid: 50 PCT of rated deflection.
    f. Spring diameter and hanger frame's lower hole size shall be large enough to permit hanger rod to swing through a 30 degree arc before contacting hole and short circuiting spring.
4. Type 3P isolator for suspended supports:
    a. Similar to ASHRAE Type 3 spring hanger.
    b. Same as Type 3N except spring is precompressed to rated deflection so piping/equipment is maintained at a fixed elevation during installation.
    c. Provide a release mechanism to free spring after installation is complete and hanger is subjected to its full load.
5. Type 4 isolator:
    a. Similar to ASHRAE Type 4 restrained spring isolator.
    b. Free-standing, laterally stable spring isolator.
    c. Provide resilient vertical limit restraints to prevent spring extension during weight changes.
        1) During normal operation, restraints shall not contact spring assembly. (Minimum clearance: 1/2 IN.
    d. Provide acoustical neoprene separator between spring(s) and base plate to prevent short circuiting through baseplate anchor bolts.
    e. Installed height shall equal operating height.
6. Type 5 thrust restraint:
    a. Similar to ASHRAE Type 5 thrust restraint.
    b. Same as Type 3 isolator for suspended supports except with angle-iron and rod attachments configured for mounting across flexible duct connection.

2.4 BASES

A. Bases:
1. Type B, structural steel base:
    a. Rectangular in shape except for equipment which may require "T" or "L" shaped bases.
    b. Bases for split case pumps:
        1) Provide supports for suction and discharge base ells.
        2) Size base large enough to support base-ell supports.
    c. Perimeter members: Beams with a minimum depth equal to 0.10 of longest dimension of base.
    d. Beam depth need not exceed 14 IN provided that deflection and misalignment is kept within acceptable limits as determined by manufacturer.

e. Provide height saving brackets in mounting locations to provide a base clearance of 1 IN.
2. Type C, concrete-filled, structural steel base:
   a. Rectangular structural beam or channel concrete forms for floating foundations.
   b. Minimum base depth: 0.083 of longest dimension of base, but not less than 6 IN.
   c. Base depth need not exceed 12 IN unless specially recommended by base manufacturer for mass or rigidity.
   d. Bases for split case pumps:
      1) Provide supports for suction and discharge base ells.
      2) Size base large enough to support base-ell supports.
   e. Provide minimum concrete reinforcement consisting of 1/2 IN bars or angles welded in place on 6 IN centers running both ways in a layer 1-1/2 IN above bottom, or additional steel as is required by structural conditions.
   f. Provide steel members to hold anchor-bolt sleeves when anchor bolts fall in concrete locations.
   g. Provide height saving brackets in mounting locations to maintain a 1 IN clearance below base.

2.5 PIPING CONNECTIONS

A. Pipe Connections:
1. Flexible pipe connectors (FPC):
   a. Flexible neoprene/EPDM:
      1) Straight connectors: Twin sphere type.
      2) Elbow connectors: Single sphere type.
   b. Multiple plys of friction nylon tire cord with EPDM cover and liner.
   c. Do not use steel wire or rings as pressure reinforcement.
   d. Connectors:
      1) 2 IN NPS and smaller: Threaded or flanged ends.
      2) 2-1/2 IN NPS and larger: Floating galvanized steel flanges.
   e. Minimum pressure ratings:
      1) Twin spheres: 250 PSI at 170 DEGF and 165 PSI at 250 DEGF.
      2) Elbows and reducing twin spheres: 220 PSI at 170 DEGF and 145 PSI at 250 DEGF.
2. Flexible pipe hoses (FPH):
   a. Braided, stainless-steel type.
   b. Stainless steel braid: Type 321.
   c. Fittings: Carbon steel.
   d. Connections:
      1) 2-1/2 IN NPS and smaller: Male nipples or copper sweat to match specified piping joints.
      2) 3 IN NPS and larger: Flanged.
   e. Minimum transverse motion: ± 3/8 IN with no permanent misalignment.

PART 3 - EXECUTION

3.1 VIBRATION CONTROL

A. Install vibration control equipment in accordance with manufacturers installation instructions and as specified.

B. Select vibration control equipment as specified, and size in accordance with weight distribution, pull, and torque imposed by equipment being isolated.
1. Base selection on equipment with Architect approved submittals.
2. Minimum static deflections may be revised subject to prior approval.

C. Provide revised vibration control equipment to match revised or substituted equipment.

3.2 VIBRATION ISOLATORS, BASES, AND PIPING CONNECTIONS

A. Provide vibration isolators, bases, and piping connections as indicated in the following tables.

1. Superscript numbers in parentheses refer to notes at the end of the tables.

MOUNTED ON GRADE SUPPORTED SLAB					
Equipment	Horsepower & Other	Isolator Type	Minimum Deflection	Base Type	Pipe Connection Type (1,4)
Air Compressors & Vacuum Pumps (8)					
Tank Mounted					
Horizontal	Up to 10 HP	3	0.75 IN	none	FPH
Horizontal	15 HP & Up	3	0.75 IN	C	FPH
Vertical	All	3	0.75 IN	C	FPH
Base Mounted	All	3	0.75 IN	C	FPH
Large Reciprocating	All	3	0.75 IN	C	FPH
Cooling Towers					
301 to 500 RPM	All	1	0.25 IN	none	none
Above 500 RPM	All	1	0.25 IN	none	none
Diesel Fuel Pumps	All	none	---	IP	n/a
Pumps					
Close Coupled	Up to 7.5 HP	2	0.25 IN	B	FPC
	10 HP & Up	3	0.75 IN	B	FPC
Flex Coupled	Up to 40 HP	3	0.75 IN	B	FPC
	30 HP & Up	3	0.75 IN	none	FPC
End Suction	Up to 40 HP	3	0.75 IN	C	FPC
	50 to 125 HP	3	0.75 IN	C	FPC
	150 HP & Up	3	0.75 IN	C	FPC
Grouped On Base	All	1	0.30 IN	IP	FPC
Packaged Systems (8)	All	3	0.75 IN	C	FPC

MOUNTED ON STRUCTURAL FLOOR								
		21 TO 30 FT FLOOR SPAN			31 T0 40 FT FLOOR SPAN			Pipe
Equipment	Horsepower & Other	Isolator Type	Minimum Deflection	Base Type	Isolator Type	Minimum Deflection	Base Type	Connection Type (1,4)
Boilers	All	4	1.50 IN	B	4	2.50 IN	B	none
Chillers								
Centrifugal	All	4	1.50 IN	C	4	1.50 IN	C	FPC
Screw	All	4	1.50 IN	none	4	1.50 IN	none	FPC
Pumps								
Close Coupled	Up to 7.5 HP	3	0.75 IN	B	3	0.75 IN	C	FPC
	10 HP & Up	3	1.50 IN	B	3	1.50 IN	C	FPC
Flex Coupled	Up to 40 HP	3	1.50 IN	B	3	1.50 IN	C	FPC
	50 to 125 HP	3	1.50 IN	C	3	2.50 IN	C	FPC
	Over 125 HP	3	3.5 IN	C	-	-	-	-
End Suction	Up to 40 HP	3	1.50 IN	C	3	1.50 IN	C	FPC
	50 to 125 HP	3	1.50 IN	C	3	2.50 IN	C	FPC
	150 HP & Up	3	2.50 IN	C	3	3.50 IN	C	FPC
Packaged Systems (8)	All	3	1.50 IN	C	3	2.50 IN	C	FPC

SUSPENDED FROM STRUCTURE								
		21 TO 30 FT FLOOR SPAN			31 T0 40 FT FLOOR SPAN			Pipe
Equipment	Horsepower & Other	Isolator Type	Minimum Deflection	Base Type	Isolator Type	Minimum Deflection	Base Type	Connection Type (1,4)
Fans, Inline (3)	Up to 0.5 HP	3 or 3N	0.50 IN	none	3 or 3N	0.50 IN	none	n/a
	0.75 to 3 HP	3 or 3N	0.75 IN	none	3 or 3N	0.75 IN	none	n/a
	5 to 7.5 HP	3 or 3P & 5	1.50 IN	none	3 or 3P & 5	1.50 IN	none	n/a
	10 HP & Up	3 or 3P & 5	1.50 IN	none	3 or 3P & 5	2.50 IN	none	n/a
	10 HP & Up	3 or 3N & 5	1.50 IN	none	3 or 3N & 5	2.50 IN	none	n/a
Fans Coil Units	Up to 0.5 HP	2	0.50 IN	none	2	0.50 IN	none	FPC
	0.75 to 1.0 HP	3 or 3N	0.75 IN	none	3 or 3N	0.75 IN	none	FPC
	1.5 HP & Up	3 or 3P	0.75 IN	none	3 or 3P	1.50 IN	none	FPC
Piping (9) First 3 supports from equipment connection Remaining supports within 50 FT of equipment connection	All	3P	Note 11	none	3P	Note 11	none	n/a
Suspended Individually	Up to 3 IN	3N	0.75 IN	none	3N	0.75 IN	none	n/a
	4 IN & Up	3P	0.75 IN	none	3P	0.75 IN	none	n/a
Suspended on Trapeze	All	3P	1.50 IN	none	3P	1.50 IN	none	n/a
	All	3N	2.50 IN	none	3N	2.50 IN	none	n/a
Piping in Mechanical Rooms (10,12,14)								
	Up to 3 IN	3N	0.75 IN	none	3N	0.75 IN	none	n/a
	4 to 6 IN	3P	1.50 IN	none	3P	1.50 IN	none	n/a
	8 IN & Up	3P	1.50 IN	none	3P	1.50 IN	none	n/a
	8 IN & Up	3N	2.50 IN	none	3N	2.50 IN	none	n/a
Piping at Building Expansion Joints								
Nonflammable Gases (non-medical)	All	n/a	n/a	none	n/a	n/a	none	FPH or Loop
Potable Water	All	n/a	n/a	none	n/a	n/a	none	FPC or Loop
Other Systems	All	n/a	n/a	none	n/a	n/a	none	loop
Piping at Plenum Penetrations	All	n/a	n/a	none	n/a	n/a	none	Note 14
Pumps								
Inline	Up to 2 HP	3 or 3N	0.75 IN	none	3 or 3N	0.75 IN	none	FPC
	3 to 5 HP	3 or 3P	1.50 IN	none	3 or 3P	1.50 IN	none	FPC
	7.5 HP & Up	3 or 3P	1.50 IN	none	3 or 3P	1.50 IN	none	FPC
	7.5 HP & Up	3 or 3N	2.50 IN	none	3 or 3N	2.50 IN	none	FPC

MOUNTED ON ROOF								
		21 TO 30 FT FLOOR SPAN			31 T0 40 FT FLOOR SPAN			Pipe
Equipment	Horsepower & Other	Isolator Type	Minimum Deflection	Base Type	Isolator Type	Minimum Deflection	Base Type	Connection Type (1,4)
Air Handling Units With internal (blower) isolation	All	See Blower/Fans			See Blower/Fans			n/a
Blowers/Fans								
Externally Isolated	Up to 5 HP	3	0.75 IN	E	3	0.75 IN	E	n/a
	7.5 HP & Up	3	1.50 IN	E	3	1.50 IN	E	n/a
Internally Isolated	Up to 10 HP	3	0.75 IN	E	3	1.50 IN	E	n/a

B. Notes to Tables:
1. Install piping connectors on equipment side of equipment isolation valves.
2. Size indicates diameter of wheel.
3. Provide Type 5 isolators on units operating at 2 IN or more static pressure.
   a. Mount one pair of isolators (on opposite sides) on each of fan's flexible connections.
   b. Adjust isolators to prevent flexible connections from extending to a tension condition.
   c. Attach isolators to duct at flanged joint through angle iron on back side of joint.
   d. See Section 23 31 13.
4. A swing joint with three flexible mechanical groove couplings may be substituted for an FPC.
5. Spring diameter: 2.50 IN.
6. Spring diameter: 4 IN.
7. Spring diameter: 6 IN.
8. On packaged systems, provide only external isolation.
9. Provide isolators on piping connected to vibrating equipment (i.e., equipment for which piping connections are specified).
10. Provide isolators for drainage and vent piping only if connected to vibrating equipment.
11. Same type as specified for equipment, except minimum deflection is 0.75 IN, and maximum deflection is 2.00 IN.
12. Mechanical rooms:
    a. Mechanical rooms:
       1) Provide isolators for piping within mechanical rooms.
       2) Where isolators are indicated for piping connected to vibrating equipment, provide isolators which have the largest indicated minimum deflections.
13. Integral with base D.
14. Piping connection types:
    a. Water: FPC.

END OF SECTION

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SECTION 20 05 53
MECHANICAL IDENTIFICATION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Mechanical Identification Systems, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Piping system identification:
   1. ASME/ANSI-A13.1 Scheme for the Identification of Piping Systems.

1.3 SUBMITTALS

A. Product Data:
   1. Pipe markers.
   2. Valve tags.
   3. HVAC duct markers.
   4. Equipment name plates.

B. Contract Closeout Information:
   1. Valve Chart.
      a. Submit completed Spare Parts and Maintenance Material Transmittal form.
      b. See Section 01 78 43.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Mechanical Identification Systems:
   1. Pipe, valve and equipment markers:
      a. Base:
         1) Seton Name Plate.
      b. Optional:
         1) Brady, WH.
         2) EMED.
         3) Kolbi Industries.
         4) 3M.
         5) Craftmark Identification Systems.
         6) Marking Services, Inc.
         7) Carlton Industries.
         8) Brimar.
   2. Underground marking tape:
      a. Base:
         1) Reef Industries.
      b. Optional:
         1) Seton Name Plate.
         2) EMED.

2.2 PIPE MARKERS

A. Conform to ASME/ANSI-A13.1.

B. Pressure sensitive vinyl self-adhesive material.

C. Mechanically fastened type: Snap on or strap on.
   1. For dirty greasy, oily pipe where pressure sensitive markers may not perform satisfactorily.

D. Provide with arrows indicating direction of flow.

E. Letter sizes: In accordance with table in Part 3.

2.3 VALVE TAGS

A. Brass or anodized aluminum type.

B. Brass:
   1. Minimum 19 gauge, polished, 1-1/2 IN diameter with following lettering:
      a. Service: 1/4 IN stamped black filled letters.
      b. Valve numbers: 1/2 IN stamped black filled letters.

C. Aluminum:
   1. 2 IN diameter, 0.032 IN thick, with following lettering:
      a. Service: 1/4 IN engraved letters.
      b. Valve numbers: 1/2 IN engraved letters.

D. Valve tag fasteners:
   1. 4 ply 0.018 IN copper or monel wire meter seals, brass "S" hooks or No.16 brass jack chain.

2.4 HVAC DUCT MARKERS

A. HVAC Duct Markers:
   1. 1-1/2 IN black stenciled letters denoting system number (e.g., AHU-1, RF-3, EF-5), type (supply, return, exhaust) and flow direction.

2.5 EQUIPMENT NAME PLATES

A. Equipment name plates:
   1. 1/16 IN rigid plastic, Setonply, Emedolite or bakelite with four edges beveled; or engraved aluminum with black enamel background and natural aluminum border and letters.
      a. Two 3/8 IN mounting holes.
      b. Lettering size: Minimum 1/2 IN high.

2.6 CHART AND DIAGRAM FRAMES

A. Extruded aluminum with plexiglass or glass windows.

PART 3 - EXECUTION

3.1 VALVE IDENTIFICATION

A. Identify valves, with service designation and valve number designation on valve tags.
   1. Tagging of valves at unit heaters, fan coil units, air terminal unit reheat coils and plumbing fixture stops are not required.
   2. Install tags on valves using valve tag fasteners in manner for easy reading.

B. Furnish 4 charts including valve identification number, location (room number, department) and purpose.
   1. Mount 1 chart in frame and secure on wall in location directed by Owner.
   2. Include remaining 3 sets in Operation and Maintenance Manuals.

3.2 PIPE IDENTIFICATION

A. Fire-protection and Sprinkler Piping.
   1. Painting not required in non-finished areas.

B. Identify piping systems with indicated lettering:

Drawing Symbol	Pipe Identification Lettering
CA	Compressed Air
CD	Condensate Drain
CWR	Condenser Water Return
CWS	Condenser Water Supply
CW	Domestic Cold Water
CHWR(__)	Chilled Water Return (temperature)
CHWS(__)	Chilled Water Supply (temperature)
DI	Deionized Water
DW	Distilled Water
F	Fire Protection
FOR	Fuel Oil Return
FOS	Fuel Oil Supply
G	Natural Gas
HW(___)	Domestic Hot Water Supply (temperature)
HWC(___)	Domestic Hot Water Circulating (temperature)
HWR	Heating Hot Water Return
HWS	Heating Hot Water Supply
LA	Laboratory Air (55 PSI)
NPW	Nonpotable Water
P	Discharge Plumbing-Sump Pump/Sewage Ejector
PCWR	Process Cooling Water Return
PCWS	Process Cooling Water Supply
S	Sprinklers
SCW	Soft Cold Water

C. Locate identification lettering as follows:
   1. Next to each valve and fitting, except on plumbing fixtures and equipment.
   2. At each branch or riser take off.
   3. At each passage through walls, floors and ceilings, both sides.
   4. At each pipe passage to underground.
   5. On horizontal pipe runs every 20 FT, at least once in each room and each story traversed by piping system.
   6. Identify piping contents, flow direction, supply and return.
   7. So it is readable from access panels and not obscured by other work.
   8. At least once in or above every room.

D. Size lettering, marker color fields, and arrows as follows:

IN	IN	IN
3/4 to 1-1/4	8	1/2
1-1/2 to 2	8	3/4
2-1/2 to 6	12	1-1/4
8 to 10	24	2-1/2
Over 10	32	3-1/2

E. Pipe Markers:
   1. Install markers with tape color bands over each end of marker, extending around pipe and overlapping a minimum of 30 DEG.

F. Where piping is heat traced, provide warning labels on insulation adjacent to each piping system identifier.
   1. Heat tracing cable: See Section 20 05 33.

3.3 DUCTWORK IDENTIFICATION

A. Locate duct markers as follows:
   1. At each branch or riser take-off.
   2. Next to equipment.

B. Stencil ductwork or exterior surface of insulation.

3.4 EQUIPMENT IDENTIFICATION

A. Attach equipment nameplates in conspicuous location, directly on item of equipment or apparatus such as starters, pumps, fans, HVAC units and control panels.
   1. Secure nameplates with self-tapping screws, or nuts and bolts.

B. For unsuitable surfaces, such as high temperature or lack of space, use copper or brass rings or chains to attach tags.

C. Identify devices located above ceilings with additional identification.
   1. Use access panel markers (metal tack style) for acoustical tile ceilings, or engraved plastic style, 3/4 IN square, for mounting on panel door; or equipment nameplates.
   2. Coordinate with Owner on identification method and color codes.
   3. Provide markers on all removable ceilings and ceiling access panels to indicate locations of valves, dampers, smoke detectors, etc., and other mechanical items that may need servicing or adjustment. Glue marking tacks in place to prevent their falling out.
   4. Where fire protection devices are located inside ductwork, provide an additional tag on the duct access door identifying device inside.
      a. Identification letter size: 1-1/2 IN high minimum.
   5. Color code access panel markers as follows:
      a. Red: Fire dampers, smoke detectors, sprinkler shutoff valves and duct type smoke detectors.
         1) Notation:
            D - Damper
            V - Valve
            S - Smoke Detector
            H - Heat Detector
      b. Yellow: Reheat and chilled water valves:
         1) Notation:
            V - Valve
      c. Gold: Automatic and balancing dampers:
         1) Notation:
            V - Valve
            D - Damper
      d. Blue: Gases (valves):
         1) Notation
            N - Nitrogen
            T - Temperature Control Air

3.5 CONTROL DIAGRAMS AND INSTRUCTIONS

A. Provide HVAC control and systems instructions and diagrams in wall mounted frames.
   1. Mount framed diagrams in conspicuous, easily accessible places in equipment rooms housing appropriate HVAC system.

B. Diagrams and instructions may be reduced in size provided they are easily readable and lettering is not smaller than "elite" type of standard typewriter.

END OF SECTION

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SECTION 20 07 00

PIPE, DUCT AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Pipe, Duct and Equipment Insulation, as indicated, in accordance with provisions of Contract Documents.

B. Insulation Applications:
   1. Pipe insulation.
   2. Duct insulation.
   3. Equipment insulation.
   4. Insulation jacketing and prefabricated fitting covers.
   5. Insulation fasteners: Adhesives, mastics, and caulking.
   6. Special Considerations at hangers and bracing: See Section 20 05 29 Penetrations and Supports.

C. Definitions:
   1. Concealed: Outside surfaces are isolated from room ambient air conditions by physical barrier.
      a. Concealed items are typically accessed through suspended ceilings, through access doors, or by cutting and patching.
      b. Listed below are examples of spaces that typically contain concealed items:
         1) Walls.
         2) Partitions.
         3) Chases.
         4) Shafts.
         5) Ceiling spaces.
   2. Exposed: Outside surfaces are not isolated from room ambient air conditions by physical barrier.
      a. Exposed items are typically accessed directly from within a room or space.
      b. Listed below are examples of rooms/spaces that typically contain exposed items:
         1) Mechanical rooms.
         2) Tunnels.
         3) Rooms without ceilings.
   3. Exposed to weather: Outside surfaces are not isolated by physical barrier(s) from weather or outside ambient air conditions.
   4. Runouts: Piping not more than 12 FT in length.
   5. Thermal conductivity (k): Btu/(h-ft-degF).
   6. Serviceable: strainers, cleanouts.
   7. Non-Serviceable: fittings, valves.

D. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Comply with the following fire and smoke hazard ratings:
   1. Test products by procedure ASTM E84, NFPA-255 and ANSI/UL-723.
   2. Rating requirements:
      a. Maximum Flame Spread: 25.
      b. Maximum Smoke Developed: 50.
   3. Properly identify products for flame and smoke ratings.
      a. Shipping cartons may be labeled instead of product.

B. Comply with requirements of the following:
   1. ASTM C547 Standard Specification for Mineral Fiber Preformed Pipe Insulation.
   2. ASTM C533 Standard Specification for Calcium Silicate Pipe and Block Insulation.
   3. ASTM C534 Standard Specification for Preformed Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
      a. Products are allowed to deviate from this standard with regard to insulation density.
   4. ASTM C552-00 Standard Specification for Cellular Glass Thermal Insulation.
   5. ASTM C553 Standard Specification for Mineral Fiber Blanket and Felt Insulation.
   6. ASTM C585 Recommended Practice for Inner and Outer Diameters of Rigid Pipe 'Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
   7. ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
   8. ASTM C1136 Standard Specification for Flexible Low Permeance Vapor Retarders for Thermal Insulation.
   9. ASTM C795 Thermal Insulation for Use Over Austenitic Stainless Steel.
   10. Federal Specification HH-I-558B Mineral Fiber Boards, Blankets, Pipe Covering.
   11. ASTM E 84, Surface Burning Characteristics: Underwriters Laboratories Applied Fireproofing Listing Nos. 11660-2, 11660-4.
   12. ASTM E 814, Through-Penetration, 2-Hour Firestop Test.
   13. ASTM E 119 Standard Method of Fire Tests of Building Construction, 2 Hour Wall Panel Test, 2 Hour External Total Engulfment Test, hose stream evaluation.
   14. ASTM C 518 Aging Test, Steady State Heat Flux Measurements and Thermal Transmission Properties.
   15. ASTM E 162, Surface Flammability of Materials.
   16. ASTM E 136, Combustion Characteristics of Building Materials in a Vertical Tube Furnace.
   17. ISO 6944-1985, Method of Determining Fire Resistance of Ventilation Ducts.
   18. National Commercial and Industrial Insulation Standards (2013 seventh edition).
      a. Published by Midwest Insulation Contractors Association (MICA).
      b. Endorsed by National Insulation Association (NIA).
      c. MICA plate numbers listed in this specification reference this document.

1.3 SUBMITTALS

A. Product Data:
   1. Pipe insulation.
   2. Precut insulation inserts.
   3. Ductwork insulation.
   4. Insulation for hot equipment.
   5. Insulation for high-temperature equipment.
   6. Insulation for cold equipment.
   7. Jacketing and prefabricated fitting covers.
   8. Insulation fasteners.
   9. Schedule of services and insulation thicknesses.
   10. Grooved coupling system insulation procedures and methods.

PART 2 - GENERAL

2.1 ACCEPTABLE MANUFACTURERS

A. Pipe, Duct and Equipment Insulation:
   1. Insulation materials:
      a. Base: As indicated.
      b. Optional:
         1) Owens-Corning Fiberglass.
         2) Armacell.
         3) Nomaco K-Flex.
         4) CertainTeed Insulations.

5) Knauf Insulation.
6) Johns Manville.
7) Pittsburgh Corning.

2. Jacketing:
   a. Base: As indicated.
   b. Optional:
      1) Ceel-Co.
      2) Childers Products.
      3) Johns Manville.
      4) Proto PVC Corporation.
      5) RPR Metals.
      6) Pabco Metals Corporation.
3. Prefabricated fitting covers:
   a. Base: As indicated.
   b. Optional:
      1) Ceel-Co.
      2) CertainTeed Insulations.
      3) Childers Products.
      4) Proto PVC Corporation.
      5) Johns Manville.
      6) RPR Metals.
      7) Pabco Metals Corporation.
4. Adhesives, mastics, caulkings, and finishes:
   a. Base: As indicated.
   b. Optional:
      1) Foster Products, Division of HB Fuller.
      2) Armacell.
      3) Childers Products.
      4) Dow Corning.
      5) Johns Manville.
      6) Knauf Insulation.

2.2 MATERIALS

A. General:
   1. Do not use material that exceeds specified flame and smoke ratings.
   2. Use permanent treatments to jacketings and facings to impart specified fire ratings.
   3. Use of water soluble treatments is prohibited.

2.3 PIPE INSULATION - NON-FLEXIBLE FIBERGLASS

A. Preformed commercial-grade fiberglass.

B. Temperature range: 0 DEGF to 850 DEGF.

C. Thermal conductivity at mean temperature:
   1. $k \leq 0.23$, 75 DEGF.
   2. $k \leq 0.29$, 200 DEGF.
   3. $k \leq 0.54$, 500 DEGF.

D. Facing: All service jacket.

E. Integral vapor retarder: Provide where indicated in Part 3.

F. Seams, longitudinal: 2 IN self-sealing facing tabs.
   1. Provide adhesive on both contacting surfaces.
   2. Designed to perform without stapling.

G. Pipe insulation, non-flexible; cellular glass:

2.4 PIPE INSULATION - FLEXIBLE

A. Commercial-grade closed-cell elastomeric or unicellular polyolefin thermal insulation.

B. Temperature range: 40 to 200 DEGF.

C. Thermal conductivity at mean temperature:
   1. $k \leq 0.27$, 75 DEGF.
   2. $k \leq 0.276$, 90 DEGF.

D. Seams, longitudinal: Factory-cut and self-sealing.
   1. Base product: AP Armaflex SS.

2.5 DUCTWORK INSULATION, NON-FLEXIBLE

A. Commercial-grade fiberglass thermal insulation formed with a thermosetting resin into semi-rigid or rigid boards.

B. Temperature range: 0 to 450 DEGF.

C. Minimum density:
   1. Semi-rigid: 3.0 PCF.
   2. Rigid: 6.0 PCF.

D. Thermal conductivity at mean temperature:
   1. Semi-rigid:
      a. $k \leq 0.22$, 75 DEGF.
      b. $k \leq 0.27$, 150 DEGF.
      c. $k \leq 0.38$, 300 DEGF.
   2. Rigid:
      a. $k \leq 0.23$, 75 DEGF.
      b. $k \leq 0.27$, 150 DEGF.
      c. $k \leq 0.37$, 300 DEGF.

E. Facing: All-Service-Jacket (ASJ).

F. Temperature range: -20 to 150 DEGF.

G. Base Products:
   1. Semi-Rigid: Owens-Corning Fiberglas Type 703.
   2. Rigid: Owens-Corning Fiberglas Type 705.

2.6 DUCTWORK INSULATION - FLEXIBLE

A. Interior Use:
   1. Commercial-grade fiberglass thermal insulation, formaldehyde free.
   2. Temperature range: 40 to 250 DEGF.
   3. Thermal conductivity at mean temperature: $k \leq 0.27$, 75 DEGF.
   4. Installed R-value: 5.6 HR-ft2-degF/BTU based on 2 IN nominal thickness.
   5. Density: 3 .75 PCF
   6. Facing: Foil-Reinforced-Kraft (FRK) vapor-retarding.
   7. Seams: 2 IN facing tab.
   8. Base product: Owens-Corning Fiberglass commercial-grade all-service duct wrap.

B. Exterior Use:
   1. Commercial-grade closed-cell elastomeric or unicellular polyolefin thermal insulation.
   2. Temperature range: –40 to 180 DEGF.
   3. Thermal conductivity at mean temperature: $k \leq 0.27$, 90 DEGF.
   4. Water vapor permeability: 08 perm-in.
   5. Base Product: AP Armaflex Sheet and Roll.

2.7 INSULATION FOR HOT EQUIPMENT

A. Same as Pipe Insulation - Nonflexible.

2.8 INSULATION FOR HIGH-TEMPERATURE EQUIPMENT

A. Calcium Silicate:
   1. Designed for application on systems operating at temperatures up to 1200 DEGF.
   2. Minimum density: 14.5 PCF.
   3. Thermal conductivity at mean temperature:
      a. $k \leq 0.40$, 200 DEGF.
      b. $k \leq 0.45$, 400 DEGF.
      c. $k \leq 0.55$, 600 DEGF.

B. Mineral Wool Batts:
   1. Designed for application on systems operating at temperature range: up to 1200 DEGF.
   2. Minimum density: 38 PCF.
   3. Thermal conductivity at mean temperature:
      a. $k \leq 0.30$, 200 DEGF.
      b. $k \leq 0.38$, 300 DEGF.
      c. $k \leq 0.48$, 400 DEGF.

2.9 INSULATION FOR COLD EQUIPMENT

A. Material: Commercial-grade elastomeric thermal insulation.

B. Designed for application with complete adhesive coverage on systems operating at temperatures between -40 and 180 DEGF.

C. Thermal conductivity at mean temperature:
   1. $k \leq 0.27$, 75 DEGF.
   2. $k \leq 0.276$, 90 DEGF.

D. Base product: AP Armaflex sheet insulation.

2.10 JACKETING AND PREFABRICATED FITTING COVERS

A. General:
   1. Fitting Covers:
      a. Designed to fit over precut insulation inserts.
      b. Designed specifically for fitting being covered.
      c. 2-gore covers are not acceptable.

B. Jacketing and Fitting Covers:
   1. High impact PVC.
   2. Minimum 0.028 IN thick.

C. Metal Jacketing and Fitting Covers:
   1. Material: As indicated in Part 3.
   2. On cold systems and equipment, provide factory moisture barrier.
   3. Attaching method:
      a. 0.020 x 3/8 IN bands on 9 IN centers unless indicated otherwise in Part 3.
      b. Band material: Same as jacketing and covers.
   4. Minimum 2 IN overlap at joints.
   5. Tubular jacketing: Locking longitudinal seams.
   6. Base manufacturer: Childers.

2.11 INSULATION FASTENERS

A. Insulation Adhesive:
   1. Flexible pipe insulation: Manufacturers standard adhesive as approved for application.
   2. Foster 30-36.

3. Foster Spark-Fas 85-70.

B. Insulation Mastic:
1. Childers CP-30.
2. Foster 35-00-GPM.

C. Insulation Caulking:
1. Dow No.11.

PART 3 - GENERAL

3.1 APPLICATION

A. General:
1. Apply products per manufacturer's recommendations and as specified.
    a. Include allowance for thermal expansion and contraction.
2. MICA plate numbers are listed under some insulation applications to clarify scope and acceptable methods of insulation application for particular listing.
3. Do not insulate piping until satisfactory completion of required pressure tests.
4. Do not insulate piping until heat tracing cable has been installed.
5. Do not insulate piping below grade.
    a. Specific exceptions may exist under Pipe Insulation - Flexible.
6. Apply insulation to clean, dry surfaces and within manufacturers recommended temperature range.
7. Butt edges of insulation firmly together, and seal joints with compatible jackets, facings and adhesives as specified.
8. Apply insulation with a continuous, unbroken vapor retarder including, but not limited to, insulation of following.
    a. Vapor seals on hangers, supports, and anchors secured directly to cold surfaces.
9. Continue insulation through sleeves and wall and ceiling openings.
10. Insulate fittings, unions, valve bodies, flanges and other pipeline accessories.
11. Insulation at piping supports: Coordinate with Section 20 05 29.
12. Rectangular and flat-oval ductwork exposed to weather:
    a. Apply insulation and jacketing so top of ductwork crowns to prevent pooling of water.
        1) Minimum crown slope: 1/4 IN/FT.
13. Insulation installed in multiple layers: Stagger joints between layers.

3.2 PIPE INSULATION - NONFLEXIBLE FIBERGLASS

A. General:
1. Provide either type of lap seal at joints:
    a. Self-sealing facing tabs.
    b. 3 IN wide pressure-sensitive joint-sealing tape matching facing.
        1) Manufacturer: Same as insulation.
    c. Insulation application standard: MICA plate number 1-100.
    d. Insulation application for heat traced piping standard: MICA plate number 1-900.
2. Fittings:
    a. On non-serviceable items, use either of the following methods:
        1) Built-up systems:
            a) Elbows: MICA plate numbers 2-100 through 2-800 as applicable.
            b) Valves and fittings: MICA plate number 2-530 or 2-536 as applicable.
            c) Flanges: MICA plate number 2-535.
            d) Tees: MICA plate number 2-120.
        2) Prefabricated fitting cover encapsulated:
            a) Elbows: MICA plate number 2-500.
            b) Valves and fittings: MICA plate number 2-130.
            c) Flange or grooved coupling: MICA plate number 2-535.

b. Serviceable items: Provide prefabricated fitting covers attached with bands.
   1) Exception: On systems exposed to weather, attach with method described as best by manufacturer.
c. Exposed fittings, flanges, valves, and pipe terminations: Provide prefabricated fitting covers.
d. Built-up system:
   1) DN50 2 IN and smaller: Finish with mineral fiber cement to thickness of adjoining pipe insulation.
   2) DN65 2-1/2 IN and larger: Insulate with insulation insert, mitered pipe insulation segments or preformed fiberglass fittings.
      a) Secure with vinyl faced insulation strapping tape or 20 AWG galvanized annealed wire finished with one coat of mineral fiber cement.
   3) Finish with Glass Fab embedded in 2 coats of Foster 30-36 adhesive.

B. Provide non-flexible insulation on following piping systems in wall thickness indicated:
   1. Hydronic systems:
      a. Heating water piping, to 200 DEGF:
         1) DN32 1-1/4 IN and smaller: 1-1/2 IN.
         2) DN40 1-1/2 IN and greater: 2 IN.
   2. Plumbing systems:
      a. Domestic cold water piping:
         1) DN40 1-1/2 IN and smaller: 1 IN.
         2) DN50 2 IN and greater: 1-1/2 IN.
      b. Domestic hot/recirculating water, 100 to 140 DEGF:
         1) DN32 1-1/4 IN and smaller: 1 IN.
         2) DN40 1-1/2 IN and greater: 1-1/2 IN.
      c. Domestic hot/recirculating water 141 to180 DEGF:
         1) DN32 1-1/4 IN and smaller: 1-1/2 IN.
         2) DN40 1-1/2 IN and greater: 2 IN.
   3. Lab air systems:
      a. Lab air intake piping:
         1) All sizes: 1 IN.
         2) Lab air intakes are cold systems.

C. Piping Within Air Handling Units:
   1. Flame-resistant, aluminum-faced, vapor retarder jacket over non-flexible insulation on heating water, and chilled water piping inside air handling units.
   2. Extend vapor retarder jacket outside of unit enclosure.
   3. Cover joints with 3 IN wide pressure sensitive tape matching jacket.

3.3 PIPE INSULATION - NONFLEXIBLE CELLULAR GLASS

A. General:
   1. Provide non-flexible insulation on following piping systems in wall thickness indicated:

3.4 PIPE INSULATION - FLEXIBLE

A. General:
   1. Install insulation sleeve over piping.
   2. Do not make longitudinal field cuts.
   3. Seal joints with manufacturer approved adhesive.
   4. Do not use flexible pipe insulation on systems with heat tracing cable or temperature maintenance cable.

B. Fittings:
   1. Insulate fittings and valve bodies with segments cut from pipe insulation.

C. Provide flexible insulation on following piping systems in wall thickness indicated:
   1. Hydronic systems:

a. Cooling coil condensate:
    1) All sizes: 1 IN.
b. Chilled water piping, 40 to 55 DEGF:
    1) DN40 1 1/2 IN and smaller: 1 IN.
    2) DN50 2 IN and above: 1 1/2 IN.

2. Plumbing systems:
    a. Domestic cold water piping:
        1) DN40 1-1/2 IN and smaller: 1/2 IN.
        2) DN50 2 IN and larger: 1 IN.
    b. Waste piping from lab sinks to main stacks:
        1) All sizes: 1/2 IN.
    c. Waste piping from water coolers and drinking fountains to first point of mixing with waste from a different type of fixture:
        1) All sizes: 1/2 IN.
    d. Domestic water piping below grade within 5 FT of outside walls:
        1) All sizes: 1/2 IN.
    e. Horizontal rain leaders, including overflow systems and 24 IN up and down from horizontal and up to underside of roof deck:
        1) All sizes: 1 IN.
        2) Rain leaders are cold systems.
    f. Horizontal condensate drain leaders (serving condensate drain discharge from cooling coil condensate drains and floor drain:
        1) All sizes: 1 IN.
        2) Condensate drain leaders are cold systems.

3.5 DUCTWORK INSULATION - NONFLEXIBLE

A. General:
1. Secure insulation to ductwork by impaling over welded-pin or adhesive-pin mechanical fasteners.
    a. Secure insulation on mechanical fasteners with speed clips.
    b. Space mechanical fasteners to hold insulation securely in place.
        1) Maximum spacing: 12 IN centers.
2. Where access is not possible for pin attachment, use adhesive or caulk.
    a. Cover entire surface with brush applied adhesive.
    b. Apply caulk in continuous bead on 6 IN centers.
3. Seal joints and speed clips with 3 IN wide pressure-sensitive joint-sealing tape matching facing.
    a. Staple corners of tape with outward clinching staples.
4. Cold systems only: Coat staples with mastic.
5. Reinforce edges with metal corner angles.
6. Apply insulation to ductwork from unit housing to ends of duct runs including diffuser necks and register ducts.
7. Do not apply insulation over coil and damper access panels.
8. Use FRK facing on concealed ductwork.
9. Use ASJ facing on exposed ductwork.

B. Provide non-flexible insulation on following ductwork in thickness indicated:
1. Supply-air ductwork exposed in occupied spaces, except equipment rooms:
2. Exhaust-air plenums below exhaust fans:
    a. All sizes: 2 IN.

3.6 DUCTWORK INSULATION - FLEXIBLE

A. General:
1. On ductwork 24 IN wide and less, secure insulation to bottom of ductwork with 4 IN wide bands of brush-applied adhesive on 12 IN centers.

2. On ductwork over 24 IN wide, secure insulation to bottom of ductwork by impaling over welded-pin or adhesive-pin mechanical fasteners.
    a. Secure insulation on mechanical fasteners with speed clips.
    b. Space mechanical fasteners to hold insulation securely in place.
        1) Maximum spacing: 12 IN centers.
    c. Seal speed clips with 3 IN wide pressure-sensitive joint-sealing tape matching jacket.
        1) Staple corners of tape with outward clinching staples.
        2) Cold systems only: Seal staples with mastic.
3. Provide either type of lap seal at joints:
    a. Seal facing tab over adjoining facing with lap adhesive.
        1) Secure lap with outward clinching staples on 6 IN centers.
    b. Use 3 IN wide pressure-sensitive joint-sealing tape that matches facing.
        1) Secure both sides of tape with outward clinching staples on 6 IN centers.
    c. Cold systems only: Seal staples with mastic.
4. Apply insulation to ductwork from unit housing to ends of duct runs, including diffuser necks and register ducts.
5. Do not apply insulation over coil and damper access panels.

B. Provide flexible insulation on following ductwork in thickness indicated:
1. Supply-air ductwork, including downstream of terminal units, sound attenuators, reheat coil casings and tube ends, except where specified to be covered by nonflexible insulation:
    a. All sizes: 2-1/8 IN; minimum installed R-value of 6.0.
2. Return-air ductwork in non air conditioned areas (including utility shafts):
    a. All sizes: 2-1/8 IN; minimum installed R-value of 6.0.
    b. Ceiling spaces directly above conditioned spaces are considered conditioned.

C. Flexible Elastomeric:
1. For exterior ductwork exposed to weather.
2. Install in accordance with MICA National Commercial and Industrial Standards Plate No.: 20A.
3. Adhesive: Applied as required to assist installation.
4. Mechanical fasteners: As required to assist installation.
5. Provide one of following as a weather barrier:
    a. Jacket: metal.
    b. Aluminum composite facing with UV/weather resistant coating.
        1) Example: K-Flex LS sheet.
        2) Product must be provided with a twenty-five (25) year limited warranty against breakdown of the membrane due to ultraviolet radiation.
    c. Factory applied multi-ply laminate UV/weather resistant facing.
        1) Example: Armaflex ArmaTuff Plus II.
        2) Thickness: 16 MIL laminated covering membrane.
            a) UV protective, blended polymeric top surface.
            b) Puncture-resistant blended polymeric base around a scrim reinforced core.
        3) Product must be provided with a ten (10) year limited warranty against breakdown of membrane due to ultraviolet radiation.
6. Insulation of standing seams: insulation manufactures field-cut pipe insulation with weather barrier.
7. Apply insulation and jacketing so that top of ductwork has crown that effectively prevents pooling of water.
    a. Minimum crown slope: 1/4 IN/FT.
8. Provide flexible elastomeric insulation on the following exterior ductwork in thickness indicated:

3.7 INSULATION - HOT EQUIPMENT

A. General:
   1. Secure insulation to bottom of flat surfaces wider than 24 IN by impaling over adhesive-pin mechanical fasteners.
      a. Secure insulation on mechanical fasteners with speed clips.
      b. Space mechanical fasteners to hold insulation securely in place.
         1) Maximum spacing: 12 IN centers.
   2. Seal joints and speed clips with 3 IN wide pressure-sensitive joint-sealing tape that matches facing.
      a. Secure both sides of tape with outward clinching staples on 3 IN centers, 5 MM 1/4 IN from edge.
   3. Insulate flanges and fittings as indicated under Pipe Insulation, Nonflexible.
   4. Reinforce ends and irregular surfaces with Glass Fab embedded in 2 coats of Foster 30-36 adhesive.

B. Provide hot-equipment insulation on following equipment in thickness indicated:
   1. Air separators: 2 IN.
      a. Insulation assembly standard: MICA plate number 4-100 or 4-120.
   2. Domestic hot water instantaneous heaters (unless factory insulated): 2 IN.
      a. Insulation assembly standard: MICA plate number 4-100.
   3. Domestic water heater storage tanks (unless factory insulated): 2 IN.
      a. Use unfaced insulation.
      b. Insulation assembly standard: MICA plate number 4-100.

3.8 INSULATION - HIGH-TEMPERATURE EQUIPMENT

A. Calcium silicate:
   1. Apply blocks in layers over high ribbed lath.
   2. Butt block surfaces tightly together.
   3. Secure with 16 AWG galvanized annealed wire or 0.015 x 1/2 IN wide galvanized bands on 12 IN maximum centers.
   4. Anchor wire and bands to welded pins, clips or angles.
   5. Apply 1 IN hex galvanized wire over insulation.
   6. Fill voids with 1/4 IN insulating cement.

B. Thermal insulating wool batts:
   1. Secure insulation to metal surfaces by impaling over weld-pin mechanical fasteners.
      a. Secure insulation on mechanical fasteners with speed clips.
      b. Space mechanical fasteners to hold insulation securely in place.
         1) Maximum spacing: 16 IN centers.

C. Provide high-temperature equipment insulation on following equipment in number of layers and total thickness indicated:
   1. Boiler breeching and flue systems inside building: 2 layers, 3-1/2 IN.
      a. Insulation assembly standard: MICA plate number 1-100.

3.9 INSULATION - COLD EQUIPMENT

A. Apply insulation with adhesive and coatings approved by manufacturer.
   1. Completely cover joining surfaces (equipment surfaces, and back and butting edges of insulation).
   2. Apply with 1/8 IN overlay pressure on butt joints.
   3. Apply 2 coats of white latex enamel to outside layer.

B. Provide cold-equipment insulation on following equipment in number of layers and total thickness indicated:
   1. Water chiller boxes: 2 layers, 1-1/2 IN.
      a. Insulation assembly standard: MICA plate number 50.

2. Evaporator heat exchangers of double shell chillers: 1 layer, 3/4 IN.
   a. Insulation assembly standard: MICA plate number 50.
3. Chilled water pump casing: 1 layer, 3/4 IN.
   a. Insulation assembly standard: MICA plate number 50.
4. Domestic water meter: 1 layer, 3/4 IN.
   a. Insulation assembly standard: MICA plate number 8-400.
5. Roof drain bodies: 1 layer, 20 MM 3/4 IN.
6. Chilled water expansion tanks: 1 layer, 3/4 IN.
   a. Insulation assembly standard: MICA plate number 4-200.
7. Chilled water air separators: 1 layer, 3/4 IN.
   a. Insulation assembly standard: MICA plate number 4-200.
8. Water softeners: 1 layer, 3/4 IN.
   a. Insulation assembly standard: MICA plate number 4-200.

3.10 JACKETING AND PREFABRICATED FITTING COVERS

A. General:
   1. Stagger jacketing and insulation joints.

B. Systems exposed to weather:
   1. Material:
      a. 0.016 IN smooth aluminum.
   2. Attach as recommended by manufacturer.
   3. Joints:
      a. Orient joint laps to prevent entry of water.
      b. Seal joints weather tight.

C. Hot Equipment:
   1. Material:
      a. 0.016 IN smooth aluminum.
   2. Attach as recommended by manufacturer.

D. High-temperature equipment:
   1. Material:
      a. 0.010 IN smooth stainless steel.
   2. Attach with stainless-steel screws or 0.020 IN x 3/4 IN stainless steel bands on 8 IN centers.

END OF SECTION

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SECTION 20 08 00
TESTING AND BALANCING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Testing and Balancing, as indicated, in accordance with provisions of Contract Documents.

B. Test, balance and adjust following mechanical systems:
   1. Air distribution systems.
   2. Air handling units and air moving equipment.
   3. Heating hot water systems including pumps.
   4. Chilled water systems including pumps.
   5. Heating and cooling coils.
   6. Existing air distribution systems affected by new installation.
   7. Existing hydronic systems affected by new installation.
   8. Temperature Controls:
      a. Assist Temperature Controls installer with calibration of air and waterside control components such as airflow stations, flow meters, etc as outlined in Section 25 10 00.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Agency qualifications: Independent test and balance agency, member of Associated Air Balance Council (AABC), or National Environmental Balancing Bureau (NEBB).
   1. Work supervised by a certified Testing and Balancing Engineer.
   2. Indicate at least 5 successfully completed projects of similar size and scope.

B. Testing and balancing standards: AABC or NEBB standards and procedures.

1.3 RESPONSIBILITIES OF TESTING AND BALANCING (TAB) AGENCY

A. Review contract document ductwork drawings before bid and advise 23 31 13 contractor as to the number and size of additional branch main volume dampers required to facilitate balancing.

B. In accordance with 23 31 13, review contractor ductwork installation drawings before fabrication and advise where additional volume dampers are required to facilitate balancing.

C. Schedule work with trades involved.

D. Check, adjust, and balance system components to obtain optimum conditions for function and operation of system.

E. Evaluate operation of systems and advise installer of necessary adjustments and corrective measures.

F. Prepare and submit test reports.
   1. Submit to Owner and to Contractor for Submittal to Architect.

1.4 RESPONSIBILITIES OF MECHANICAL INSTALLER

A. Coordinate and schedule with testing agency.

B. Start up system and keep in correct operation during balancing operations.

C. Provide necessary adjustments and corrections to systems as directed by Testing and Balancing Agency.

D. Maintain accessibility to test locations and devices requiring adjustment.

E. Provide additional sets of pulleys and belts as required by Testing and Balancing Agency.

F. Provide a complete set of approved mechanical-equipment shop drawings to Testing and Balancing Agency.

G. Provide a complete set of "As-built" drawings to Testing and Balancing Agency.

1.5 JOB CONDITIONS

A. Balance at time directed by Architect.
   1. If balancing is not done during peak cooling season demonstrate satisfactory balancing during next peak cooling season.

B. Keep dust, dirt and debris to an absolute minimum and reinstall removed ceiling tiles to original positions at end of each work day.

1.6 CORRECTIVE WORK

A. Provide extended warranty of ninety (90) days, after completion of test and balance work, during which time Architect may, at Architect's discretion, request recheck or resetting of equipment or system which is not performing satisfactorily. Provide technicians to assist as required in making such tests.

1.7 SUBMITTALS

A. Project Information:
   1. Within sixty (60) days of award of contract submit a complete Submission Report including:
      a. A company resume listing its personnel and project experience in air and hydronic balancing.
      b. An inventory and calibration data of instruments and devices in possession of balancing agency whether or not they will be used on this project.
      c. A working agenda that includes procedures for testing and balancing each air and water flow system.
      d. Test and Balance Report Forms and Field Data Sheets that will appear in final report, with design data already filled in.
      e. A written, system-by-system description of measurements, test locations and procedures that will be employed during test and balance.

B. Contract Closeout Information:
   1. Final test and balance report:
      a. Use forms similar to AABC or NEBB latest editions.
      b. Report(s) signed by TAB Engineer.

PART 2 - PRODUCTS

2.1 JOB SITE INSPECTIONS

A. During construction inspect installation of piping, sheet metal work, temperature controls, flow meters, pressure taps, strainers and other components of HVAC system as specified in contract documents.

B. Note any deficiencies and submit them, in writing, to Architect.
   1. Include these inspection reports in final TAB report.

2.2 FINAL TEST AND BALANCE REPORT

A. Using field data, test forms and procedures outlined in Submission Report, perform and record measurements, and complete final TAB report including:
   1. Preface:
      a. General discussion of system including any abnormalities and problems encountered.

2. Instrumentation list:
    a. List of instruments including type, model, manufacturer, serial number and calibration date.
3. System identification:
    a. On each Test and Balance Report Form, number and/ or letter air terminal units, zones, supply, return and exhaust openings and traverse points to correspond to numbers and letters on Field Data Sheets.
4. Air handling equipment:
    a. Manufacturer, model number, and serial number.
    b. Design and manufacturer related data.
    c. Total actual air flow rate by traverse if practical; if not practical, sum of outlets may be used, or a combination of each of these procedures.
        1) For specific systems, such as ones with diversity, see AABC National Standards.
    d. Suction and discharge static pressure of each fan, as applicable.
    e. Outside air and return air total air flow rate.
    f. Actual operating current, voltage, and brake power of each fan motor.
    g. Final RPM of each fan.
    h. Static pressure controls final operation set points.
5. Pumps:
    a. Manufacturer, size, and serial number.
    b. Design and manufacturer's related data.
    c. Pump operating suction and discharge pressures, and final total dynamic head.
    d. No-flow (pump discharge valve closed) suction and discharge pressures, and corresponding total dynamic head. (This procedure is to determine actual impeller size.)
    e. Rated and actual operating current, voltage and brake power of each pump motor.
    f. Submit pump curve indicating design, operating, and no-flow points of operation.
6. Chillers:
    a. Manufacturer, model number, and serial number.
    b. Design and manufacturer's rated data.
    c. Rated and actual pressure drops across evaporators and condensers and related water flow rates.
    d. Entering and leaving water temperatures.
    e. Rated and actual operating current and voltage.
7. Heat exchangers:
    a. Manufacturer and model number.
    b. Design and manufacturer's related data.
    c. Service and location.
    d. Actual pressure drop and related water flow rate, primary side.
    e. Actual pressure drop and related water flow rate, secondary side.
    f. Primary side entering and leaving temperatures.
    g. Secondary side entering and leaving temperatures.
    h. Temperature control setting.
8. Heating and cooling coils:
    a. Manufacturer.
    b. Design and manufacturer's related data.
    c. Rated and actual water pressure drops through each coil and related water flow rate.
    d. Rated and actual static air pressure drops across each coil.
    e. Entering and leaving water temperatures.
    f. Wet bulb and dry bulb temperatures entering and leaving each cooling coil.
    g. Dry bulb temperatures entering and leaving each heating coil.
    h. Water flow rate from flow stations.
9. Cooling tower:
    a. A copy of cooling tower test data summary sheet.
    b. A sketch of cooling tower installation indicating tower orientation, principal dimensions, location of temperature and flow-rate measurement points, and notation of any building obstructions or other equipment in immediate vicinity of tower.

c. Copies of completed test data sheets.
d. A copy of test calculations, including performance curves and cross plots.
e. Observations on compliance with test code limitations and uniformity of test conditions. Include comments on any suggested changes to tower such as increasing fan speed or blade pitch to obtain rated brake power.

10. Air terminal units, diffusers, registers and grilles:
    a. Adjust air terminal units to deliver design maximum and minimum air-flow conditions.
    b. Flow rate at each air outlet (diffuser).
    c. Flow rate at each return and exhaust air inlet (register or grille).
11. Room Pressure relationships.
    a. Maintain pressure relationships in rooms that are either positive (supply greater than return/ exhaust) or negative (supply less than return/exhaust).
    b. In the final test and balance report, indicate that these pressure relationships were maintained.

B. Units of measure:
1. Flow rates:
   a. Air: ____ CFM.
   b. Water: ____ GPM.
2. Temperatures: ____ DEGF.
3. Pressures:
   a. Air: ____ IN WC.
   b. Steam: ____PSIG.
   c. Water: ____ PSIG.
4. Pump heads: ____ FT.
5. Power: ____ HP.

PART 3 - EXECUTION

3.1 GENERAL

A. Final reports are required to be completed and submitted far enough in advance of local agencies final inspections for occupancy to provide adequate time for Engineer to review, Contractor to correct any deficiencies and reports to be revised for agencies final inspections.

B. Coordinate and schedule testing and balancing with Contractor and Mechanical Contractor.
1. Report deficiencies in systems to Mechanical Contractor for resolution.

C. Accurately calibrate and maintain test instruments in good working order.
1. If requested, conduct tests of instruments in presence of Engineer.

D. If requested, conduct balancing tests in presence of Engineer.

E. Do not begin balancing until system(s) have been substantially completed and are in good working order to permit preliminary measurements of total air or water volumes and system pressures.

F. Proceed with final balancing and adjustments when systems are 95 to 100 PCT complete.

G. Record inspections, tests and adjustments.

3.2 AIR BALANCING METHODS

A. Balance each air system that is served by air filters, using artificial static loading of system, to demonstrate, test and obtain system design pressure drop data.
1. Provide dirty filter pressure drop conditions on system.
2. Do not use high efficiency filters (75 PCT and above) in testing and balancing.
3. Static pressure losses may be simulated by using wood or sheet steel blanking plates in high efficiency filter racks and housings.
4. Do not install blanking plates within 2 FT of low efficiency filter unit or rack.

3.3 AIR BALANCE TESTING PROCEDURE

A. Perform tests and balance system in accordance with approved Submission Report.

B. Take readings of airflow stations if installed or make pitot tube traverse of main supply, return and exhaust air ducts.
   1. Obtain flow rates at fans at both maximum and minimum outside air operation.

C. Test and adjust each diffuser, grille, and register served by an air terminal unit to within 10 PCT of design requirements.

D. In cooperation with HVAC Controls installer, set automatically operated dampers to operate as indicated.
   1. Check controls for proper calibration and list controls requiring adjustment.

3.4 WATER BALANCE TESTING PROCEDURE

A. Complete air balancing before commencing water balancing.

B. Perform test and balance systems in accordance with approved Submission Report.

3.5 OPERATING TEST

A. After systems are balanced, conduct operating test of not less than 8 HRS duration to demonstrate to satisfaction of Architect that system(s) comply with requirements of plans and specifications, and that equipment and controls are functioning properly.

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SECTION 20 11 00
PIPE AND FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Pipe and Fittings, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
   1. Pressurized piping.
   2. Nonpressurized piping.
   3. Accessories:
      a. Dielectric fittings.
      b. Unions.

C. This specification lists a variety of piping that may be applicable to the project. Not all piping and fittings listed are applicable to the project, refer to appropriate spec sections for project applicability.

D. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Pipe and fittings to be ASTM labeled for rating specified.

B. Pipe and fittings to be marked with the collective trademark of the Cast Iron Soil Pipe Institute and be listed NSF International.

C. Welder qualifications: Certified under requirements of ANSI/ASME-B31.1 Power Piping.

1.3 SUBMITTALS

A. Project Closeout Information:
   1. Manufacturer of listed products.
   2. Pre-insulated conduit piping system test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. PVC plastic pipe:
   1. Base:
      a. Plastiline.
   2. Optional:
      a. Cresline.
      b. DuPont.
      c. Eslon Thermoplastics.
      d. R & G Sloane Manufacturing.
      e. Schuller International.
      f. Nibco.
      g. CertainTeed Pipe & Plastics.
      h. Clow Water Systems.
      i. Tyler Pipe.

B. Cast Iron Pipe.
  1. Base:
     a. Tyler.
  2. Optional:
     a. AB&I.
     b. Charlotte Pipe.

C. Fittings, Mechanical Groove-end and Plain-end Pipe:
  1. Base:
     a. Victaulic Company of America.
  2. Optional:
     a. Anvil International, Inc.
     b. Grinnell.

D. Fittings, Ring Seal Crimped Copper:
  1. Base:
     a. Viega.
  2. Optional:
     a. Nibco.
     b. Apollo.

E. Dielectric Waterway Fittings:
  1. Base:
     a. Perfection Corp. Victaulic Company of America.
     b. Grinnell.
     c. Victaulic.

2.2 PIPE

A. Black Steel Pipe:
  1. Seamless or welded steel pipe, ASTM-A53, standard weight unless otherwise indicated.
  2. For fire sprinkler service:
     a. The following Testing Standards and listed grades are acceptable:
        1) ASTM-A135, Grade B
        2) ASTM-A53, Grade B.
        3) ASTM- A795, Grade B.
     b. Weight: Schedule-40 unless otherwise indicated.

B. Galvanized Steel Pipe:
  1. Seamless or welded, hot-dipped galvanized steel pipe, ASTM-A53 or ASTM-B36.
  2. Joints:
     a. Threaded.
     b. Welded.
     c. Cut or rolled grooved.

C. Stainless Steel Pipe:
  1. Type 304L, ASTM 312, ASTM A778 or ANSI B 36.19.
  2. Joints:
     a. Welded.
     b. Roll grooved.
     c. Stainless steel ASTM 312, ASTM A778 or ANSI B 36.19.

D. Copper Pipe:
  1. Seamless copper tubing, ASTM B88, Type-K, Type-L, or Type-M as indicated.
  2. Joints:
     a. Soldered: Use ASTM B32, 95 PCT tin, 5 PCT antimony solder, or Silvabrite 100.
     b. High temperature soldered: Use 1,000 DEGF solder.
     c. Roll grooved.
     d. Ring seal crimped, where specified and permitted by authority having jurisdiction.

3. 400 PSI fittings: Heavy wall type, Mueller "Steamline".
4. 400 PSI fittings: Heavy wall type, Mueller "Steamline".

E. Cast Iron Soil Pipe:
   1. ASTM A74.
   2. Bell and spigot joints: Use oakum and lead, or neoprene gaskets when allowed by code.
   3. Gaskets: ASTM C564.
   4. Bear the collective trademark of the Cast Iron Soil Pipe Institute and be listed NSF International.

F. No Hub Cast Iron Pipe:
   1. CISPI 301 or ASTM A888.
   2. Mechanical joints:
      a. Conform to ASTM C1540: Join hubless pipe and fittings with heavy duty stainless steel couplings with neoprene gaskets.
      b. Approved manufacturers: Husky SD 4000, Clamp All 125 or MG Couplings.
   3. Gaskets: ASTM C564.
   4. Bear Cast Iron Soil Pipe Institute trademarkand NSF International listed.

G. Ductile Iron Pipe:
   1. Centrifugally cast, ANSI/AWWA-C151/A21.51, lined and coated.
   2. Joints:
      a. Gasketed mechanical joints: ANSI/AWWA-C111/A21.11.
         1) Gaskets: ANSI/AWWA-C111/A21.11.
      b. Cut grooved.

H. Cast Iron pressure pipe:
   1. ANSI/AWWA-C105/A21.5, lined and coated.
   2. Thickness class: 22.
      a. Exception: When depth of cover exceeds 8 FT, use thickness class 23.
   3. Joints: Use mechanical or push-on joints below grade.
   4. Mechanical or push-on joints for water: ANSI/AWWA-C111/A21.11.
   5. Mechanical joints for fuel gas piping: ANSI-B31.2.
   6. Gaskets: Suitably formed of high quality vulcanized rubber, made to exact dimensions, and in form of a solid ring, with durometer hardness of approximately 85; for joint rating of 350 PSI internal liquid pressure, minimum.

I. Polyvinyl Chloride (PVC) Plastic Sewer Pipe:
   1. ASTM D3034, SDR35.
   2. Joints: Integral bell and spigot type, ASTM D3212.
   3. Gaskets: ASTM F477, rubber.
   4. Fittings: Push-on joint compatible with pipe and conforms to ASTM D3034.
   5. Workmanship:
      a. Pipe and fittings: Homogeneous throughout and free from cracks, holes, foreign inclusions, or other injurious defects.

2.3 FITTINGS AND COUPLINGS

A. Steel Pipe Fittings:
   1. Socket welding fittings: ANSI/ASME-B16.11 and ASTM A234.
   2. Butt welding fittings: ANSI/ASME-B16.9, ANSI/ ASME-B16.25 and ASTM A105.
   3. Grooved fittings: Square cut, ASTM-A53 steel, or roll grooved, ASTM A135.
   4. Flanged fittings: ANSI/ASME-B16.5 and ASTM A105.
   5. Flange bolts: ASTM A193 Grade B7.
   6. Gaskets: Spiral wound metallic.

B. Malleable Iron Pipe Fittings:
   1. Threaded fittings: ANSI/ASME-B1.20.1 and ANSI/ASME-B16.3, Class 150.
   2. Threaded couplings: Same as threaded fittings except Class 300.

3. Grooved couplings: ASTM A47, coupling segments with EPDM Grade-E gasket.
4. Galvanized malleable iron couplings: Victaulic; or ITT Grinnell.

C. Cast Iron Pipe Fittings:
   1. Drainage fittings: Coated or galvanized, ASTM A74.
   2. Threaded fittings: ANSI/ASME-B1.20.1 and ANSI/ASME-B16.4, Class 125.
   3. Threaded drainage fittings: ANSI/ASME-B1.20.1, ANSI/ASME-B16.12 and ASTM A126.
   4. Flanged: ANSI/ASME-B16.1, Class 125.

D. Copper Pipe Fittings:
   1. Wrought copper fittings: ANSI/ASME-B16.22.
   2. Cast brass fittings: ANSI-B16.18.
   3. Mechanical groove-end fittings: Factory roll grooved.
   4. Flared tubing fittings: Use only on annealed pipe.
   5. Cast flanged fittings: ANSI/ASME-B16.24, Class 150.
   6. 400 PSI fittings: Heavy wall type, Mueller "Steamline".

E. Stainless Steel Pipe Fittings:
   1. ASTM A182.
   2. Roll grooved: Stainless steel, Victaulic type.
   3. Butt welding fittings: ANSI/ASME-B16.9.
   4. Socket welding fittings: ANSI/ASME-B16.11.

F. Ductile Iron Pipe Fittings:
   1. ANSI/AWWA-C110/A21.10.
   2. Gasketed mechanical joints: ANSI/AWWA-C111/A21.11.
   3. Laying Length, AWWA fittings: Short body dimensions.
   4. Flanged fittings: ANSI/ASME B16.5.
   5. Thickness of iron: Not less than for ductile iron pipe with additional thickness as required for proper reinforcement of branches for tees and crosses.

G. Cast Iron Pressure Pipe Fittings:
   1. ANSI/ASME B16.1 and ANSI/AWWA C111/A21.11 mechanical joint type, suitable for minimum working pressure of 150 PSI plus 100 PSI surge pressures.
   2. Laying length:
      a. AWWA fittings: Short body dimensions.
      b. ANSI mechanical joint fittings: ANSI/AWWA-C110/A21.10.
      c. Others: ANSI/ASME-B16.1.
   3. Thickness, 6 through 12 IN: Not less than for cast iron pipe with additional thickness as required for proper reinforcement of branches for tees and crosses.

H. Polyvinyl Chloride (PVC) Plastic Pipe Fittings:
   1. Socket type: ASTM D2466 or ASTM D2467, Schedule-40 and Schedule-80, long radius patterns.
   2. Threaded type: ASTM D2464, Schedule-80, long radius patterns.
   3. Same pressure and temperature rating as pipe.

I. Dielectric Fittings:
   1. General:
      a. Standard product for prevention of galvanic corrosion.
   2. Dielectric union:
      a. Ground-joint union with end connections of different material.
         1) End connection materials: Compatible with respective piping materials.
         2) Gasket and inert, non-corrosive thermoplastic sleeve shall electrically isolate end connections from each other.
   3. Dielectric waterway fitting:
      a. ASTM A53 Schedule-40, hot dip galvanized, steel pipe casing with inert, non-corrosive thermoplastic lining (NSF/FDA listed).

b. Threaded or threaded X rolled grooved connections.
c. Victaulic, "Clearflow".

J. Mechanical Groove-end Couplings and Fittings:
1. Couplings:
a. Malleable iron, ASTM A47 or ductile iron, ASTM A536.
b. Gaskets: EPDM Grade-E conforming to ASTM D2000 for water services up to 230 DEGF.
c. Gaskets on plastic piping: ASTM F477.
d. Bolts and nuts: ASTM A183.
1) Heat treated plated carbon steel, track-head.
2) Minimum tensile strength: 110,000 PSI.
2. Fittings:
a. Malleable iron, ASTM-A47 or ductile iron, ASTM-A536.
b. Copper:
1) 2 IN to 4 IN: ASTM-B75, C12200.
2) 5 IN to 6 IN: ASTM-B584, CDA 844 (81-3-7-9).

K. Unions.
1. Same type, pressure rating and material as piping.
2. Flanges: Raised face type of same type, pressure rating and material as piping.
3. Unions in copper pipe:
a. 2 IN and smaller: Use wrought copper solder joint copper to copper unions.
b. 2-1/2 IN and larger: Use brass flange unions.
4. Dielectric unions: See Dielectric fittings:

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with ANSI/ASME B31.9 for pressure piping installations.
1. Install piping without "bull-head" fittings.

B. Flush out water piping systems with clean water prior to adding treatment.

C. Flush out fuel oil piping with compressed air.

D. In general, make connections to components in piping systems with 3-elbow swing joints to allow for movement.
1. Movement includes but not limited to expansion, contraction, seismic, and equipment vibration isolation.

3.2 PIPING

A. Install piping parallel to building walls at such heights as not to obstruct portion of window, doorway, stairway, or passageway.
1. Where interference develops in field, offset or reroute piping as required to clear such interferences.
2. Consult Drawings for exact location of pipe spaces, ceiling heights, door and window openings or other architectural details and report discrepancies to Architect, before installing piping.

B. Pitch Piping to Drain:
1. Minimum pitch of 1 IN in 100 FT(except drainage piping).
2. Make piping and equipment drainable.
3. Accomplish pipe drainage using drain valves located on equipment and fixtures or separate drains.
4. Drains: See Section 20 05 19.

C. Factory cut and thread nipples from seamless stock.
   1. Use nipples of same material as pipe with which they are used.
   2. Do not use close nipples except where such use is unavoidable.
   3. Use Schedule-80 seamless pipe for close nipples and nipples of pipes 3/8 IN or smaller.

D. Provide backing and sleeves required in walls or floors for setting of fixtures or equipment.

E. Where transition occurs from sweated fittings (as at connection to fixture supplies, etc.), provide rigid anchorage so that no strain will be placed upon tubing.

3.3 JOINTS

A. Threaded Joints:
   1. Cut piping carefully, ream, thread and work into place without springing.
   2. Use a small amount of prepared pipe thread lubricant on outside threads only.
   3. Provide in accordance with ANSI/ASME-B1.20.1.

B. Flanged Joints:
   1. Take care to ensure that there is no restraint on opposite end of pipe or fittings which would prevent uniform gasket compression or cause unnecessary stress in flanges.
   2. Keep one flange free to move in any direction while flange bolts are being tightened.
   3. Do not pack or assemble bell and spigot joints affected by flanged joints until such flanged joints have been tightened.
   4. Tighten bolts gradually and at a uniform rate, so that gasket compression is uniform over entire area of gasket.

C. Mechanical Joints:
   1. Assemble in accordance with instructions and recommendations of pipe manufacturer.
   2. Clean joint surfaces and lubricate with soap solution or water soluble lubricant immediately before joint is assembled.
   3. Groove-end and plain-end joints:
      a. Use mechanical joint system only with pipe meeting joint manufacturer's requirements.
         1) When joint manufacturer's pipe requirements exceed specified requirements, provide pipe that meets joint manufacturer's requirements.
      b. Prepare pipe and install system in accordance with joint manufacturer's instructions and recommendations.

D. Use dielectric waterway fittings for connections between dissimilar metals.

3.4 UNIONS

A. Provide a union between valves, at connection to each fixture, device or item of equipment, and elsewhere as required to facilitate installing, servicing, making up and disconnecting piping.
   1. Install each union to facilitate removal of parts, equipment or fixtures for inspection or cleaning.
   2. Install in a position which will permit device, fixture or part to be removed without disconnecting piping except unions.

B. Install unions in accordance with Fluid Controls Institute (FCI).
   1. Grooved piping systems:
      a. Grooved type couplings may serve as unions.
   2. Make connections between couplings and flanged equipment with slip-on flanges and a grooved nipple, or groove-to-flange adapter.
   3. Welded piping systems:
      a. Where flanged end-service valves are used at equipment connections, flange unions will not be required.
      b. Make connections to flanged valves and equipment using ANSI welding neck or slip on type welding flanges.
      c. Flanged cast iron ells may be used for connections between pumps, strainers, check valves and other flanged equipment.

C. Install dielectric fitting at each piping joint and equipment connection between ferrous and non-ferrous materials.

3.5 PIPING EXPANSION

A. Install piping to allow thermal expansion and contraction without injury to piping, equipment or structure.
   1. Use loops or expansion joints where necessary and where detailed.
   2. Provide pipe guides at loops as indicated.

B. Where screwed piping is used for soil, waste or vent risers, or downspouts, use caulked joints or expansion joints at intervals to allow expansion movement.

3.6 WELDED STEEL PIPING

A. Where welded piping is specified, make welds by oxy-acetylene or electric process in accordance with ANSI/AWS D10.12 and ANSI/AWWA C206.
   1. Welding rods: Grade recommended for purpose by manufacturer; each rod stamped with manufacturer's name and identification.

B. Line Welds:
   1. Single V-butt type.
   2. Mill or machine bevel pipe at 37.5 DEG to within 1/16 IN of inside wall, except that in field, limited amount of pipe may be flame beveled.
   3. Pipe with a wall thickness of 3/16 IN or less need not be beveled but may be welded by melting down into, and building up over abutting ends.
   4. Separate abutting ends of joints before welding to permit complete fusion to bottom without overlapping.
   5. Tack in 2 or more points to maintain alignment, and fusion weld.
   6. Weld continuously around pipe.

C. Make welds of sound weld metal, thoroughly fused into ends of pipe, and to bottom of vee.
   1. Build in excess of pipe wall to give reinforcement of 0.25 pipe wall thickness.
   2. Weld metal shall present a gradual increase in thickness from surface of pipe to center of weld.
   3. Minimum weld width: 2.5 times thickness of pipe wall.

D. Use welding ells at turns in welded lines except where pipe bends are indicated or are required for flexibility.

E. Mitered ells will not be permitted.

F. Do not weld pipe couplings in place of welding fittings for branch connections.

G. Weld-O-Lets and Thread-O-Lets:
   1. Scribe and cut openings in main pipes for welded branches accurately taking care to remove plug and cuttings from main pipe.
   2. Full weld fillet welds for full depth of fillet, with additional beads to form well rounded connection as recommended by Weld-O-Let manufacturer.
      a. Partially filled fillets not acceptable.

H. Cut openings into pipe for welded connections accurately to give carefully matched intersections.

I. Make welded fittings of same material with same pressure and temperature rating as pipe with which they are used.

J. Make flanged connections to control valves, pump suction, and specialties with ANSI standard welding neck flanges.
   1. Other flange connections may be made with slip-on flanges provided they are seal welded on inside.

K. Fuse fillet welds for flanges or fittings into pipe and plate for minimum distance of 1.5 times pipe wall thickness and depth of weld of 1.25 times pipe wall thickness.

3.7 THREADED STEEL PIPING

A. Branch connections to screwed piping may be made with Weld-O-Lets or Thread-O-Lets.

B. Do not weld pipe couplings in place of welding fittings for branch connections.

3.8 DUCTILE IRON AND CAST IRON PRESSURE PIPING

A. Perform cutting without damage to pipe or to cement lining.
   1. Make pipe cuts smooth, straight and at right angles to pipe axis.
   2. Use approved type mechanical pipe cutters.
   3. In locations where use of mechanical cutters would be difficult or impracticable, existing pipe may be cut with diamond point chisels, saws, or other tools which will not cause damaging impact or shock.

B. Use equipment, tools and methods in handling and laying pipe and fittings which prevent damage.
   1. Hooks inserted in ends of pipe shall have broad, well padded contact surfaces.

C. Replace pipe and fittings in which cement lining has been broken or loosened.
   1. Where damaged areas are small and readily accessible, lining may be repaired, if Architect approved.

D. Repair pipe coating which has been damaged before installing pipe.

E. Make connections between below ground piping and above ground piping with a flanged spigot adapter.
   1. Hold spigot piece in place with bolts on 2 sides of flanges between mechanical joint and flange connector.

F. Comply with AWWA C600 for installation.

3.9 CAST IRON DRAINAGE PIPING

A. Lay underground pipe on undisturbed earth excavated to provide firm bearing on at least 0.333 of pipe circumference for full length, with bell holes cut out.
   1. Where excavation has been carried too deep, place a layer of sand well tamped to bring pipe to proper grade.
   2. Where fill or unsound earth is encountered, place a layer of 2500 PSI concrete to properly bed pipe.

B. Bell and Spigot Joints:
   1. Install neoprene gaskets in accordance with manufacturer's recommendations.
   2. Caulk tarred oakum well into joint and pour in molten lead continuously around joint, using at least 12 OZ of lead per IN of pipe diameter.
   3. Furnish sufficient lubricant to provide a thin coat on each spigot end.
   4. Use lubricant that is non-toxic, imparts no taste or odor to conveyed liquid, and has no deleterious effect on rubber gasket, with consistency so that it can be easily applied to pipe in hot or cold weather and will adhere to either wet or dry pipe.

C. Threaded Joints:
   1. Clean cut, American National taper pipe threads.
   2. Ream pipe ends to full pipe size and remove burrs, chips, cuttings before making up.
   3. Pipe joint cement permitted on male threads only.

3.10 COPPER PIPING

A. Brazed High Temperature Soldered Joints:
   1. Take care to avoid annealing of pipe material.

2. For pipe sizes 2 IN and larger: Use a circular torch such as Circa Torch by Cedarberg Industries, for soldering joints.

B. Solder: Lead-free.

C. T-drilling:
1. Tapped pipe shall be least 1 IN diameter and branch shall be at least 2 pipe sizes smaller.
2. Braze high temperature solder joints.
3. Branch pipe shall not protrude into main.

3.11 PVC PIPING

A. Pipe Cuts:
1. Make cuts square and straight with pipe centerline.
2. Use fine toothed hand wood saw with 14 or more points per inch.
3. After cutting, slightly ream pipe inside and remove external burrs.

B. Pipe Threading:
1. Form standard tapered pipe thread using sharp dies with a negative rake angle of 5 DEG.
2. Perform threading over inserted tapered wooden plugs to assure uniform deep threads.
3. Dies must be sharp and clean.
4. Assemble threaded joint using either graphite base compound or compound recommended by pipe manufacturer.
5. Apply to male threads only and seat joint at slightly more than hand tightness.
6. Wrench marks will not be allowed on either fitting or pipe.

C. Chemical Welding:
1. Perform in strict accordance with manufacturer's recommendations.
2. Comply with ASTM-D2855.
3. Clean both pipe and fitting contact areas with recommended cleaner.
4. Apply cement lightly to both pipe and fitting and slide fitting on to pipe with one continuous motion and at proper time.
5. Rotate fitting lightly to distribute cement.
6. Wipe off excess cement.
7. Deliver cement for chemical welding to job site in sealed pint containers and keep covered at all times when not in use.
8. Do not dilute, thin or alter cement.
9. Use only cement recommended by pipe manufacturers.

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DIVISION 21

FIRE SUPPRESSION

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SECTION 21 10 00
FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Fire Protection Systems, as indicated, in accordance with provisions of Contract Documents.

B. Fire Protection Systems Included:
   1. Water based:
      a. Standpipe-and-hose system.
      b. Wet-pipe sprinkler system.
   2. Products:
      a. Pipe, fittings, and supports.
      b. Alarm and signal devices.
      c. Backflow protection devices.
      d. Fire alarm system control panel.
      e. Fire department connections.
      f. Fire department valves.
      g. Fire hose valve cabinets.
      h. Fire pump system.
      i. Fire system valves.
      j. Manual valves.
      k. System accessories.
      l. Sprinklers.
      m. Flexible sprinkler hose fittings.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Use only new material of first class construction, designed and guaranteed to perform service required.
   1. All grooved joint couplings, fittings, valves, and specialties shall be the product of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
   2. All casings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality insurance and traceability.

B. Provide fully operational systems.

C. Provide complete fire protection systems as described in the Contract Documents and according to criteria of authority having jurisdiction (AHJ) and the Owner's insurance carrier.
   1. Where system requirements as described in the Contract Documents exceed those of the AHJ, meet requirements of both.
   2. Where discrepancies exist among the AHJ, Owner's insurance carrier, and Contract Documents, the most stringent requirements shall take precedence.

D. Addition, deletion or relocation of existing sprinklers, and rerouting of existing pipe may be necessary.

E. Do not downsize piping indicated to serve future areas.

F. Authorities Having Jurisdiction:
   1. Code Enforcement Agencies.
   2. Fire Marshall's Office.
   3. State Insurance Office.
   4. Water Supply Authority.

G. Owners Insurance Carrier: Factory Mutual (FM).

H. Referenced Criteria (applicable as referenced by AHJ and Owner's insurance carrier):
   1. Latest edition of referenced criteria applies unless an earlier edition is specifically indicated by the AHJ and Owner's insurance carrier.
   2. National Fire Protection Association (NFPA).
   3. Underwriter's Laboratories (UL).
   4. Factory Mutual Engineering Commission (FM).

I. Factory testing of fire pump system:
   1. Perform operating test on pump, motor, engine and controller units at factory.

J. Installer Qualifications:
   1. Fire Protection Installer shall be licensed, and shall provide evidence of the successful completion of at least five projects of equal or greater size and complexity.
   2. Use workmen skilled in this trade.
   3. Provide documentation that welders, and welding operators are certified in accordance with American Welding Society Standard AWS D10.9.
   4. Installation of the following items/systems shall be done by authorized representatives of respective manufacturers:
      a. Fire pump.
      b. Fire system valves.

K. Piping and Fittings: Section 20 11 00.

L. Outside Utilities: Division 33.

1.3 SUBMITTALS

A. Product Data:
   1. Backflow protection devices.
   2. Fire pump system.
      a. Include pump performance data.
   3. Standpipe-and-hose system.
   4. Wet-pipe sprinkler system.

B. Project Information:
   1. Submit detailed data and complete layout of fire protection systems approved by authorities having jurisdiction (including Owner's insurance carrier) and prepared in accordance with the requirements for Working Plans described in applicable NFPA standards.
      a. Include calculations prepared in accordance with the requirements for Hydraulic Calculations described in applicable NFPA standards.
   2. Architect reviews for project information and general conformance with contract documents.

C. Contract Closeout Information:
   1. Letter, with Owner acceptance signature, stating spare parts and extra materials per NFPA requirements have been delivered.
   2. Operation and Maintenance Data.
   3. Owner instruction report.
   4. Test reports:
      a. Factory pump tests as indicated in this section's Part I "Quality Assurance" paragraph.
      b. Certification that tests as indicated in FIELD QUALITY CONTROL (Part 3) have been successfully completed and approved by authorities having jurisdiction.

1.4 JOB CONDITIONS

A. Arrange and pay for permits, fees and inspections required.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Alarm and Signal Devices:
   1. Base:
      a. Viking.
   2. Optional:
      a. System Sensor.
      b. Federal Signal.
      c. Fire-Lite Alarms/Notifier.
      d. Potter Electric Signal.
      e. Potter Roemer.
      f. Simplex Access Controls.
      g. United Electric Controls.

B. Alarm-test Device:
   1. Base:
      a. Viking.
   2. Optional:
      a. Grinnell.
      b. Victaulic.
      c. AGF Manufacturing Inc.

C. Backflow Protection Devices:
   1. Base:
      a. Ames Fire & Waterworks.
   2. Optional:
      a. Febco.
      b. Watts Control Valves.

D. Fire Department Connections, Fire Department Valves, Fire Hose Valve Cabinets, Test Headers and Hydrants:
   1. Base:
      a. Elkhart Brass.
   2. Optional:
      a. Croker West.
      b. Potter Roemer.
      c. American Fire Hose & Cabinet.

E. Fire Pump System, includes jockey pump:
   1. Base:
      a. Aurora Pump.
   2. Optional:
      a. Fairbanks Morse Pumps.
      b. Allis-Chalmers, ITT.
      c. Patterson Pump.
      d. Peerless Pump.

F. Fire Protection Systems, Water Based:
   1. Base:
      a. Viking.
   2. Optional:
      a. Victaulic.
      b. Reliable Automatic Sprinkler.
      c. Tyco Fire Protection Products.

G. Sprinklers:
   1. Base:
      a. Viking.
   2. Optional:
      a. Victaulic.
      b. Reliable Automatic Sprinkler.
      c. Tyco Fire Protection Products.

H. Flexible Sprinkler Hose Fittings
   1. Base:
      a. Victaulic, VicFlex or equivalent with 2 IN bend radius.

I. Water Meters:
   1. Base:
      a. Hersey Measurement.
   2. Optional:
      a. Rockwell International.
      b. Neptune.

J. Fire Pump Controller/Automatic Transfer Switch, Jockey Pump Controller:
   1. Base:
      a. Master Control Systems, Inc.
   2. Optional:
      a. Firetrol.
      b. Joslyn Clark Control.
      c. Metron.
      d. Cutler-Hammer Eaton.

K. Submit other pipe materials, joining methods, and equipment not specified, but accepted by applicable NFPA standards and approved by Authority Having Jurisdiction, in accordance with Section 01 25 00.

2.2 DESIGN REQUIREMENTS

A. Design fire sprinkler systems.

B. Design fire sprinkler and suppression systems.
   1. Obtain water supply fire flow test prior to designing systems.
      a. Flow hydrant location: FH43 (NE corner of Building #15).
      b. Gauge hydrant location: FH45 (NW corner of Building #20 parking lot).
   2. Compare flow test results to those listed below, and use lowest pressure of the two to design systems.
      a. Provider: Whitman, Requardt & Associates, LLP
      b. Date: March 25, 2017
      c. Static pressure: 67 PSIG
      d. Residual pressure: 60 PSIG.
      e. Flow: 1,200 GPM.
      f. Pitot pressure: 52 PSIG.
      g. Nozzle size: 2.5 IN.
      h. Butt Coefficient: 0.9.
      i. Elevation: 407 FT.
   3. Design systems using adjusted water supply curve:
      a. Adjust the flow test water supply curve to correspond with the low hydraulic grade line as provided by the water supplier.
      b. Adjust the flow test water supply curve to correspond with the actual site elevation.
   4. Designs shall include a minimum safety allowance of 10 PSIG below the adjusted water supply curve.

5. For systems with fire pumps, demonstrate (through calculations) that adjusted water supply is capable of providing a minimum of 20 PSIG at the suction side of the fire pump while the pump is operating at 150 PCT of its rated capacity.

2.3 PIPE, FITTINGS, AND SUPPORTS

A. Pipe and Fittings - General:
   1. Meet or exceed applicable NFPA standards and Section 20 11 00.
   2. Working pressure: Not less than 175 PSI.
   3. The following are not permitted:
      a. Lightwall, Schedule 5 and Schedule 10 pipe.
      b. Plain end, pressure fit type fittings.
      c. Hole cut mechanical tee fittings.
   4. Fittings: galvanized where galvanized piping is used.
   5. Corrosion Resistance Ratio (CRR) of all pipe used: equal to or greater than one.

B. Above ground pipe normally containing water:
   1. Examples: Wet-pipe and standpipe-and-hose fire protection systems.
   2. Sprinkler piping 4 IN and greater:
      a. Black steel, Schedule-40:
         1) Welded joints.
         2) Mechanical coupling joints:
            a) Rolled groove type (cut grooving not allowed).
   3. Sprinkler piping less than 4 IN:
      a. Black steel, Schedule-40:
         1) Threaded joints.
         2) Welded joints.
         3) Mechanical joints:
            a) Cut or rolled groove type.
   4. Seamless copper tubing.
      a. High temperature soldered joints.

C. Above Ground Pipe normally containing air:
   1. Examples: Piping for alarm and sensing devices.
   2. Black steel, Schedule-40:
      a. Threaded joints.
      b. Welded joints.
      c. Mechanical joints:
         1) Cut or rolled groove type.
   3. Seamless copper tubing:
      a. High temperature soldered joints.
   4. Brass pipe, Schedule-40 (only for valve trim):
      a. Threaded.

D. Pipe, below ground:
   1. Same as outside utility fire protection piping.
      a. See Division 33.

E. Fittings:
   1. Threaded:
      a. Black cast iron, Class 150.
      b. Black malleable iron.
      c. Galvanized malleable iron.
   2. Flanged:
      a. Black cast iron, short body, Class 125.
      b. Galvanized malleable iron.
      c. Gaskets: Full face of 1/8 IN minimum red sheet rubber.

d. Flange bolts: ANSI-B18.2.
   1) Hexagon head machine bolts with heavy semi-finished hexagon head nuts, cadmium plated.

3. Welded:
   a. Black steel, standard weights.
4. Mechanical: ASTM-A536.
   a. Ductile iron, 300 PSI working pressure.
   b. Coupling gasket material: Butyl rubber or EPDM rubber.
   c. UL listed.
   d. Approved by FM, NFPA-13, and NFPA-14.
   e. Fittings shall be ductile iron conforming to ASTM A536, Grade 65-45-12. Short pattern, with flow equal standard pattern fittings.
   f. Grooved joint couplings shall consist of two ductile iron housing segments, pressure responsive elastomer gasket, and ASTM A449 zinc-electroplated steel bolts and nuts.
      1) Rigid: Coupling housings with offsetting, angle pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with NFPA-13. Couplings fully installed at visual pad-to-pad offset contact. Couplings that require gapping of bolt pads or specific torque ratings for proper installation are not permitted. Installation-Ready, for direct stab installation without field disassembly.
5. High temperature soldered:
   a. Wrought copper.
   b. Cast bronze.

F. Pipe Supports:
   1. All-purpose type, UL listed and FM approved.
   2. Manufacture: Comply with Section 20 05 29.
   3. All hangers to be installed per NFPA 13.
   4. Supports, hanger rods, inserts and clamps acceptable to NFPA.

2.4 ALARM AND SIGNAL DEVICES

A. UL listed and FM approved.

B. Coordinate electrical requirements with electrical installer.

C. Alarm Devices:
   1. Local alarm devices:
      a. General:
         1) Provide local alarm on systems of sufficient size as indicated in NFPA-13.
         2) Use alarm bell and visible light alarm on electrically operated supplemental fire detection (valve release) systems.
         3) Use water motor gong on hydraulically or pneumatically operated supplemental fire detection (valve release) systems.
         4) Devices shall be weatherproof.
      b. Alarm bell, electric:
         1) Shall provide audible alarm signal upon activation of fire protection system.
         2) 10 IN weatherproof bell.
         3) Provide backer plate to prevent birds and insects from entering inside of bell housing.
      c. Visible light alarm:
         1) Semi-flush, 24 volt DC.
         2) Tamper-resistant white lexan lens, with "FIRE" imprinted in red.
         3) Light shall be mountable on either ceiling or wall.

D. Signal Devices:
   1. Valve tamper switch:
      a. Shall signal Fire Alarm System Control Panel upon valve movement.

2. Waterflow detector:
   a. Shall signal Fire Alarm System Control Panel when water flows in system.
   b. Vane type flow switch with retard mechanism or manual adjustment to prevent false alarm.
   c. 175 PSI rated.
   d. Suitable for working pressure of 150 PSI with sensitivity adjusting screw.

2.5 BACKFLOW PROTECTION DEVICES

A. Provide on water supply at location indicated on drawings to prevent contamination of potable water system.

B. Corrosion resistant materials.

C. Totally rebuildable.

D. Flanged ends.

E. Rating: Water at 175 PSI working pressure and between 33 to 110 DEGF.

F. Before fire pump, provide OS&Y inlet and outlet isolation valves.

G. Provide four test cocks.
   1. Provide No. 1 test cock on inlet valve.

H. Approved by authority having jurisdiction.

I. UL listed and FM approved.

J. Double Check Detector:
   1. Two independently operating check valves.
   2. Bypass line with two independently operating check valves, water meter, three test cocks, and outlet shutoff valve. Bypass shall allow 8-10 GPM of flow before main-line assembly opens.

2.6 FIRE ALARM SYSTEM CONTROL PANEL

A. Fire alarm system control panel: Provided under Electrical Specification Divisions.

2.7 FIRE PROTECTION SYSTEMS, WATER-BASED

A. Standpipe-and-Hose Fire Protection System:
   1. Class I:
      a. Standpipes, fire department connections, fire-hose valve cabinets, and fire department valves.

B. Wet Pipe Fire Protection Sprinkler System:
   1. Description: Automatic system shall employ closed sprinklers attached to a piping system filled with pressurized water.
      a. Normal operation:
         1) Actuation of sprinkler allows water to flow through actuated sprinkler.
         2) Waterflow in zone sends signal to Fire Alarm System Control Panel.
      b. Failure of sprinkler allows water to flow through sprinkler.
         1) Waterflow in zone sends signal to Fire Alarm System Control Panel.

2.8 FIRE DEPARTMENT CONNECTIONS

A. Components and assemblies UL listed and FM approved.

B. Minimum 175 PSI non-shock cold-water working pressure.

C. Inlet threads for connections to fit local fire department standards.

D. Outlet threads for hydrants to fit local fire department standards.

E. Fire Department Siamese Connections.
   1. Outside type.
   2. Inlet:
      a. Quantity:
         1) Four.
      b. Size:
         1) 2-1/2 IN.
      c. Fittings:
         1) Chrome plated brass snoots, chrome plated brass pin-lug swivels, chrome plated brass pin-lug plugs, chains, and gaskets.
   3. Outlet:
      a. Quantity:
         1) One.
      b. Size:
         1) 6 IN.
   4. Finish:
      a. Chrome plated brass.
   5. Raised lettering:
      a. "AUTOSPKR & STANDPIPE".
   6. Connection style:
      a. Flush, wall-mounted.
      b. Provide pressure reducing device capable of handling inlet pressures up to 300 PSI where required.
   7. At the low point near the fire department connection, provide a 90-degree elbow with drain connection to allow for localized system drainage to prevent freezing.

2.9 FIRE DEPARTMENT VALVES AND FIRE HOSE VALVE CABINETS

A. Components and assemblies UL listed and FM approved.

B. Outlet threads shall match local fire department standards.

C. Valves:
   1. Minimum 175 PSI non-shock cold-water working pressure.

D. Cabinet:
   1. For use with fire department valves.
   2. Door frame:
   3. For use with recessed and semi-recessed cabinets.
      a. 16 or 18 GA steel.
   4. Door:
      a. Continuously hinged 20 GA steel.

E. Fire Department Valves:
   1. General:
      a. 2-1/2 x 2-1/2 IN valve.
      b. Cap and chain.
      c. Pattern: Straight or angle.
   2. FDV, Fire department valve without cabinet:
      a. Finish: Polished brass.
   3. FVC-1, Fire department valve with cabinet:
      a. Cabinet mounting:
         1) Recessed.
      b. Door style:
         1) Solid with lever handle cam latch.
      c. Cabinet and door finish:
         1) Prime painted.

d. Valve finish:
    1) Rough brass.
e. Mark: "FIRE DEPARTMENT VALVE".

2.10 FIRE PUMP SYSTEM

A. Provide a complete fire pump system including but not limited to:
   1. Fire pump unit.
      a. Pump.
      b. Driver.
      c. Controller.
   2. Jockey pump unit.
      a. Pump.
      b. Controller.
   3. Flow measuring system.

B. Comply with requirements of NFPA-20.

C. UL listed and FM approved.

D. Capacities, suction conditions, driver characteristics as indicated.

E. Provide pump rated to deliver not less than 150 PCT of rated flow at not less than 65 PCT of rated head with maximum head not to exceed 140 percent of rated head.

F. Pump suction lift capacity: 15 FT at 150 PCT capacity rating point.

G. Suction pressure is at 150 PCT of rated capacity.

H. Maintain fire pump system pressure through controller capable of automatically starting and stopping jockey pump on a signal from a pressure switch.

I. Fire Pump:
   1. See drawings for preliminary sizing: Preliminary estimate is 1,250 gpm at 90 PSI nominal; 150 hp maximum. Contractor to propose final selection based upon hydraulic calculations and shop drawing submittal to be approved by Engineer.
   2. Split case, double suction, centrifugal design with class 30 cast iron casing, bronze casing wearing rings, bronze impeller, bronze impeller wearing rings, steel shaft with renewable bronze shaft sleeves through packing boxes, split-bronze packing-box glands, and grease-lubricated cartridge-type anti-friction bearings.
   3. ANSI Class 125 suction flange.
   4. ANSI Class 125 discharge flange.
   5. Horizontal position:
      a. Pump and motor mounted on common base plate of cast iron or steel and directly connected through flexible coupling.
   6. Fire pump fittings and accessories:
      a. Discharge and suction gauges: See System Accessories Article.
         1) Suction gauge: Compound.
      b. 1/2 IN auto air release valve.
      c. Coupling guard.
      d. Eccentric suction reducer.
      e. Concentric discharge increaser.
      f. Minimum 3/4 IN casing relief valve.

J. Fire Pump Drive Motor:
   1. Open drip-proof, ball bearing induction type with 1.15 service factor rated for continuous operation at 40 DEGC rise above ambient.
   2. Wound for 3 phase, 60 Hz, 460 volt operation.
   3. Size not exceeding permissible loading limits of NFPA 20 or FM.
   4. Locked rotor current not exceeding values allowed in NFPA 20.
   5. Maximum HP: As scheduled.

K. Fire Pump Controller/Automatic Transfer Switch Assembly for Electric Motor Drive:
   1. Starting:
      a. Automatic controller starts fire pump motor on drop in system pressure.
         1) Controller to have soft start, soft stop and system sensing capabilities for reduced current starting.
      b. Automatic transfer switch signals building emergency generator to start on loss of normal power and transfers fire pump to that source when generator is up to speed.
   2. UL listed, FM approved.
   3. Factory assembled as a single unit and listed for fire pump service.
   4. Equipment mounted within drip-proof, moisture resistant NEMA II enclosure.
      a. Wall or floor mounted.
   5. Unit furnished as package by fire pump supplier and completely assembled, wired and factory tested.
   6. Controller components and accessories:
      a. Isolation switch externally operable, quick break type with lock-up off provision.
      b. Circuit breaker system with 3 phase overload locked rotor protection set 300 PCT of rated motor full load current.
      c. Maximum integral time delay: 20 seconds at 600 PCT full load current.
      d. Current sensors for locked rotor protector.
      e. Motor starter contactor(s).
      f. Magnetic starter operated automatically through pressure switch or manually by emergency start handle.
         1) Type: Solid State.
      g. Latching hook for emergency switch.
      h. Symmetrical ampere circuit breaker interrupt capacity in accordance with NFPA-20 and ANSI/UL-508 (440-480 voltage only).
      i. Pressure switch set to cut in and out at adjustable settings.
      j. Run period timer set in accordance with NFPA-20.
      k. Automatic/soft stop.
      l. Control transformer.
      m. Power availability relays with contacts to remote signal loss of line power in any phase and control transformer failure, or disconnection.
      n. Power availability pilot light.
      o. Contacts for operation of remote and local alarms and signals.
      p. In addition to the code required for pump and transfer switch alarm contacts, provide one extra set of alarm contacts.
      q. Low suction pressure alarm.
      r. Floor stand for floor mount installations.
      s. Top drip hood.
      t. Label FIRE PUMP CONTROLLER.
   7. Automatic transfer switch:
      a. Housed in barrier compartment of fire pump controller and marked AUTOMATIC TRANSFER SWITCH.
      b. Ampere rating: Minimum 115 PCT of total fire pump motor and accessories load.
      c. Suitable for switching pump motor locked rotor current.
      d. Comply with Section 26 36 23.
      e. Provide manually operable motor circuit or molded case isolation switch ahead of emergency source terminals and within automatic transfer switch compartment.
         1) Horsepower rating: Equal to motor horsepower.
         2) Ampere rating: 115 PCT of nameplate current rating.
      f. Provide auxiliary contact(s) with isolation switch to initiate an alarm when isolation switch is in OPEN position.
      g. Provide an additional contact to prevent engine generator from starting when isolation switch is open.

8. Local alarm panel:
    a. Visual signals and audible alarms to monitor status of pump controller and transfer switch.
    b. Install on controller/transfer switch.
    c. Indicate:
        1) Fire pump controller in PUMP RUN condition.
        2) Loss of line power to controller in any phase.
        3) Failure or disconnection of control transformer in controller.
        4) Loss of separate supervisory power supply to alarm panel.
        5) Alarm silence pushbutton.
        6) Automatic transfer switch isolation switch in open position.
9. Remote alarm panel: Visual signals and audible alarms to monitor status of pump controller and transfer switch.
    a. Install remote from fire pump in Fire Pump E151.
    b. Indicate:
        1) Fire pump controller in PUMP RUN condition.
        2) Loss of line power to controller in any phase.
        3) Failure or disconnection of control transformer in controller.
        4) Loss of separate supervisory power supply to alarm panel.
    c. Alarm silence pushbutton.
    d. Automatic transfer switch isolation switch in OPEN position.
10. Remote fire alarm system indications:
    a. Provide following indications through fire alarm system:
        1) Fire pump running.
        2) Loss of line power.
        3) Phase reversal.
        4) Water flow.
        5) Emergency isolation switch OPEN.

L. Jockey Pump:
    1. Centrifugal or turbine type.
    2. Cut in pressure 10 PSI above primary fire pump rated pressure; operate until pressure returned to 20-25 PSI above primary pressure.
    3. Voltage: Same as fire pump.
    4. Provide factory mounted relief valve.

M. Jockey Pump Controller:
    1. UL listed and FM approved.
    2. Equipment mounted in NEMA-I enclosure.
    3. Furnished by fire pump supplier suitable for operation with fire pump control system.
    4. HAND/OFF/AUTO switch.
    5. Magnetic starter with 3 phase overload protection.
    6. Auto start characteristics responsive to water pressure.
    7. Control transformer.

N. Flow Test System:
    1. Hose valve manifold flow test system.
        a. Hose gate valves:
            1) UL listed and FM approved.
            2) Cast brass.
            3) Non-rising stem.
            4) Inlet: 3 IN.
            5) Outlet: 2-1/2 IN with caps and chains.
            6) Quantity in accordance with NFPA-20 to accommodate pump capacity.
        b. Flush, wall mounted headers:
            1) Cast brass or ductile iron body.

2) Brass face plate with raised lettering.
c. Raised lettering: "FIRE PUMP TEST" or similar.
d. Finish of exposed ductile iron components: Red.
e. Finish of exposed brass components including valves:
1) Polished brass.

2.11 FIRE SYSTEM VALVES

A. UL listed and FM approved.

B. Body: Ductile or cast iron.

C. Pressure rating: 175 PSI non-shock cold-water working pressure.

D. 2 IN and smaller: Threaded.

E. 2-1/2 IN and larger: Flanged or grooved.

F. Trim to meet NFPA requirements.

G. Trim to meet performance as indicated in descriptions of fire protection systems.

2.12 MANUAL VALVES

A. See Section 20 05 23 for additional information.

B. Isolation Valves:
1. Gate valves:
a. 2 IN and smaller: V-49.
b. 2-1/2 IN and larger: V-50.
2. Butterfly valves:
a. 2 IN and smaller: V-55.
b. 2-1/2 IN and larger: V-51.
3. Butterfly valves with tamper switches:
a. 2-1/2 IN and smaller: V-59.
b. 3 IN and larger: V-61.

C. Check Valves 2-1/2 IN and larger: V-53 or V-54.

D. Wall-type Post Indicator Valve Assembly:
1. Valve: V-52.

E. Outside Valve Boxes:
1. 3 piece cast iron, extension type, 5-1/4 IN shaft, 5-1/4 IN drop lid, screw or slip type.
2. Screw type lid: Tyler 6860 with No.6 bell base.
3. Slip type lid: Tyler 6865 with No.8 bell base.
4. Mark lids with WATER cast in metal.

F. Automatic Ball Drip Valve:
1. 1/2 IN straight or angle cast-brass ball drip shall close against pressure.
a. When pressure drops, valve shall open to drain pipe.

2.13 SPRINKLERS

A. UL listed sprinklers of style and type required for service indicated.

B. Sprinklers in systems sized from pipe schedules shall have 1/2 IN nominal orifices.

C. Finish of exposed parts: As indicated.

D. Sprinkler types: Metallic fusible link.

E. Sprinkler Styles:
1. Upright:
a. Finish: Standard bronze.

2. Pendant:
   a. Finish: Chrome.
3. Concealed pendant:
   a. Ceiling plate flush with finished ceiling.
   b. Flat cover plate.
   c. Housing: 1/2 IN adjustment.
   d. Finish: Chrome.
4. Horizontal sidewall:
   a. Finish: Chrome.
5. Horizontal sidewall, extended coverage:
   a. Finish: Chrome.
6. Dry pendant:
   a. For coverage of exterior area from interior wet-pipe system.
   b. For systems with piping that is subject to freezing.
   c. Finish: Chrome.
7. Flexible Sprinkler Hose Fittings:
   a. Hose fittings – general
      1) Flexible stainless steel sprinkler drop systems may be used to locate sprinklers as required by final finished ceiling tiles and walls. The drop shall include a braided hose with a bend radius to 2 IN to allow for proper installation in confined spaces. Union joints shall be provided for ease of installation. The flexible drop shall attach to the ceiling grid using one-piece open gate Series AB1 or AB2 bracket. The bracket shall allow installation before ceiling tile is in place. The braided drop system is UL listed and FM Approved for sprinkler services to 175 PSI.
   b. Hose fittings shall be braided stainless steel, hose fittings and accessories shall be FM 1637 approved.
8. Window sprinkler:
   a. Finish: Chrome.

2.14 SYSTEM ACCESSORIES

A. Alarm Test Device:
   1. Optional replacement for alarm test loop.
   2. Single device or unit that provides visual verification of waterflow in a fire sprinkler system and allows for draining of all or a portion of that system.
   3. Contains sight glass, inspector test valve, auxiliary drain valve and test orifice.
   4. UL listed and FM approved.

B. Pressure Gauges:
   1. UL listed and FM approved.
   2. See Section 20 05 19.
   3. Pressure range and gauge increments as required by NFPA 13, 14 and 20.

C. Spare Parts:
   1. Tools:
      a. Furnish one emergency rubber ball shutoff on long handle to be used for temporary closing of sprinkler after fire has been extinguished.
      b. Furnish testing apparatus capable of producing the heat or impulse necessary to operate supplemental fire detection systems in manner recommended by manufacturer of detection system.
   2. Sprinkler cabinet, Wall mounted:
      a. Provide spare sprinklers of each type and sprinkler wrench for each type in quantities required by NFPA-13.

D. Sprinkler Guards:
   1. UL listed.
   2. Heavy duty welded wire.
   3. Red baked enamel finish.

4. Escutcheons and guards shall be listed and supplied for use with the sprinkler by the sprinkler manufacturer.

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate with other trades to ensure adequate space for equipment and piping placement.

B. Review plans, specifications and shop drawings of other trades to coordinate work.

C. Do not begin installation until after Agency approvals have been submitted to Architect.

D. Test systems in accordance with System Standards, manufacturers' instructions, and applicable NFPA publications.

E. Install systems in accordance with System Description, manufacturers' instructions, and approved shop drawings.
   1. Modifications to system design or arrangement after approval of drawings may only be made after receiving written approval of Architect and authority(ies) having jurisdiction.
   2. Such modifications do not include minor relocations in piping or sprinkler placement.
   3. Make revisions in accordance with NFPA.

F. Maintain fire and smoke ratings where mechanical items penetrate fire and fire/smoke rated building elements.

G. Field quality control: Give advance notice and arrange for field tests and inspections by authority(ies) having jurisdiction.

3.2 PIPING, SPRINKLERS, AND SUPPORTS

A. Piping - General:
   1. Install sprinkler piping within first 6 IN of space under floor construction.
      a. Where conditions of construction require piping installation at a lower elevation, route piping to avoid interference with work of other trades.
   2. Avoid interconnecting standpipes through sprinkler system piping.
   3. Offset, crossover and otherwise route piping to install system in available space.
      a. Not every offset is indicated.
   4. Install chromed escutcheons on finished-area sides of pipe penetrations.
      a. Secure escutcheons so they make contact with floor, wall, or ceiling.
   5. When risers are concealed, provide wall flange at each FDV and within cabinets.
   6. Pitch branch lines, cross mains, feed mains and risers to drains.
   7. Paint fire sprinkler piping in accordance with Section 09 91 23.
   8. Flush outside fire-main piping prior to connecting to inside system.
   9. Grooved joints: Install in accordance with the manufacturer’s latest published installation instructions. Pipe ends shall be clean and free from indentions, projections and roll marks in the area from pipe end to (and including) groove. Gasket shall be manufactured by the coupling manufacturer and verified as suitable for the intended service. A factory trained representative (direct employee) of the coupling manufacturer shall provide on-site training for contractor’s field personnel in the use of grooving tools, application of groove, and product installation. The representative shall periodically visit the job site and review installation to ensure best practices in grooved joint installation are being followed. Contractor shall remove and replace any improperly installed products.

B. Sprinklers - General:
   1. Install sprinklers to provide and maintain minimum 18 IN clear between bottom of deflector and top of storage, files, shelving, and cabinets.
   2. Standard-application temperature rating:
      a. Sprinkler type:
         1) Fusible link: 165 DEGF.

b. Where non-standard applications exist, use higher rating.
   1) Use sprinklers rated at least 50 DEGF higher than anticipated ambient temperature.

C. Supports:
   1. Install in accordance with NFPA-13 and NFPA-14.

D. Testing - General:
   1. Test sprinkler and standpipe piping, including outside supplies, under hydrostatic pressure of 200 PSI for 2 HRS.
      a. Prove system tight to satisfaction of Architect.
      b. Inside piping shall indicate no leakage.
      c. Leakage in underground piping shall be in accordance with NFPA-24.

E. Piping and Sprinkler - Application by room type:
   1. Areas subject to freezing:
      a. Sprinkler styles: Upright or dry pendant.
         1) Temperature rating: As required for room type.
      b. Provide sprinkler guards on pendant sprinklers.
   2. Electrical rooms/closets:
      a. Sprinkler styles: Upright.
      b. Provide sprinkler guards.
   3. Elevator machine rooms:
      a. Provide shielding to protect electrical elevator equipment from sprinkler system discharge.
         1) Coordinate with elevator installer.
         2) Coordinate with authority(ies) having jurisdiction.
      b. Sprinkler styles: Upright, pendant, or horizontal sidewall (standard or extended coverage).
         1) Fusible link temperature rating: 220 DEGF.
      c. Provide sprinkler guards.
   4. Finished rooms (rooms with ceilings):
      a. Sprinkler styles:
         1) Concealed pendant.
         2) Horizontal sidewall, standard or extended coverage.
      b. Where ceiling exists in area subject to freezing, comply with requirements for areas subject to freezing.
      c. Install sprinklers so that escutcheons do not cover ceiling grid.
      d. Locate sprinklers to coordinate with ceiling layout.
         1) Locate sprinklers centered in ceiling tile and in center of metal strip in linear metal ceilings, if such location makes added sprinklers necessary, provide added sprinklers as required to meet code.
   5. Mechanical equipment rooms:
      a. Sprinkler styles: Upright.
         1) Fusible link temperature rating: 220 DEGF.
      b. Provide sprinkler guards.
   6. Telephone/Communication rooms/closets:
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall (standard or extended coverage).
      b. Provide sprinkler guards.
   7. Unfinished rooms (rooms without ceilings):
      a. Sprinkler styles: Upright.
   8. Do not install sprinklers that have been dropped or damaged.
   9. Sprinkler link protector shall be removed by hand after installation. Do not use tools or any other device(s) to remove the protector that could damage the link in any way.

3.3 ALARM AND SIGNAL DEVICES

A. Where multi-zone, wet-pipe fire protection sprinkler systems exist, provide waterflow detector at each zone take off immediately after isolation valve.

B. Install valve tamper switch on each isolation valve indicated below:
   1. Valves at bases of standpipes.
   2. Valves at fire system valves.
   3. Valves in fire pump suction piping including valves across water meters and backflow protection devices.
   4. Valve at fire pump discharge.
   5. Sprinkler-zone valves.
   6. Post indicator valves.

3.4 FIRE PROTECTION SYSTEMS

A. Factory trained Engineer shall supervise installation of fire protection systems.

B. On combination sprinkler and standpipe-and-hose systems, do not interconnect standpipes through sprinkler piping.

C. Factory trained Engineer shall provide following services:
   1. Supervise installation of fire protection systems.
   2. Instruct Owner's personnel in systems operations.

D. Test completed alarm systems including control and signal circuits wired by Electrical installer.
   1. Coordinate with electrical.
   2. Complete testing prior to substantial completion.

3.5 FIRE DEPARTMENT CONNECTIONS, FIRE DEPARTMENT VALVES, AND FIRE HOSE VALVE CABINETS

A. Install fire department connections, fire department valves, and fire hose valve cabinets at height required by authority having jurisdiction.
   1. Position valve to allow 12 IN spanner wrench clearance for connecting hoses.

3.6 FIRE PUMP SYSTEM

A. Grout base of fire pump for proper alignment.

B. Route drain line from fire pump base and bearing brackets to floor drain.

C. Test fire pump system:
   1. Factory trained Engineer shall conduct final field tests for fire pump system acceptance.
   2. Test fire pump under hydrostatic pressure to at least twice its working pressure but not less than 250 PSI.
   3. Conduct complete running test and prepare characteristic curves from test results.
   4. Perform operating and pressure tests in presence of authority having jurisdiction and Owner's representative.

3.7 MANUAL VALVES

A. Provide isolation valves at following locations:
   1. Bases of standpipes.
   2. Fire system valves.
   3. Suction and discharge of fire pump.
      a. Suction isolation valve must be OS&Y type.
      b. Discharge isolation valve must be indicating type.
   4. Flow test system:
      a. Inlet to hose valve manifold.
   5. On combination sprinkler and standpipe-and-hose systems, provide isolation valve at each sprinkler-zone take off from standpipes.

B. Provide check valves at following locations:
   1. Outlet of fire pump: In-line, spring-actuated check.
   2. Fire department connection.
   3. After control valve for each sprinkler system zone take off.

C. Install indicator posts approximately 3 FT above grade.

D. Provide automatic ball drip at low points.
   1. Piping between outside fire department connection and check valve.
   2. Piping between outside fire department connection and pump test header shutoff valve.

E. Provide valve boxes at each underground valve (except PIV's).

3.8 SYSTEM ACCESSORIES

A. Alarm Test Loops:
   1. Provide after each waterflow detector.
   2. Alarm test loop consists of two parallel branches.
      a. First branch: Inspector's test branch shall contain a shutoff valve and a restricting orifice imitating the flow through the smallest sprinkler on the system. Provide means for inspector to observe water flow (e.g., drain water within sight of valve or provide sight glass).
      b. Second branch: Drain branch shall contain shutoff valve.
      c. Alarm test loop sizing criteria:
         1) Riser or Main is 2 IN or smaller: 3/4 to 2 IN.
         2) Riser or main is 2-1/2 to 3-1/2 IN: 1-1/4 to 2 IN.
         3) Riser or main is 4 IN or larger: 2 IN.
   3. Extend loops to nearest floor drain or mop sink.
      a. Loops may be terminated outside when approved by authority having jurisdiction.
   4. Label valves and outlets.

B. Drains:
   1. Permit complete draining of systems without disconnection of piping.
   2. Drain consists of dirt leg, valve, and piping.
   3. Extend drain piping to nearest floor drain or mop sink.
   4. Required locations:
      a. At low points of systems.
      b. At fire pump.
      c. At alarm test loops.
      d. At fire system valves.
      e. At bases of risers and standpipes.
         1) 1-1/2 IN hose threads that match local fire department threads may be provided instead of extending piping.
   5. Size drain valve and piping according to alarm test loop sizing criteria in this section.
   6. At offsets, plugs may be substituted for drains when approved by authority having jurisdiction.

C. Pressure Gauges:
   1. Provide at following locations:
      a. On each discharge pipe from fire pump.
      b. At service entrance to building.
      c. At top of each standpipe.
      d. At top of each sprinkler riser.
      e. At alarm test loops.
      f. At other indicated locations.
   2. Provide shutoff valve and drain for each gauge.

D. Sprinkler Cabinets:
      a. Install sprinkler head cabinets at each riser location per NFPA 13 requirements.

3.9 ELECTRICAL WIRING

A. Provide Following:
   1. Wiring diagrams for devices.
   2. Supplemental fire detection systems and their wiring.
   3. Wiring not specified but required to provide an operating system.
   4. Control wiring from fire pump controller to pressure switch(es).
   5. Interlock wiring between fire pump and emergency generator(s).

B. Electrical Installer shall provide following:
   1. Fire pump wiring:
      a. 3 phase power wiring to fire pump and jockey pump controllers and from controllers to pumps.
      b. Supervised wiring to Fire Alarm System Control Panel.
         1) Coordinate number of wires with indications required.
   2. Alarm and signal device wiring:
      a. Tamper switches: Supervised wiring to Fire Alarm System Control Panel.
      b. Waterflow detectors: Supervised wiring to Fire Alarm System Control Panel.
      c. Alarm pressure switches: Supervised wiring to Fire Alarm System Control Panel.
      d. Pressure supervising switches: Supervised wiring to Fire Alarm System Control Panel.
      e. Supervised wiring from waterflow detector to outside alarm bell.

END OF SECTION

SECTION 21 22 00
CLEAN-AGENT FIRE-EXTINGUISHING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Piping and piping specialties.
   2. Extinguishing-agent containers.
   3. Extinguishing agent.
   4. Detection and alarm devices.
   5. Control and alarm panels.
   6. Accessories.
   7. Connection devices for and wiring between system components.
   8. Connection devices for power and integration into building's fire-alarm system.

1.2 ACTION SUBMITTALS

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

B. LEED Submittals:
   1. Product Data for Credit EA 4: Documentation indicating that clean agents comply.

C. Shop Drawings: For clean-agent fire-extinguishing system signed and sealed by a qualified professional engineer.
   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include design calculations.
   3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   4. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Permit Approved Drawings: Working plans, prepared according to NFPA 2001, that have been approved by authorities having jurisdiction. Include design calculations.

B. Field quality-control reports.

C. Seismic Qualification Certificates: For extinguishing-agent containers and control panels from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. FM Global Compliance: Provide components that are FM Approved and that are listed in FM Global's "Approval Guide."

C. UL Compliance: Provide equipment listed in UL's "Fire Protection Equipment Directory."

PART 2 - PRODUCTS

2.1 CLEAN-AGENT SYSTEMS

A. Basis-of-Design Product: Subject to compliance with requirements, provide PYRO_CHEM; FM 200:

B. Description: Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the Control Room W174 and Anechoic Chamber W176A hazard area including below the ceiling.

C. Delegated Design: Design clean-agent fire-extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class A, B, and C fires as appropriate for areas being protected, and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.
   1. The Contract Documents are diagrammatic in nature and are not intended to show exact locations and exact quantities of components. Contractor shall coordinate final routing with other trades additional offset of fittings required for proper installation.
   2. Final tank locations shall be field verified prior to installation. If tank locations need to be shifted in the field, verification calculations shall be performed to ensure proper flow and delivery of the agent at no cost to the Owner.

D. Performance Requirements:
   1. Performance requirements for HFC 227 per NFPA.

E. Cross-Zoned Detection: Sound alarm on activating single-detection addressable device, and discharge extinguishing agent on actuating single-detection addressable confirming device.

F. System Operating Sequence:
   1. Actuating First Detector: Visual indication on annunciator panel. Energize audible and visual alarms (slow pulse bell), shut down air-conditioning and ventilating systems serving protected area, close doors in protected area, and send signal to fire-alarm system.
   2. Actuating Second Detector: Visual indication on annunciator panel. Energize audible and visual alarms (fast pulse bell), shut down power to protected equipment, start time delay for extinguishing-agent discharge for 30 seconds, and discharge extinguishing agent. On agent discharge, release preaction valve to allow water to fill sprinkler system.
   3. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.
   4. See sequence of operations sheet in contract drawings for further detail.

G. Manual stations shall immediately discharge extinguishing agent when activated.

H. Operating abort switches will delay extinguishing-agent discharge while being activated, and switches must be reset to prevent agent discharge. Release of hand pressure on the switch will cause agent discharge if the time delay has expired.

I. EPO: Will terminate power to protected equipment immediately on actuation.

J. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure.

K. Power Transfer Switch: Transfer from normal to stand-by power source.

L. Seismic Performance: Fire-suppression piping and containers shall withstand the effects of earthquake motions determined according to ASCE.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2.2 PIPING MATERIALS

A. See "Manufacturer's Installation Manual". Article for applications of pipe, tube, fitting, and joining materials.

B. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.

2.3 PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106/A 106M, Grade A ; Schedule 40, Schedule 80, and Schedule 160, seamless steel pipe.
   1. Threaded Fittings:
      a. Malleable-Iron Fittings: ASME B16.3, Class 300.
      b. Flanges and Flanged Fittings: ASME B16.5, Class 300 unless Class 600 is indicated.
      c. Fittings Working Pressure: 620 psig (4278 kPa) minimum.
      d. Flanged Joints: Class 300 minimum.
   2. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.
   3. Steel, Grooved-End Fittings: FM Approved and NRTL listed, ASTM A 47/A 47M malleable iron or ASTM A 536 ductile iron, with dimensions matching steel pipe and ends factory grooved according to AWWA C606.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8 IN maximum thickness unless thickness or specific material is indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for clean-agent service, and matching steel-pipe dimensions. Include ASTM A 536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

2.4 VALVES

A. General Valve Requirements:
   1. UL listed or FM Approved for use in fire-protection systems.
   2. Compatible with type of clean agent used.

B. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.

C. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure relief device.

D. Electrical valve actuators shall be of brass construction and stackable design with swivel connections to allow removal of actuators for maintenance and testing.

E. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.

2.5 EXTINGUISHING-AGENT CONTAINERS

A. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.

B. Finish: Redenamel or epoxy paint.

C. Manifold: Fabricate with valves, pressure switches, and connections for multiple storage containers, as indicated.
   1. Manifold: Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.
   2. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

D. First filling of the cylinder assembly shall be by manufacturing facility.

E. Cylinder Bracket
   1. Each cylinder assembly shall be furnished with a bracket made from welded steel. The bracket shall hold the cylinders in a saddle with a front bracket piece that secures the cylinders. The brackets shall be modular in design to allow added bracketing or stacking of cylinders depending on installation requirements.
   2. Cylinder brackets shall be UL listed and/or FM approved for use with the FM 200 system.

2.6 FIRE-EXTINGUISHING CLEAN AGENT

A. HFC 227ea Clean Agent: Heptafluoropropane.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide PYRO_CHEM; FM 200 or comparable product by one of the following:
      a. DuPont.
      b. Great Lakes Chemical Corporation; a Chemtura company.

2.7 DISCHARGE NOZZLES

A. Equipment manufacturer's standard one-piece brass or aluminum alloy of type, size, discharge pattern, and capacity required for application.

2.8 CONTROL PANELS

A. Description: FM Approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire-alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

C. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.
   1. Mounting: Recessed flush with surface.

D. Supervised Circuits: Separate circuits for each independent hazard area.
   1. Detection circuits equal to the required number of zones, or addressable devices assigned to the required number of zones.
   2. Manual pull-station circuit.
   3. Alarm circuit.
   4. Release circuit.
   5. Abort circuit.
   6. EPO circuit.

E. Control-Panel Features:
   1. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.
   2. Automatic switchover to standby power at loss of primary power.
   3. Storage container, low-pressure indicator.
   4. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.

F. Standby Power: Sealed, valve-regulated, recombinant lead acid batteries with capacity to operate system for 72 hours and alarm for minimum of 15 minutes. Include automatic battery charger that has a varying charging rate between trickle and high depending on battery voltage, and that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, automatic transfer switch, and suitable enclosure.

2.9 DETECTION DEVICES

A. General Requirements for Detection Devices:
   1. Comply with NFPA 2001, NFPA 72, and UL 268.
   2. 24-V dc, nominal.

B. Air sampling detection: See Section 28 31 30.

2.10 MANUAL STATIONS

A. General Description: Semirecessed FM Approved or NRTL listed, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

B. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

C. Abort Switch: "ABORT" caption, momentary contact, with green finish.

2.11 SWITCHES

A. Description: FM Approved or NRTL listed, where available, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.
   1. Low-Agent Pressure Switches: Pneumatic operation.
   2. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.
   3. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.

2.12 ALARM DEVICES

A. Description: Listed and labeled by an NRTL or FM Approved, low voltage, and surface mounting. Comply with requirements in Section 28 31 13 "Fire-Alarm System and Detection"

B. Bells: Minimum 6 IN diameter.

C. Strobe Lights: Blue lens, with "AGENT" or similar caption.

2.13 MAINTENANCE BYPASS SWITCHES

A. The maintenance lock-out switch shall be used where it is desired to disable the fire suppression system during routine maintenance.

B. The switch shall be key operated allowing removal of the key only in “Normal” position. A red indicator lamp shall be included on the switch assembly to be illuminated when in the “Lock-Out” position. The control unit is used to indicate a supervisory condition when in the Lock-Out position.

C. The switch shall include 1 set of normally open and 1 set of normally closed control contacts rated for 2A resistive @30VDC.

D. The terminal connections shall be of the screw type.

2.14 ROOM INTEGRITY

A. The Contractor shall construct the spaces of the Control Room W174 and Anechoic Chamber W176A so that they are ‘sealed’ before performing the room integrity tests. If the tests fail, the Contractor shall fix the problems and retest at the Contractor’s expense.
   1. All doors leading from the protected areas or into another protected zone shall have door seals:
      a. On the bottoms, weather-stripping
      b. Around the jambs, latching mechanisms and automatic door closing hardware.
      c. Double doors shall have a weather-stripped astragal to prevent leakage between doors. In general, doors shall be treated as though they are being ‘weatherproofed’ for outside use with no light possible passing around all sides.
      d. Ductwork not in service, leading from or into a protected area shall be permanently sealed off with metal plates caulked and screwed in place. Ductwork left in service from the building air handling unit shall have butterfly blade type dampers installed with neoprene seals. Dampers shall be spring loaded and provide 100% air shutoff. Dampers shall be located at the wall line where the ducts enter and exit the zone. The ducts shall be fitted with inspection ports to allow inspection of the damper blades.
      e. All conduits leading from or into a protected area shall be sealed with firestop sealant. All electrical switch boxes and receptacles, including computer LAN connections shall be sealed to prevent leakage from the area.
      f. All walls shall be caulked around the inside perimeter of the room where the walls rest on the floor slab and where the walls intersect with the ceiling slab above. Sealing shall take place on the inside surface of the areas to avoid leakage into the partition wall void. For ceilings with corrugated overhead pan: The pockets shall be sealed with properly rated material.
      g. Any ceiling tiles in the space shall be clipped in place and no tiles shall be missing.
      h. All holes, cracks and penetrations leading into or out of the protected areas shall be sealed. This includes pipe chases and wire troughs. Wire troughs and cable trays shall be sealed with reusable, intumescent, rated sealbags.

PART 3 - EXECUTION

3.1 HFC 227EA AGENT PIPING APPLICATIONS

A. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.

B. NPS 2 (DN 50) and Smaller: Schedule 40, steel pipe; malleable-iron threaded fittings; and threaded joints.

C. NPS 2-1/2 (DN 65) and Larger: Schedule 40, steel pipe; forged-steel welding fittings; and welded joints and steel, grooved-end fittings; steel, keyed couplings; and grooved joints.

3.2 CLEAN-AGENT PIPING INSTALLATION

A. Install clean-agent extinguishing piping and other components level and plumb, according to manufacturers' written instructions.

B. Grooved Piping Joints: Groove pipe ends according to AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant according to manufacturer's written instructions.

C. Install extinguishing-agent containers anchored to substrate.

D. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 2001, Section "Distribution."

1. Install valves designed to prevent entrapment of liquid, or install pressure relief devices in valved sections of piping systems.
2. Support piping using supports and methods according to NFPA 13.
3. Install seismic restraints for extinguishing-agent containers and piping systems.
4. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

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

F. Where installing piping adjacent to equipment, allow space for service and maintenance.

G. Connect electrical devices to control panel and to building's fire-alarm system. Electrical power, wiring, and devices are specified in Section 28 31 00 "Fire-Alarm and Detection Systems".

H. Identify piping, extinguishing-agent containers, other equipment, and panels according to NFPA 2001.

I. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire-extinguishing system.

J. Install signs at entry doors to advise persons outside the room the meaning of the, bell(s), and strobe light(s) outside the protected space.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

C. Tests and Inspections:

D. The completed installation shall be inspected by factory authorized and trained personnel. The inspection shall include a full operational test of all components per the equipment manufacturer's recommendations. A system discharge may also be performed if the AHJ requires one.

E. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections "Inspection and Test Procedures" and "System Function Tests." Certify compliance with test parameters.
1. Inspection shall be performed in the presence of the owner's representative, architect's or engineer's representative, insuring authority and/or the local AHJ.
2. All piping shall be reamed, blown clear, swabbed with appropriate solvent to remove mill varnish and cutting oils before assembly.
3. Equipment installation and maintenance manuals shall be provided in addition to the as-built drawings.
4. The quantity of agent shall reflect the actual design quantity of FM 200 agent.
5. A functional test shall be completed prior to the concentration test consisting of detection, alarm, release, accessories related to the system control unit, and a review of the cylinders, piping, fittings, hangers, and cylinder pressure.
6. Concentration testing shall be performed under the supervision of the contractor's authorized personnel in the presence of the; A/E, owner's representative, local authorities and any other insuring authority.
7. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
8. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

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

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

G. Prepare test and inspection reports.

H. Room Integrity Testing
   1. Room Integrity tests shall be conducted for each space in accordance with NFPA 2001.
   2. An inspection shall be made to ensure that all required dampers, door bottom seals, weather-stripping, caulking and foam sealants have been installed and that all areas protected will contain the gas. Visually inspect the room for possible leakage points prior to testing. Notify the Contractor of all possible leaks that need to be sealed. The Ensure all automatically closable openings are closed. The Contractor shall be responsible for closing any openings.
   3. Room integrity tests shall be performed with the Contractor, Owner's Representative, AHJ, and A/E.
   4. Visually inspect the room for possible leakage points prior to testing. Ensure all automatically closable openings are closed. The Contractor shall be responsible for closing any openings.

3.4 SYSTEM FILLING

A. Preparation:
   1. Verify that piping system installation is completed and cleaned.
   2. Check for complete enclosure integrity.
   3. Check operation of ventilation and exhaust systems.

B. Filling Procedures:
   1. Fill extinguishing-agent containers with extinguishing agent, and pressurize to indicated charging pressure.
   2. Install filled extinguishing-agent containers.
   3. Energize circuits.
   4. Adjust operating controls.

3.5 DEMONSTRATION

A. Prior to final acceptance, the contractor shall provide operational training in all concepts of the system to the owner's key personnel. Training shall consist of:
   1. Control system operation
   2. Trouble procedures
   3. Abort procedures
   4. Emergency procedures
   5. Safety requirements
   6. Demonstration of the system (excluding FM 200 agent release)

B. Train Owner's maintenance personnel to adjust, operate, and maintain clean-agent fire-extinguishing systems.

C. Provide two (2) separate training sessions, each with four (4) hours of manual and "hands-on" training.

D. Provide instruction as required to building personnel. "Hands-on" demonstrations of operation of system components and entire system shall be provided.
   1. Each training session shall include emergency procedures, abort functions, system control panel operation, trouble procedures and safety requirements.
   2. Each session shall include complete demonstration of system.

3.6 WARRANTY

A. Components/System: Limited one-year warranty shall be offered for defects in workmanship and material.

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DIVISION 22

PLUMBING

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SECTION 22 08 00

COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 01 91 13 – Commissioning General Requirements

C. Section 25 08 00 – Commissioning of Integrated Automation Systems

D. Section 26 08 00 – Commissioning of Electrical Systems

E. Commissioning Plan

1.2 DESCRIPTION OF WORK

A. The purpose of this section is to specify the Division 22 responsibilities and participation in the commissioning process. All contractors responsible for Division 22 installation or other activities shall have commissioning responsibilities described herein.

B. Work under this contract shall conform to requirements of Division 1, General Requirements, Conditions of the Contract, and Supplementary Conditions. This specification covers Commissioning of Plumbing Systems, which are a part of this project.

C. Commissioning shall be a team effort to ensure that all plumbing equipment and systems have been completely and properly installed and function together correctly to meet the design intent. Additionally, system performance parameters shall be monitored and documented for fine tuning of control sequences and operational procedures. Commissioning shall coordinate and document equipment installation, equipment start-up, control system calibration, testing and balancing, and verification and performance testing.

D. The Commissioning Team is defined in Specification 01 91 13 Section 1.3 – Definitions. The mechanical trades represented on the Commissioning Team shall include but not be limited to; sheet metal, pipe and fitting, controls, test and balance, plumbing, chemical treatment and fire protection. The lead person for each trade who will actually perform or supervise the work is to be designated as the representative to the Commissioning Team. Responsibility for various steps of the commissioning process shall be divided among the members of the Commissioning Team, as described in this section.

E. Plumbing Contractor(s) are responsible for plumbing system installation, start-up, testing, preparation of O&M manuals, and operator training as defined in various Division 22 specification sections. Plumbing Contractor(s) are responsible for coordination, observation, and verification of commissioning as defined in this section and Section 01 91 13. Neither Section 01 91 13 - Commissioning General Requirements nor Section 22 08 00 – Commissioning of Plumbing systems shall relieve the Plumbing Contractor(s) from their obligations to complete all portions of work in a satisfactory and fully operational manner. Furthermore, Section 22 08 00 – Commissioning of Plumbing systems shall not relieve the Electrical Contractor(s) or Controls Contractor(s) from any obligations set forth within Division 1, Division 25, Division 26, including Section 01 91 13 – Commissioning General Requirements.

1.3 DEFINITIONS

A. Plumbing Contractor(s): The term Plumbing Contractor(s) utilized herein refers to any and all subcontracting companies or venders whom are responsible for the construction or other provisions regarding any of the systems which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 22 of the specifications. Subcontracting parties outside of the scope of the Systems to be Included in Commissioning or outside of the scope of Division 22 are not included.

B. Equipment Manufacturer(s): The term Equipment Manufacturer(s) utilized herein refers to any and all subcontracting companies whom are responsible for the provision of equipment or components which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 22 of the specifications. Equipment Manufacturer(s) shall refer to the direct representative of the maker and/or distributor of the equipment or component being provided. This may include either the actual equipment manufacturer or the supplier thereof, under the provisions that the supplier has a thorough knowledge of the equipment or component and is recognized by the actual equipment manufacturer as being a proper representative.

1.4 SCOPE OF WORK

A. The Plumbing Contractor(s) shall be required to Commission all equipment, components and accessories of each of the commissioned systems as outlined within Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning. In order to accomplish a complete commissioning process, the Plumbing Contractor(s) shall be required to fulfill all requirements set forth within Specification 22 08 00 Section 1.5 – Roles and Responsibilities. Additionally, the Plumbing Contractor(s) shall be required to fulfill all requirements set forth within Specification 01 91 13.

B. Through the Commissioning Process, the Plumbing Contractor(s) shall accomplish thorough documentation, organized scheduling and coordination, detailed installation verification, and detailed system functional verification. For this, the Plumbing Contractor(s) must cooperate and coordinate with the Commissioning Agent.

1.5 ROLES AND RESPONSIBILITIES

A. In addition to the Commissioning Agent, Owner and System Design Professional(s), the Commissioning Team is comprised of a minimum of one individual to represent each contracting company or venders whom are responsible for the construction or other provisions regarding any of the systems which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 22 of the specifications. See Specification 01 91 13 Section 1.3 – Definitions for the definition of the Commissioning Team.

B. Contracting companies providing members shall include but not be limited to; sheet metal, pipe and fitting, controls, test and balance, plumbing, chemical treatment and fire protection contractors whose responsibilities are defined herein.

C. In addition to all roles and responsibilities defined herein, all Plumbing Contractor(s) shall be required to fulfill all requirements described within Specification 01 91 13 Section 1.4 – Roles and Responsibilities.

D. Plumbing Contractor(s)
   1. General Requirements:
      a. Include all cost to complete commissioning requirements for plumbing systems in the contract price. Contractor costs shall be reflected within the Schedule of Values as specified within Specification 01 91 13 Section 2.2 – Schedule of Values.
      b. Ensure cooperation and participation of specialty Contractors and Sub-Contractors.

c. Ensure participation of major Equipment Manufacturers in appropriate start-up, testing and training activities.
d. Attend Commissioning Meetings for construction phase coordination as scheduled by the Commissioning Agent. Additionally, attend the Commissioning Kick-Off Meeting as scheduled by the Commissioning Agent.

2. Commissioning Schedule
   a. Prepare a Preliminary Schedule for plumbing systems and equipment, including component installation, start-up and checkout, and system start-up. Integrate commissioning activities into this Preliminary Schedule including Pre-Functional and Functional Performance Tests. Coordination of the commissioning activities and their integration into the schedule shall be conducted within the Commissioning Meetings.
   b. Update the Preliminary Schedule and submit a Final Schedule which shall reflect all items within the Preliminary Schedule and shall also include but not be limited to: inspections, O&M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, TAB, and task completion. All Contractor(s) shall integrate schedule activities into one complete Final Schedule which shall be reflected within the Construction Manager's/General Contractor's overall project schedule. The Final Schedule shall be continuously updated throughout the Construction Phase.
3. Submittal Requirements:
   a. Comply with all Submittal requirements as outlined within Specification 01 91 13 Section 2.3 – Submittals.
   b. Comply with all requirements as outlined within Specification 01 91 13 Section 2.5 – Start-Up and Test Reports.
   c. Provide a complete set of O&M manuals to the A/E and the Commissioning Agent.
   d. Provide the following documentation to the Commissioning Agent for the purpose of construction updates:
      1) General construction progress and status reports
      2) Updated Architect, Owner, System Design Professional, and Contractor deficiency logs
      3) Minutes from all construction and coordination meetings not otherwise conducted by the Commissioning Agent
      4) Pre Start-Up and Start-Up procedures
      5) Value Engineering Proposals and a list of all accepted VE items
      6) Pressure Test Reports, Flushing Reports and Start-Up Reports
      7) Construction document changes resulting from plumbing Requests for Information
4. Pre-Functional Checklist Requirements:
   a. Detailed installation verification shall be performed on all installed equipment and systems to ensure that the installations conform to the contract documents, local and applicable codes, and standard practice. This shall be accomplished through the completion of Pre-Functional Checklists. The creation, distribution, completion and maintenance of Pre-Functional Checklists are detailed in Specification 01 91 13 Section 2.4 – Pre-Functional Checklists.
   b. Complete Pre-Functional Checklists on all plumbing equipment and system components installed or provided by the Plumbing Contractors(s).
   c. Notify the Commissioning Agent a minimum of two weeks (14 days) in advance, of the time for start of the TAB work.
   d. Notify the Commissioning Agent a minimum of two weeks (14 days) in advance, so that witnessing Equipment and System Start-Up can begin.
   e. Provide written notification to the Commissioning Agent for each system listed in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, that the system installation is complete in its entirety and that the system is fully operational, online, and ready for Functional Performance Testing.

5. Equipment and Systems Start-Up
    a. Perform all initial check-out and start-up procedures as outlined within the specifications and as per the Equipment Manufacturer's recommendations. Provide full documentation of all start-up and check-out procedures and results. Documentation is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist.
    b. Perform all pressure tests, weld tests, vibration analysis and any other system component test required by the specifications requiring a 3rd party test agency. Provide full documentation of all tests procedures and results. Documentation is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist
    c. Perform all Test, Adjustment and Balance requirements for hydronic piping systems and air distribution systems. Submit copies of the TAB Report to all interested and reviewing parties as required by the specifications and to the Commissioning Agent. Also, submit a copy of the preliminary TAB documentation including the TAB Plan, Forms and Report format to the Commissioning Agent for review and approval. The TAB Contractor shall assist as the TAB Report is spot-checked by the Commissioning Agent. See the Specification 22 08 00 Section 1.5 – Roles and Responsibilities, Subsection E for additional TAB Contractor Requirements.
    d. Perform all equipment, system and component cleaning and flushing as required by the specifications and Equipment Manufacturer's recommendations. Provide full documentation of all cleaning and flushing procedures and test results (i.e. pH test results, etc.) Documentation is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist
6. Functional Performance Test Requirements:
    a. Detailed testing shall be performed on all installed equipment and systems to ensure that operation and performance conform to contract documents, local and applicable codes, and standard practice. This shall be accomplished through the completion of Functional Performance Tests. The creation, distribution and completion of Functional Performance Tests are detailed in Specification 01 91 13 Section 2.6 – Functional Performance Tests.
    b. Provide all appropriate equipment and materials as necessary to execute and complete all Functional Performance Tests. Comply with all requirements as outlined within Specification 01 91 13 Section 2.8 – Test Equipment.
    c. Provide appropriate technicians for participation during system verification and functional performance testing. Technicians shall demonstrate system performance to Commissioning Agent including all modes of system operation (e.g. normal, abnormal, emergency, etc.)
    d. Verify all functional performance tests prior to requesting test witness by the Commissioning Agent, demonstrate all Functional Performance test tasks in the presence of the Commissioning Agent and assist the Commissioning Agent in all verification and functional performance tests.
    e. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Commissioning Agent for verification or diagnostic purposes. Typically, TAB Verification shall occur in conjunction with Functional Performance Testing.
    f. Cancellation or delays of any system tests or Functional Performance Testing upon the day of that particular scheduled test, due to lack of preparation or status of installation shall be considered a failed test due to the additional time required by the Commissioning Agent to witness electrical testing. These additional tests shall be treated in accordance with Specification 01 91 13 Section 3.6-A.

7. Training Requirements:
   a. Comprehensive training of O&M personnel shall be performed by the Plumbing Contractor(s) and Equipment Manufacturer(s) prior to turnover of the systems to the Owner. Training shall include but not be limited to classroom instruction and hands-on instruction of the installed equipment and systems. Training shall be coordinated by the Commissioning Agent via review and approval of the Contractor(s) Training Plan, Forms and Schedule. Alternately, the Commissioning Agent may provide a Training Plan including all forms for completion by the Plumbing Contractor(s).
   b. The Training Schedule is to be coordinated and completed by the Plumbing Contractor(s). The Training Schedule is to be updated and maintained as construction progresses. The Training Schedule and all updates shall be coordinated with and approved of by the Owner. A copy of the Training Schedule and all updates shall be provided to the Commissioning Agent.
   c. Contractor(s) responsible for the installation or provision of any piece of equipment or system shall attend, at minimum, the initial training session for that equipment or system.
   d. All Training Documentation shall be assembled and organized in a binder or set of binders. Coordinate with all other Contractor(s) to provide one complete bound Training Record. This requirement shall not be negated, unless other specific complete Project Training Record requirements, encompassing ALL project training documentation, is outlined elsewhere within the specifications.
   e. Contractor to make professional video recordings of all O&M staff training sessions.
8. Close-out Requirements:
   a. Remedy all deficiencies identified during commissioning. Provide all materials, equipment, labor, etc. to accomplish these remedies.
   b. Provide a complete set of Record Documents (As-Built Drawings and Specifications) to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval by the Commissioning Agent.
   c. Provide a Project Training Record to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval to the Commissioning Agent.
   d. Provide a complete copy of Equipment and System Warranties to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval by the Commissioning Agent.
   e. Provide to the Commissioning Agent, a complete record of Attic Stock as delivered to the Owner and as approved by the Owner.
   f. Contractor to provide CMMS data and MAXIMO documentation to Owner as required by project specifications.

E. Test, Adjust, and Balance Contractor(s):
   1. Comply with all requirements as outlined within Specification 22 08 00 Section 1.5 Sub-Section D – Plumbing Contractor(s).
   2. Submit the TAB procedures to the Commissioning Agent and Design Professional for review and acceptance. TAB procedures must include the TAB Plan, TAB Forms and TAB Report Format. These documents must be approved prior to proceeding with the Test, Adjustment and Balance.
   3. Attend the TAB review meeting scheduled by the Commissioning Agent. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the HVAC system.
   4. Issue a statement that TAB work has been completed. Submit through the Contractor(s) a copy of the preliminary version of the Test and Balance Report to the Commissioning Agent and System Design Professional. Submit for review, a Final Version of the Test and Balance Report to the Commissioning Agent and System Design Professional within the amount of time allotted within the Specifications. The Commissioning Agent and Systems Design Professional must both accept the Final TAB Report.

5. The Commissioning Agent shall be provided with a copy of the Test, Adjustment and Balance Report a minimum of two weeks (14 days) prior to the scheduled spot check of the balanced system. The report may be a Preliminary or Final version. A representative of the Test and Balance firm shall be required to assist with the spot check. The Test and Balance firm shall provide calibrated testing equipment as per Specification 01 91 13 Section 2.8 - Test Equipment. Equipment shall be similar in style and type as used to initially perform Test, Adjustment and Balance procedures.
6. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Commissioning Agent for verification or diagnostic purposes.

F. Equipment Manufacturer(s):
1. Comply with all requirements as outlined within Specification 22 08 00 Section 1.5 Sub-Section D – Plumbing Contractor(s).
2. Assist in scheduling of training sessions. Provide training of Owner's Maintenance Personnel with adequacy required for full comprehension of equipment and maintenance procedures. Coordinate training with the Commissioning Agent. Training forms for Agenda and Training Record shall be provided by the Commissioning Agent. These forms are to be utilized for all Training Sessions. Manufacturer's standard training forms shall not be accepted as Training Records if Commissioning Forms are provided. Manufacturer standard training forms may be submitted as supplemental information, but the Commissioning Forms must be completed in their entirety.
3. Review installation for Equipment Manufacturer's specific requirements. Verify safeties, limits, relays and all other equipment specific settings are correct. Verify these settings optimize equipment performance and efficiencies.
4. Perform, approve and document all start-up services as outlined within the specifications for each piece of equipment, component and accessory. Perform all standard manufacturer services as outlined on manufacturer supplied forms. Additionally, perform all other requirements specifically called for within the project specifications, not otherwise performed in a manufacturer standard startup service. Provide additional documentation for these services on forms with manufacturer's letterhead.
5. Demonstrate performance of equipment as required within Functional Performance Tests.

1.6 DOCUMENTATION

A. The Commissioning Agent shall oversee and maintain the development of Commissioning Documentation. The Commissioning Documentation shall be kept in three ring binders, and organized by system and sub-system when practical. All pages shall be numbered, and a table of contents page(s) shall be provided. The Commissioning Documentation shall include the following which is to be maintained by the Contractor(s):
1. Start-Up and Check-Out Documentation: Organized and arranged with its associated Pre-Functional Checklist.
2. System and Component tests (i.e. Weld Test Reports, Cleaning & Flushing Reports, etc.): Organized and arranged with its associated Pre-Functional Checklist.
3. Pre-Functional Checklist: Organized and arranged as per provided by the Commissioning Agent. Typically these forms are organized by System and Sub-System and according to the order of standard specifications as outlined by American Institute of Architects (AIA.)
4. Test, Adjustment and Balance Report: The approved Final Report shall be provided to the Commissioning Agent for inclusion into the Final Commissioning Report.
5. Functional Performance Tests: All tests performed by the installing contractors for internal checkout and for witness by the Commissioning Agent shall be kept by the Contractor(s), organized and arranged by System and Sub-System, and turned over to the Commissioning Agent for inclusion into the Final Commissioning Report.
6. Project Training Record: The Training Record shall be provided with a Table of Contents followed by the updated Training Schedule and finally followed by each Training Session Agenda and Record. The Training Session Agenda and Record shall be organized by System and Sub-System.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The appropriate Contractor(s) shall furnish all special tools and equipment required during the commissioning process. A list of all tools and equipment to be used during commissioning shall be submitted to the Commissioning Agent for approval. The owner shall furnish necessary utilities for the commissioning process. Additional test equipment requirements are found in Specification 01 91 13 Section 2.8 – Test Equipment.

2.2 TEST EQUIPMENT - PROPRIETARY

A. 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.

PART 3 - EXECUTION

3.1 GENERAL

A. A pre-construction meeting of all Commissioning Team members shall be held at a time and place designated by the General Contractor. The purpose shall be to familiarize all parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.

B. A Final Commissioning Plan shall be developed by the Commissioning Agent. The Plumbing Contractor(s) shall assist the Commissioning Agent in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation in a timely manner. If contractor initiated system changes have been made that alter the commissioning process, the Commissioning Agent shall notify the Owner.

C. The Commissioning Process shall follow the schedule and procedures set forth within the Final Commissioning Plan.

D. The Plumbing Contractor(s) shall complete all phases of work so the systems can be started, tested, balanced, and acceptance procedures undertaken. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, and change orders.

E. The Plumbing Contractor(s) shall coordinate all Commissioning Activities into the project as required herein and as outlined within the Commissioning Plan. The Plumbing Contractor(s) shall complete all required Commissioning and Construction Activities correctly and on schedule.

3.2 PARTICIPATION IN ACCEPTANCE PROCEDURES

A. The Plumbing Contractor(s) shall provide skilled technicians to start-up and debug all systems within Division 22. These same technicians shall be made available to assist the Commissioning Agent in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the Commissioning Agent and coordinated by the Plumbing Contractor(s). Plumbing Contractor(s) shall ensure that the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. System performance problems and discrepancies may require additional technician time, Commissioning Agent time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods, at no cost to the owner, until the required system performance is obtained.

C. The Commissioning Agent reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and willingness to work with the Commissioning Agent. The Plumbing Contractor(s) shall provide adequate documentation and tools to start-up and test the equipment, system, and/or sub-system.

3.3 DEFICIENCY RESOLUTION

A. In some systems, miss-adjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the Owner, with input from the contractor and equipment supplier. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the Owner and/or Architect shall have final jurisdiction over any additional work done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Any and all schedule items affected by this work shall be reflected on the Commissioning and Overall Project Schedules.

3.4 ADDITIONAL COMMISSIONING

A. The Plumbing Contractor, and associated sub-contractors, shall be responsible for any additional commissioning required as a result of failure of a pre-functional or a functional test. Incomplete or incorrect Pre-Functional Checklists reviewed by the Commissioning Agent shall require an additional inspection to verify the re-completed PFC is complete and accurate. Functional Performance Tests witnessed by the Commissioning Agent which fail, shall require retesting, again witnessed by the Commissioning Agent. These documents must be re-checked or re-witnessed in order for the system to be approved and accepted by the Commissioning Agent.

B. The Commissioning Agent will invoice the Owner for additional time required to witness any retesting due to failed PFC’s or FPT’s, plus expenses, and the Owner at his discretion will deduct this cost from the Construction Manager or General Contractor’s Application for Payment. The Construction Manager or General Contractor may then back charge the party responsible for the test’s failure. It is the Plumbing Contractor’s responsibility to properly de-bug systems and verify successful system performance prior to inviting the Commissioning Agent to witness the test.

3.5 SEASONAL COMMISSIONING

A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning shall be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. Heating equipment shall be tested during winter design extremes. Cooling equipment shall be tested during summer design extremes with a fully occupied building. Each contractor and supplier shall be responsible to participate in the initial and the alternate peak season tests of the systems as required to demonstrate performance.

3.6 PRE-FUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTS

A. The Commissioning Agent shall be responsible for preparing the Pre-Functional Checklist. The Plumbing Contractor(s) shall be responsible for completing their applicable sections. Detailed descriptions of Pre-Functional Checklists are outlined in Section 01 91 13-2.4.

B. The Commissioning Agent shall be responsible for preparing the Functional Performance Tests. The Commissioning Agent and Contractor (s) shall schedule the tests and assemble the commissioning team members who shall be responsible for the tests. Participating contractors, manufacturers, suppliers, etc. shall include all costs to do the work involved in these tests in their proposals. Detailed descriptions of Functional Performance Tests are outlined in Section 01 91 13-2.6.

C. Following is a list of tasks and supporting information that shall be required:
   1. Plumbing Contractor(s) - provide the services of a technician(s) who is (are) familiar with the construction and operation of this system. Provide access to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.
   2. Controls Contractor - provide the services of a controls engineer who is familiar with the details of the project. Provide details of the control system, schematics, and a narrative description of control sequences of operation.
   3. Electrical contractor - provide a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with alarm and life-safety systems. Provide access to the contract plans, and all as-built schematics of sub-systems, interfaces, and interlocks.

D. Documentation and Reporting Requirements
   1. Any contractors with responsibilities related to the equipment to be installed, i.e. plumbing, electrical, TAB, controls, Construction Manager or General Contractor, shall be responsible for completing their related portion of the Pre-Functional Checklist and Functional Performance Test forms and shall sign off on its completion.

E. The Commissioning Agent shall direct and witness the field verification of the Final TAB report. The TAB Contractor shall perform measurements as directed by the Commissioning Agent.
   1. The Commissioning Agent shall select report data for verification at random.
   2. The TAB contractor shall be given sufficient advance notice of the date of field verification. However, they shall not be informed in advance of the data points to be verified. The TAB contractor must use the same instruments (by model and serial number) that were used when the original data were collected.
   3. Failure of an item is defined as:
      a. For all readings other than sound, a deviation of more than 10 percent.
      b. For sound pressure readings, a deviation of 3 decibels. (Note: variations in background noise must be considered).
   4. A failure of more than 10 percent of the selected items shall result in the rejection of the TAB report.

F. If deficiencies are identified during verification, the construction manager must be notified, and action taken to remedy the deficiency. The final tabulated checklist data sheets shall be reviewed by the Design Professional and the Commissioning Agent, to determine if verification is complete, and the operating system is functioning in accordance with the contract documents.

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SECTION 22 10 16
PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Plumbing Piping, as indicated, in accordance with provisions of Contract Documents.

B. Systems and Products Included:
   1. Systems:
      a. Cold, hot, and circulating domestic water piping systems within building and to 5 FT outside building wall.
      b. Drainage piping systems:
         1) Soil, waste, vent, indirect, and storm piping within building and to 5 FT outside building wall.
      c. Pressure drainage piping.
      d. Exposed piping in finished areas.
   2. Products:
      a. Backflow protection devices.
      b. Cleanouts.
      c. Drains:
         1) Air gap fittings.
         2) Area drains.
         3) Downspout nozzles.
         4) Floor drains.
         5) Floor sinks.
         6) Precast trench drain system.
         7) Roof drains.
      d. Traps.
      e. Valves:
         1) Automatic trap primer valves.
         2) Backwater valves.
         3) Balancing valves, constant flow control.
         4) Check valves.
         5) Manual valves, potable water.
      f. Waste holding tank.
      g. Water hammer arresters.
      h. Water meters.

C. Definitions:
   1. Caulked: Tamped lead and oakum joint.
   2. Drainage piping: Soil, waste, vent, acid waste, acid vent, indirect, and storm piping.
   3. Brazing: High temperature soldering.
   4. Pressure drainage piping: Branch piping from discharge of sump pump or sewage ejector to connection with gravity drainage piping.

D. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Outside Utilities: See Section 20 10 10.

B. Pipe and fittings standards: See Section 20 11 00.

C. Fire Protection Systems: See Section 21 10 00.

D. Valve standards: See Section 20 05 23 (for valves labeled "V-__").

E. American Water Works Association Standard AWWA C601: Sterilization Standard.

F. Plumbing and Drainage Institute Standard WH201: Water hammer arrester standard.

G. Plumbing and Drainage Institute Standard G10: Grease interceptor standard..

H. American Society for Sanitary Engineering Standard ASSE 1001: Pipe Applied Atmospheric Type Vacuum Breakers.

I. American Society for Sanitary Engineering Standard ASSE 1013: Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers.

J. Standard: American Society for Sanitary Engineering Standard ASSE 1020: Pressure Vacuum Breaker Assembly.

K. Comply with NSF 61 for potable domestic water piping and components that come in contact with potable water.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Piping layout drawings at 1/4 IN/FT scale.
   2. Waste holding tank assembly:
      a. Tank fabrication drawings.

B. Product Data:
   1. Include sufficient information to verify compliance with specifications:
      a. Backflow protection devices.
      b. Drains.
      c. Valves.
      d. Temperature maintenance cable.
      e. Water hammer arresters.
      f. Water meters.

C. Contract Closeout Information:
   1. Pressure test reports.
   2. Disinfection test report.
   3. Operation and Maintenance Data.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Reduced Pressure Principle Backflow Protection Device:
   1. Base:
      a. Cla-Val.
   2. Optional:
      a. Watts Regulator.
      b. Febco.
      c. Hersey Measurement.
      d. Wilkins Regulator.

B. Vacuum Breakers Backflow Protection Devices:
   1. Base:
      a. Watts Regulator.
   2. Optional:
      a. Febco.
      b. Wilkins Regulator.

C. Cleanouts and Drains:
   1. Base:
      a. Wade Division/Tyler Pipe.
   2. Optional:
      a. Watts Drainage - Ancon.
      b. Josam Company.
      c. JONESPEC Plumbing Products.
      d. Jay R. Smith Manufacturing Co.
      e. Zurn Industries, Inc.
      f. Mifab.

D. Precast Trench Drain Systems:
   1. Base:
      a. ACO Polymer Products.
   2. Optional:
      a. Polydrain.
      b. Industrial Division, Quazite.
      c. Wade.

E. Automatic Trap Primer Valves:
   1. Base:
      a. Precision Plumbing Products.
   2. Optional:
      a. Jay R. Smith Manufacturing Co.
      b. Wade Division/Tyler Pipe.

F. Backwater Valves:
   1. Base:
      a. Josam Company.
   2. Optional:
      a. Jay R. Smith Manufacturing Co.
      b. Watts Drainage-Ancon, Inc.

G. Constant Flow Control Balancing Valves:
   1. Base:
      a. Griswold Controls COMBO.
   2. Optional:
      a. Flow Design Inc. - Autoflow.
      b. Preso.

H. Water Hammer Arresters:
   1. Base:
      a. Wade Division/Tyler Pipe.
   2. Optional:
      a. Jay R. Smith Manufacturing Co.
      b. Josam Company.
      c. Zurn Industries, Inc.

I. Water Meters:
   1. Base:
      a. Hersey Measurement.
   2. Optional:
      a. Badger Meter.
      b. Sensus Technologies.

2.2 PIPE AND FITTINGS

A. Domestic Water Piping:
   1. Domestic water piping at service entrance from 1 FT inside building to 5 FT outside: Same as indicated for outside utilities.
   2. 2 IN and smaller after service entrance:
      a. Above grade:
         1) Copper, type L, with solder joints, and wrought copper or cast brass fittings.
         2) Optional fitting:
            a) Ring Seal Crimp fitting system: With approval of local authority having jurisdiction.
      b. Below grade:
         1) Copper, type K soft, with brazed joints and wrought copper or cast brass fittings.
         2) Where below grade run of piping is shorter than 50 FT, below-grade joints are not acceptable.
   3. 2-1/2 IN and larger after service entrance:
      a. Non-softened cold water:
         1) Schedule 10 stainless steel pipe and joints, ASTM 312, A 778 or B36.19 as allowed by code.
         2) Copper, type L, with soldered joints and wrought copper or cast brass fittings.
         3) Copper, type L, with roll groove joints and wrought copper or cast brass fittings.
      b. Hot water and soft water:
         1) Schedule 10 stainless steel pipe and joints, ASTM 312, A 778 or B36.19 as allowed by code.
         2) Copper, type L, with solder joints and wrought copper or cast brass fittings.

B. Drainage piping (soil, waste, vent, indirect, and storm):
   1. Above grade:
      a. Sch 40 PVC, hubbed pipe and fittings with glued joints, as allowed by code.
      b. Cast iron, hubless pipe, fittings, and elastomeric sealing sleeves with stainless steel or cast iron clamps, as allowed by code.
      c. Copper (type DWV or heavier), with soldered joints and wrought copper or cast brass drainage and vent fittings, as allowed by code.
         1) Piping within MRI shielding shall be copper.
   2. Below grade:
      a. 2 IN diameter or larger.
      b. Cast iron, hubbed pipe and fittings with lead and oakum or elastomeric push joints, as allowed by code.
      c. Sch 40 PVC, pipe, fittings, and elastomeric sealing sleeves with stainless steel or cast iron clamps, as allowed by code.

C. Pressure drainage piping:
   1. Cast iron pressure pipe and fittings, with mechanical joints.

D. Exposed piping in finished areas:
   1. Chrome or nickel plated brass to wall or floor.
   2. Piping 2 IN and larger may be provided with chrome or nickel plated brass sleeves to cover pipe and fittings.
      a. See Section 20 05 00.

E. Trap primer pipe between primer device and drain:
   1. Above grade: Copper, type L, with solder joints, and wrought copper or cast brass fittings.
   2. Below grade: Copper, type K soft, with solder joints, and wrought copper or cast brass fittings.

2.3 BACKFLOW PROTECTION DEVICES

A. Backflow protection devices, general:
   1. Approved by local Public Utilities Bureau and the state Environmental Protection Agency.

B. Reduced Pressure Principle Backflow Preventer (BFP):
   1. Two check valves, test cocks, pressure differential relief valve, isolation valves and accessories assembled as an integral unit, horizontally mounted. Tested and certified in conformance with ASSE Standard No. 1013.
   2. Threaded ends: 2 IN and smaller.
   3. Flanged ends: 2-1/2 IN and larger.
   4. Provide 3/4 IN drain line from relief to floor drain, floor sink, mop sink, or service sink.
   5. Isolation valves:
      a. 2 IN and smaller: Ball valve.
      b. 2-1/2 IN and larger:
      c. Provide No. 1 test cock on inlet valve.
   6. Size BFP's to have a pressure loss less than 14 PSI at flows indicated below (refer to plans for pipe sizes):
      a. 1/2 IN pipe: 2.2 GPM.
      b. 3/4 IN pipe: 6 GPM.
      c. 1 IN pipe: 13 GPM.
      d. 1-1/4 IN pipe: 22 GPM.
      e. 1-1/2 IN pipe: 35 GPM.
      f. 2 IN pipe: 75 GPM.
      g. 2-1/2 IN pipe: 125 GPM.
      h. 3 IN pipe: 170 GPM.
      i. 4 IN pipe: 315 GPM.

C. Pressure type vacuum breakers (PTVB):
   1. Designed to protect against back siphonage in continuous pressure piping systems. Tested and certified in conformance with ASSE Standard No. 1020.
   2. Bronze body and lightweight internal floats designed to eliminate spillage.
   3. Provide isolation ball valve on inlet and outlet of PTVB.
   4. Provide outlet connection on VB compatible with equipment/fixture being served.
   5. Mount bottom of VB at least 12 IN above the flood level rim of the equipment/fixture being served.
   6. Provide test cocks.
   7. Match VB size to pipe size indicated on plans.

D. Atmospheric vacuum breakers (VB):
   1. Bronze body and lightweight internal float designed to eliminate spillage. Tested and certified in conformance with ASSE Standard No. 1001.
   2. Provide isolation valve immediately upstream of VB.
   3. Provide outlet connection on VB compatible with equipment/fixture being served.
   4. Mount bottom of VB at least 6 IN above the flood level rim of the equipment/fixture being served.
   5. Match VB size to pipe size indicated on plans.

2.4 CLEANOUTS

A. Cleanouts, general:
   1. Provide flashing collars and clamps for CO bodies being installed in floors with finishes installed over waterproofing.
      a. Coordinate with Division 09 and Room Finish installers.
   2. Dimensions are nominal.
   3. Body material (unless indicated otherwise): Coated cast iron.
   4. Cleanout plugs:
      a. Extra heavy, threaded, tapered, brass plug with solid hexagonal nut.

b. Comply with Plumbing Code.
c. Provide with American Standard pipe threads.
5. Cleanouts on lines completely accessible from within pipe chases do not require covers.
6. Cleanouts in exposed piping in equipment rooms do not require special covers.

B. Interior Floor Mounted Cleanouts:
1. Extra heavy, flanged, cast iron ferrule, tapped for cleanout plug with spigot or inside caulk outlet.

C. Example:
1. Two piece, threaded, adjustable housing.
a. ANSI load class: Light duty, unless noted otherwise.
b. Example: Wade 6000.
2. Top and cover as specified below by floor finish.
a. Resilient tile and sheet finish: Round flange top with scoriated cover.
b. Ceramic tile finish: Square flange top with scoriated cover.
c. Poured finish: Round, wide flange top with scoriated cover.
d. Carpet finish: Round top with standard top tapped for carpet marker bolt.
e. Terrazzo finish: Round top with recessed for terrazzo cover.
f. Quarry tile finish: Square, heavy duty top with heavy duty scoriated cover.
g. Concrete finish in unfinished areas:
1) Heavy, round frame; satin bronze, scoriated tractor top.
2) ANSI load class: Heavy duty.
3) Example: Wade 6000Z.

D. Cleanouts in vertical piping:
1. Tapped cleanout tee.
2. Extra heavy, threaded, brass plug with solid hexagonal nut.

E. Cleanouts in hubs of combination wye and eighth bends or wyes.
1. Tapped spigot.
2. Extra heavy, threaded, brass plug with solid hexagonal nut.

F. Cleanouts at ends of hubless combination wye and 1/8th bends or wyes.
1. Blind plug.

G. Covers over cleanouts in concealed vertical piping:
1. Square, nickel bronze frame with secured, smooth, stainless steel access cover.
2. 6 x 6 IN for pipe sizes 4 IN and less.
3. 9 x 9 for pipe sizes 5 IN and larger.
4. Example: Wade W-8480-S.

H. Exterior cleanouts: See section 20 10 00.

2.5 DRAINS

A. Drains - General:
1. Provide flashing clamps with seepage openings for drain bodies with flashing collars being installed in floors with finishes installed over waterproofing.
a. Coordinate with Division 09 and Room Finish installers.
2. Provide underdeck clamps for drain bodies except those installed in slabs on grade.

B. Air Gap Fittings:
1. Inlet: Female IPS or collar with set screw.
2. Outlet: Spigot or IPS.
3. Material: Cast iron or bronze.
4. Minimum air gap area: 2 times inlet area.
5. Examples: Jay R. Smith 3950 series.

C. Downspout Nozzles:
   1. DSN-1:
      a. Cast bronze nozzle with rough bronze finish and flange for securing nozzle to wall.
      b. Example: Jay R. Smith 1770.

D. Floor drains:
   1. General:
      a. Dimensions are nominal.
      b. Provide trap primer taps where trap primer valves are required: See paragraph on trap primer valves.
      c. Material (unless indicated otherwise): Coated cast iron.
   2. FD-1:
      a. 12 IN diameter flashing collar.
      b. Adjustable top.
      c. 8 IN diameter, removable, non-tilt tractor grate.
      d. Cast iron strainer.
      e. Example: Wade 1340TD.
   3. FD-2:
      a. 10 IN diameter flashing collar.
      b. Reversible flashing clamp with seepage openings and tapped opening for strainer body.
      c. Threaded strainer body.
      d. 6 IN diameter, secured, satin nickel bronze, removable strainer.
      e. Example: Wade 1100A.
   4. FD-3:
      a. 10 IN diameter flashing collar.
      b. Reversible flashing clamp with seepage openings and tapped opening for strainer body.
      c. Threaded strainer body.
      d. 6 IN square, secured, satin nickel bronze, removable strainer.
      e. Example: Wade 1100G.

E. Floor sinks:
   1. General:
      a. Dimensions are nominal.
      b. Provide trap primer taps where trap primer valves are required: See paragraph on trap primer valves.
      c. Material, unless indicated otherwise) Coated cast iron.
      d. Provide flashing collars.
   2. FS-1:
      a. 12 x 12 x 8 IN floor sink.
      b. Acid resistant enameled interior.
      c. Aluminum dome strainer.
      d. Full size, anti-tilt, 11 IN square, satin nickel bronze, removable grate.
      e. Example: Wade 9140.
   3. FS-2:
      a. Dimensions: 12 x 12 x 6 IN floor sink with square top.
      b. Material of construction: 304 stainless steel.
      c. Stainless-steel sediment basket, same grade as body.
      d. Grate:
         1) Removable, full size, anti-tilt type.
         2) Material of construction: stainless steel, same grade as body.
         3) Size: 10 IN square.
      e. Example: Jay R. Smith 9692.

F. Precast trench drain system:
   1. TD-1: Modular, precast, pre-sloped, trench drain system with catch basins, channels, gratings, and accessories.
      a. Catch basin.

1) Integral precast polymer concrete.
2) Galvanized steel trash buckets.
3) Knockouts for pipe connections to channels.

b. Channels.
   1) Provide channels in number required to equal scaled representation on plans.
   2) Precast polymer concrete.
   3) Top width: 6 IN.
   4) Radiused bottom inverts with 0.6 PCT slope.
   5) Interlocking tongue and groove butt joint connection and 4 horizontal anchoring ribs to key with enclosing materials.
   6) 4 and 6 IN knockouts for vertical and horizontal discharges.
c. Gratings:
   1) ANSI load class:
      a) Heavy.
   2) Material:
      a) Ductile iron.
   3) Style:
      a) Slotted.
d. Required accessories:
   1) Sidewall extensions: Precast polymer concrete to interlock into channels.
   2) Installation chairs: Fixed channel system support to hold units in place during placement of encasing materials.
   3) Sealant: As recommended by manufacturer to seal joints between accessories and units.
   4) Grating locking devices: Manufacturer's standard units.
   5) Outlets and end plates: Manufacturer's standard units to interlock into channels with PVC connectors and closed end plates.

G. Roof drains:
   1. General:
      a. Dimensions are nominal.
      b. Material (unless indicated otherwise): Coated cast iron.
      c. Provide deck clamps.
      d. Provide bearing pan/sump receiver where occuring at steel decks.
   2. RD-1:
      a. Flashing collar diameter: 16 to 19 IN.
      b. Flashing clamp with gravel stop.
      c. Mushroom dome: coated cast iron.
      d. Mushroom dome height: 5 IN.
      e. Mushroom dome diameter: 11 to 14 IN.
      f. Provide bearing pan/sump receiver.
      g. Provide solid or adjustable extension to allow for insulation thickness between concrete deck and waterproof membrane.
         1) Coordinate extension height with roof insulator.
      h. Example: Wade 3000.
   3. RD-2 (overflow drain):
      a. Flashing collar diameter: 16 to 19 IN.
      b. Flashing clamp with integral 2 IN tall water dam.
      c. Mushroom dome and dam: coated cast iron.
      d. Mushroom dome height: 5 IN.
      e. Mushroom dome diameter: 11 to 14 IN.
      f. Provide bearing pan/sump receiver.
      g. Provide adjustable extension to allow for insulation thickness.
         1) Coordinate extension height with roof insulator.
      h. Example: Wade 3000D.

2.6 FLASHINGS

A. On floors above grade, allow for flashings provided by others at penetrations in floors with finishes installed over waterproofing.
   1. Coordinate with Division 09 and Room Finish installers.

2.7 HOLDING TANKS

A. DT-1:
   1. Conventional virgin high density polyethylene, ASTM D1248, one piece seamless construction with uniform 3/16 to 3/8 IN wall thickness, and welded external flanges.
   2. Capacity: 500 Gal.
   3. Fittings: Molded polyethylene, heat fused or welded to tank.
   4. Provide cover and extension neck for tanks recessed in floors of same materials as tank, bolted to external flange.

2.8 TRAPS

A. Traps, general:
   1. Cast brass or cast iron, one piece pattern, 3 IN minimum seal.
   2. Same material, coating, and finish as piping system into which they are installed except traps 2 IN NPS and under, not buried in earth, shall be cast brass with union and cleanout.
   3. Place trap cleanouts in accessible locations.

B. Provide deep seal traps for drain bodies in ventilation housings: Traps need to maintain seal against static pressure in fan housing.

C. Traps for drains with buried outlet: Cast iron P-traps, unless otherwise indicated.

2.9 VALVES

A. Automatic trap primer valves.
   1. General:
      a. Rebuildable.
      b. Integral vacuum breaker on drain branch.
      c. Connections: Soldered or threaded.
      d. Provide trap primers as indicated on plans.
   2. Automatic trap primer valve:
      a. Serves single drain.
      b. 1/2 IN bronze.
      c. Designed to be installed in the supply line to an individual fixture with branch extended to drain.
      d. Examples: Wade 2400, Smith 2699.

B. Balancing valves, constant flow control:
   1. Factory calibrated, direct acting, automatic pressure compensating.
   2. Control flow rates within 5 PCT of flow rating over operating pressure differential range.
      a. Set flow rating according to pipe sizes indicated on plans:
         1) 1/2 IN: 1.0 GPM.
         2) 3/4 IN: 2.5 GPM.
         3) 1 IN: 6 GPM.
         4) 1-1/4 IN: 9 GPM.
   3. Pressure differential range:
      a. 4-57 PSID.
   4. Threaded brass or copper sweat body with stainless steel internal parts.
   5. Provide a metal identification tag with chain for each installed valve.
      a. Identify zone or location, valve model number, flow rate, direction of flow, and differential pressure range.
   6. Provide with integral unions to allow field exchange of internal components without removing valve body from pipeline.

7. Provide manual valve upstream and downstream of each valve.

C. Check Valves:
   1. 2 IN and smaller: V-24 or V-25.
   2. 2-1/2 IN and larger: V-28 or V-29.

D. Manual Valves, Potable Water:
   1. 2 IN and less: V-13 or V-14.
   2. 2-1/2 to 4 IN:
   3. 6 IN and larger:
      a. V-34 or V-35 or V-62.
      b. Totally enclosed gear operator and wheel handle.
      c. At equipment and at service entrance:
         1) Use lug type valves, V-33.
         2) Use groove end type valves, V-62.
   4. Balancing cocks:
      a. Constant flow control balancing valves.

E. Manual Valves, Waste Water:
   1. Drainage piping shut off: V-37.
   2. Pressure drainage piping:
      a. Shut off: V-2.
      b. Check: V-28.

2.10 WATER HAMMER ARRESTERS

A. Engineered, and certified in accordance with Plumbing and Drainage Institute (PDI) Standard WH-201.

B. Type and construction:
   1. Bellows type and constructed entirely of stainless steel.
   2. Piston type is not acceptable.

C. Water hammer arrestors shall be bellows type and constructed entirely of stainless steel.

2.11 WATER METERS

A. Use threaded fittings on meters 2 IN and less in size.

B. Use flanged connections on meters 2-1/2 IN and larger.

C. Provide valve on each side of meter.

D. Public utility water meter:
   1. Provide type and size approved by local utility.
   2. Provide full size bypass line around meter with a sealed valve.
   3. Provide capped tee immediately downstream of meter.
      a. Verify size with local utility.

E. Private water meters:
   1. Provide vertical shaft turbine meters on make up water lines to HVAC equipment.
   2. Match size to pipe size indicated on drawings.

PART 3 - EXECUTION

3.1 GENERAL

A. General:
   1. Install piping as indicated and to provide fixtures and items of equipment with proper drainage, vent, and water connections as required by governing codes.
   2. Hold piping as close to structure as possible to maintain maximum head room.

3. Run piping concealed wherever possible.
4. Under no circumstances reduce pipe size indicated without written consent of Architect.
5. Size branches to individual fixtures as scheduled.
6. Consult the following before roughing in piping:
    a. Manufacturer's data.
    b. Large scale Architectural, and Mechanical Drawings of rooms containing equipment and plumbing fixtures.
7. Stub piping through wall directly behind item being served (e.g., equipment, plumbing fixtures, vending machines).
    a. Cap and protect until such time as installation is performed.
    b. Exception: Upon approval of Architect, piping mains and/or branches may be run in lab benches, in built in counters, and in cabinet work.
8. Plug or cap piping immediately after installation.
9. Install chromed escutcheons on finished area sides of pipe penetrations.
    a. Secure escutcheons so they make contact with floor, wall, or ceiling.
10. Install equipment in accordance with manufacturer's instructions.
11. Connect equipment furnished by Owner or other divisions in accordance with Section 20 05 00.
12. Install piping supports, sleeves, and seals as indicated in Section 20 05 29.

3.2 DOMESTIC WATER PIPING SYSTEMS

A. General:
    1. Install plumbing without cross or inter connections between potable and non-potable lines.
    2. Provide unvalved system drains on trapped portions of systems: See Section 20 05 19.
    3. Provide thermometers and pressure gauges where indicated on drawings: See Section 20 05 19.

B. Service entrance installation through exterior wall: See Section 20 05 29 (water stop pipe sleeves).

C. Backflow Protection Devices.
    1. Provide at following locations:
        a. At fixtures and equipment as indicated and required by Code.
        b. Were specified in Section 22 42 00: Plumbing Fixtures.
    2. Pipe drain from reduced pressure principle backflow preventers to drain or mop sink.
    3. Install vacuum breakers over mop sink or over drain in unfinished area.

D. Balance Hot Water Circulation System.

E. Provide manual isolation valves at following locations.
    1. To isolate groups of fixtures and equipment on branch runouts from piping mains.
    2. On each branch serving a rest room.
    3. On inlet and outlet of each equipment.
    4. On each branch to hose bib or wall hydrant.
    5. At main feed points to domestic water pipe risers.
    6. As indicated and as required to adequately service parts of systems and equipment.

F. Wire isolation valves on emergency showers open and tag "Do Not Close".

G. Provide water hammer arresters on hot and cold water lines in accordance with PDI Standard WH-201 sizing and placement data; the Contractor shall be responsible for sizing of water hammer arrestors in accordance with this standard.

H. Testing of Domestic Water System:
    1. Upon completion of system or a section of system, test piping hydrostatically to pressure not less than 50 PCT in excess of pipe's working pressure, but in no case less than 150 PSI.
        a. System shall hold pressure for 24 HRS.
    2. Repair leaks or replace defective pipe disclosed by tests.
    3. Repeat tests until piping indicates tight.

I. Sterilization of Domestic Water System:
   1. Sterilize system as indicated or in accordance with AWWA C652 or CS186.
   2. Thoroughly flush potable water systems.
   3. After flushing, introduce chlorine or chlorine compound into system with dosage sufficient to give an initial residual chlorine content of 50 PPM.
   4. Collect samples from various taps and fixtures throughout buildings during introduction of chlorine to assure uniform distribution.
   5. Open and close valves several times.
   6. After a 24 HR contact period, flush traces of heavily chlorinated water from systems.
   7. After flushing is complete, indicate effectiveness of disinfection by submitting laboratory reports of bacteriological tests on samples taken from system.
   8. If unsatisfactory results are obtained, repeat disinfection process until satisfactory.
   9. Do not put system into service until tests are approved by Plumbing Inspector.

3.3 DRAINAGE PIPING SYSTEMS

A. General:
   1. Changes of direction and junctions: Make with wye fittings and eighth bends.
      a. Use sanitary tee fittings in vertical pipe only.
         1) Sanitary crosses not allowed.
   2. Provide P-trap for each direct waste pipe connection to equipment.
   3. Trap fixtures as required by governing code.
   4. For ice makers, provide either of the indirect drain options listed below:
      a. Floor sink.
      b. Dedicated, under counter P-trap.
   5. Provide air gaps at indirect drains.

B. Slopes:
   1. Install horizontal soil, waste, and storm lines with following slopes:
      a. 3 IN and smaller pipes:
         1) 1/4 IN/FT.
      b. 4 IN and larger pipes:
         1) 1/8 IN/FT.
      c. Slopes indicated on plans override those indicated here.

C. Vents:
   1. Run vent stacks parallel to soil and waste stacks to receive branch vents from fixtures.
      a. Each vent stack shall originate from a soil or waste stack at its base.
   2. To permit proper flashing, offset through the roof piping away from walls on roof before passing through roof.
   3. Carry vent stacks 4 IN and larger full size through roof.
   4. Install vent lines so they will drain and not trap water.
   5. Where possible combine soil, waste or vent stacks before passing through roof to minimize roof openings.
   6. Where minimum vent through roof size is larger than vent size, provide increaser minimum of 12 IN below roof line.
      a. Minimum vent through roof size:
         1) 4 IN.
   7. Extend vent stacks at least 12 IN above roofing.

D. Acid resistant waste and vent piping:
   1. Install piping system free of stresses and in accordance with manufacturer's recommendations.
   2. Provide accessories as indicated or required for complete connections.
   3. For glass piping at rated (fire or fire/smoke) horizontal penetrations, install coupling within 2 FT of each side of sleeve assembly.
   4. Extend acid resistant piping separately to neutralization tank.

5. Laboratory sinks furnished by other divisions:
   a. See fixture S-1 IN Section 22 42 00.
   b. Make final connections.

E. Provide cleanouts on drainage piping as indicated below and on plans.
   1. Locations:
      a. At dead ends.
      b. At changes of direction greater than 45 DEG.
      c. At junction of building drain and building sewer.
      d. 36 IN to 48 IN above finished floor in vertical piping that connects to horizontal soil, waste, or storm piping immediately below in ceiling space or under grade.
      e. As test tee to receive test plugs in each riser at least every other floor.
      f. At maximum 50 FT intervals in horizontal 4 IN and smaller drains.
      g. At maximum 100 FT intervals in horizontal, 5 IN and larger drains.
   2. Sizes:
      a. 4 IN diameter and smaller piping: Match pipe size.
      b. 5 IN diameter and larger piping: Not less than 4 IN.
   3. Where cleanouts occur in concealed spaces, provide with extensions to wall or to floor above.
      a. Make extensions using long sweep ells or wye and eighth bends.
   4. Where cleanouts are indicated in ceiling spaces above critical areas, extend cleanouts through floor above.
   5. Install carpet marker bolts after carpet installation.

F. Install piping and drains to allow for flashings provided under Roofing System section.
   1. Coordinate with Roofing installer.

G. Precast Trench Drain System:
   1. Install trench drains and accessories in accordance with manufacturer's instructions.
   2. Set trench drain units to line and level, and rigidly support each unit with chairs.
   3. Connect drain outlets to drain piping.
   4. Clean channels and catch basins prior to final placement of gratings or covers.
   5. Excavate trenches and prepare subgrade material.
      a. Structural integrity and thickness of bedding material around trench channels:
         1) Equivalent to adjacent slab or pavement.
   6. Roughen abutting surfaces of channel units and accessories by sanding or lightly wire brushing in preparation for sealing.
      a. Seal abutting surfaces.
   7. Monitor placement of concrete.
      a. Assure drain units are maintained in place and extraneous material does not enter units.

H. Drains in Plenums:
   1. Indirectly waste plenum drains to receptor outside of plenum.

I. Decontamination Tanks, below grade:
   1. Install in concrete vault as required.

J. Backwater Valves:
   1. Install valves in 30 IN diameter RCP basin.
   2. Provide light duty frame and solid cover with lift hole.
      a. Set cover at grade level.
      b. Neenah R-6450 or optional manufacturer.
   3. Set RCP on 6 IN thick, WWF reinforced, 42 IN diameter concrete pad with 12 IN diameter center hole.
   4. Set pad on 12 IN of granular fill.
   5. Set valve bottom 4 IN above top of concrete pad.

K. Drip Pans:
   1. Provide under drainage piping that runs over critical areas.
   2. Critical areas include the following:
      a. Electronic data processing areas.
   3. Provide drain piping from pans. Spill drain piping to drain in exposed area.

L. Testing of Drainage Piping Systems:
   1. Do not insulate, conceal, or install furring around pipe until it has been tested to satisfaction of Owner and Plumbing Inspector.
      a. If inspection or test indicates defects, replace such defective work or material and repeat inspection and tests.
   2. Test piping at completion of installation of each stack or section of piping.
      a. Fill system with water to highest point and check joints and fittings for leaks.
      b. Eliminate leaks before proceeding with work or concealing piping.
      c. Minimum test height: 10 FT.
      d. Make repairs to piping with new material.
      e. Peening and chiseling of holes or screwed joints is not allowed.

END OF SECTION

SECTION 22 11 13
FACILITY WATER DISTRIBUTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes water-distribution piping and related components outside the building for combined domestic and fire-service main.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, and specialty locations, and elevations.

B. Fire hydrants, appurtenances, valves, piping: Show sizing, material and manufacture specifications.

C. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
   2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
   3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

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

C. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

D. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
   1. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
   1. Ensure that valves are dry and internally protected against rust and corrosion.
   2. Protect valves against damage to threaded ends and flange faces.
   3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.

2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
   1. Notify Architect no fewer than five calendar days in advance of proposed interruption of service.
   2. Do not proceed with interruption of water-distribution service without Architect's written permission.

1.8 COORDINATION

A. Coordinate connection to water main with the Architect.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Water piping and components shall comply with NSF 14, NSF 61, and NSF 372.

2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end.
   1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
   3. Cement Lined and Asphaltic Coated: AWWA C 104 and C 151.

2.3 PIPING SPECIALTIES

A. Dielectric Fittings:
   1. General Requirements: Assembly of ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
   2. Dielectric Flanges:
      a. Description:
         1) Standard: ASSE 1079.
         2) Factory-fabricated, bolted, companion-flange assembly.
         3) Pressure Rating: 300 psig

3. Dielectric-Flange Insulating Kits:
   a. Description:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Pressure Rating: 300 psig.
      3) Gasket: Neoprene or phenolic.
      4) Bolt Sleeves: Phenolic or polyethylene.
      5) Washers: Phenolic with steel backing washers.

2.4 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:
   1. Nonrising-Stem, Resilient-Seated Gate Valves:
      a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.
         1) Standard: AWWA C509.
         2) Minimum Pressure Rating: 200 psig.
         3) End Connections: Mechanical joint.
         4) Interior Coating: Complying with AWWA C550.

2.5 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 IN in diameter.
   1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

B. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.6 FIRE HYDRANTS

A. Dry-Barrel Fire Hydrants:
   1. Description: Freestanding, with one Howard County 4-1/2 nozzle per Howard County Standard W-1.14 and two NPS 2-1/2 outlets per Howard County W-1.14, 5-1/4 IN main valve, drain valve, and NPS 6 mechanical-joint inlet. Include interior coating according to AWWA C550. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.
      a. Standard: AWWA C502.
      b. Pressure Rating: 250 psig
      c. Outlet Threads: Per Howard County W-1.14.
      d. Operating and Cap Nuts: Pentagon, 1-1/2 IN point to flat.
      e. Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.
      f. Exterior Finish: Red alkyd-gloss enamel paint.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Section 31 20 00 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING SCHEDULE

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

D. Underground Fire-Service-Main Piping NPS 4 to NPS 12 shall be of the following:
   1. Ductile-iron, mechanical-joint pipe and fittings.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

A. See Section 33 05 00 "Common Work Results for Utilities" for piping-system common requirements.

3.4 PIPING INSTALLATION

A. Bury piping with depth of cover over top at least 48 IN.

B. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
   1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

C. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

3.5 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
   1. Locking mechanical joints.
   2. Set-screw mechanical retainer glands, Megalugs.
   3. Bolted flanged joints.
   4. Tie-Rods and Hardware: ¾ inch high strength low allow steel (Corten or Mayari-R) ASTM A 242 and per AWWA C111. Nuts are ANSI B 18.22. Coat rods and hardware with coal tar epoxy, minimum dry file thickness of 16 mils.

B. Install restrained jointings for tees, plugs and caps, bends, crosses, valves, and hydrant branches according to AWWA C600.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.6 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

3.7 FIRE HYDRANT INSTALLATION

A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints, and support in upright position.

B. Wet-Barrel Fire Hydrants: Install with valve below frost line. Provide for drainage.

C. AWWA Fire Hydrants: Comply with AWWA M17.

D. UL/FMG Fire Hydrants: Comply with NFPA 24.

3.8 CONNECTIONS

A. See Section 33 05 00 "Common Work Results for Utilities" for piping connections to valves and equipment.

B. Connect new water-distribution piping to the existing capped-off valves water line.

C. Connect water-distribution piping to the interior combined domestic and fire-suppression piping.

D. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.9 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.
   1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities.

3.10 IDENTIFICATION

A. Install continuous underground warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 31 20 00 "Earth Moving."

3.11 CLEANING

A. Clean and disinfect water-distribution piping as follows:
   1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
   2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
      a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
      b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
      c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION

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SECTION 22 11 23
PLUMBING PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Plumbing Pumps, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
   1. Circulating pumps.
   2. Sump pumps.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Pipe and fittings standards: See Section 20 11 00.

B. Manual-valve and check-valve standards: See Section 20 05 23 (for valves labeled "V-__").

C. Standards:
   1. UL 778: Motor Operated Water Pumps.

1.3 SUBMITTALS

A. Product Data:
   1. Circulating pumps.
      a. Include pump curves with point of operation indicated.
   2. Sump pumps.
      a. Include pump curves with point of operation indicated.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction reports.

1.4 WARRANTY

A. Eighteen (18) months from start up.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Circulating pumps:
   1. Base:
      a. Bell & Gossett, ITT.
   2. Optional:
      a. Armstrong Pumps.
      b. Grundfos.
      c. Taco.
      d. Thrush.
      e. Aurora.

B. Sump Pumps. Submersible, simplex for hydraulic elevators.
   1. Base:
      a. Stancor.
   2. Optional:
      a. Liberty.

2.2 MATERIALS

A. Pumps - General:
   1. Motors: Section 20 05 00.
   2. Motor data: As scheduled.
   3. Pump capacities: As scheduled.
   4. Provide disconnects.
   5. Provide starters for 3-phase motors.
   6. Basins: As detailed.

B. Vibration Isolation:
   1. Provide in accordance with Section 20 05 50.

2.3 CIRCULATING PUMPS

A. Circulating Pumps:
   1. In-line centrifugal.
   2. Pump casing and impeller: Bronze, designed for domestic water circulating.
   3. Fractional-horsepower pumps: Seal-less.

2.4 SUMP PUMPS

A. Submersible, Simplex Sump Pump to serve hydraulic elevator pits.
   1. Provide pump and control systems capable of pumping water while containing oil.
   2. The system shall function automatically and shall provide for an alarm under the below conditions.
      a. The presence of oil in the pump
      b. High liquid in the sump
      c. High amps or a locked rotor condition.
   3. Motor.
      a. Thermal and overload protection.
      b. Capable of operating continuously or intermittently.
      c. Motor Housing: Constructed of #304 stainless steel.
      d. Mechanical seals: Housed in a separate compartment.
   4. Control system:
      a. UL 508 and UL 778 compliant.
      b. Nema 4X enclosure with stainless steel hinged hardware and 8 pin twist lock electrical receptacle.
      c. Dual oil sensing relays with variable sensitivity settings.
      d. Magnetic contactor with separate over current relay.
      e. Self cleaning stainless steel sensor probe,
      f. Dual floats
      g. Clearly marked terminal board and remote monitoring contacts (for “oil present” and “sump high level”).
      h. Provide mating power cable, probe cable, high level alarm cable, junction box and accessories required for connecting pump to control panel.
      i. The control unit, pump, floats and sensor probe shall be factory assembled as a complete, ready to use system and shall be tested and approved by nationally recognized testing laboratory.

B. Basins:
   1. Size: As detailed.
   2. Inlet and outlet sizes: As indicated on drawings.

PART 3 - EXECUTION

A. Install as indicated and in accordance with manufacturer's instructions and recommendations.

B. Sump pumps with gas-tight covers.

C. Extend independent vent through roof.

D. Provide galvanized guide rails for rail-mounted pumps.

E. Furnish piping, isolation valves, check valves, and fittings per manufacturer recommendation.

F. Provide manual isolation valves at following locations:
   1. On inlet and outlet of each circulating pump.
   2. On outlet of each sump pump.
   3. As indicated and as required to adequately service parts of systems and equipment.

G. Provide check valve at outlet of each pump.

H. Valve Requirements:
   1. See Section 22 10 16.

END OF SECTION

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SECTION 22 11 26

PACKAGED DOMESTIC WATER PRESSURE BOOSTER SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Packaged Domestic Water Pressure-Booster System, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
   1. Booster pumps.
      a. Variable speed system.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. Hydraulic Institute.
   2. NEMA - National Electrical Manufacturers Associations.
   3. UL - Underwriters Laboratories.
   4. NEC - National Electric Code.

B. Manufacturer Qualifications:
   1. UL listed as control panel manufacturer.
   2. Written and operational Quality Assurance program.
   3. Minimum ten (10) years experience in manufacturing and application of pumping systems.
   4. Accepting full responsibility for proper pressures and flows in the entire system.

C. Factory Tests:
   1. Hydrostatically test assembled pumping systems to 200 PSIG for a minimum of one hour.
   2. Test control system, and simulate sequences and alarms.
   3. Wire-to-water efficiency test.
      a. Perform test at 25, 50, 75 and 100 PCT of system-design flow.
   4. Prior to shipment, provide written report to Engineer.
      a. Include following for each of above system-design flows:
         1) System total dynamic heads.
         2) KW's.
         3) Wire-to-water efficiencies.
      b. Report certified by a registered professional engineer.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Packaged domestic-water pressure-booster system.
      a. System arrangement and dimension drawings.

B. Product Data:
   1. Packaged domestic-water pressure-booster system.
      a. System design information sheet.
      b. Description of system operation.
      c. Pump material and construction drawing.
      d. Pump curves indicating design points.
      e. Control wiring diagram.
      f. Catalog information on valves, strainers, and control components.

C. Contract Closeout Information:
   1. Operation and Maintenance Data.
      a. System design information sheet.
      b. Description of system operation.
      c. Packaged system dimension and general arrangement drawing.
      d. Electrical power and control wiring diagram.
      e. Bill of material.
      f. Pump operation and maintenance instructions.
      g. Special electrical component operation instructions.
   2. Factory-test reports.

1.4 DELIVERY OF EQUIPMENT

A. Configure system to be deliverable and installable through passages and doorways as indicated on Architectural drawings.
   1. Factory disassemble systems for shipping and field assembly.
   2. Provide assembly instructions.

B. Remove drain plugs from equipment where possibility of freeze damage may exist.

C. Comply with manufacturer's instructions for rigging, unloading, and transporting equipment.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Packaged Domestic Water Pressure-Booster System:
   1. Base:
      a. Systecon.
   2. Optional:
      a. Aurora Pump.
      b. Canariis.
      c. Unosource Control.

B. Pumps:
   1. Base:
      a. Bell & Gossett.
   2. Optional:
      a. Armstrong Pumps.
      b. Aurora Pump.
      c. Goulds Pumps.
      d. Allis-Chalmers, ITT.
      e. PACO Pumps.
      f. Peerless Pump.
      g. Taco.

2.2 MATERIALS

A. Packaged System:
   1. Provide components factory assembled, piped, and wired. Include the following:
      a. Electrical control panel.
      b. Pumps.
      c. Motors: Section 20 05 00.
      d. Piping, fittings, and valves: Section 22 10 16.
      e. Piping specialties: Section 20 05 19.
         1) Pressure gauges.
         2) Unions.
         3) System drains.

f. Mechanical sound, vibration & seismic control: Section 20 05 50.
    1) Vibration base with isolators.
    2) Flexible connectors.
2. Provide one suction and one discharge pipe connection, and one electrical power connection.
3. If package needs to be broken down to allow transportation to installed location, construct it to be broken down modularly.
    a. Modular construction:
        1) Field reconnections must be by unions, flanges, bolts, screws, and electrical plugs.
        2) Reconnection requiring cutting, welding, soldering, multiple connections to screw terminals, is not allowed.
4. Assemble package so ample room exists within the package for servicing of components.

B. Electrical Control Panel:
1. UL listed.
2. NEMA 1 enclosure.
3. Single door interlocked disconnect switch with individual circuit breakers.
4. Hand-off-auto switches for each pump.
5. Control circuit transformer with protected primary and secondary.
6. Power on light.
7. Run light for each pump, and contact for remote output.
8. Elapsed run-time meter for each pump.
9. Low-suction cutout with alarm and contact for remote output.
10. Pump failure alarm light, reset pushbutton, and contact for remote output.

C. Pumps:
1. Type:
    a. Centrifugal.
        1) Vertical split case.
    b. Flex-coupled.
    c. Bronze-fitted.
    d. Single-stage, double-suction.
2. Construction:
    a. Cast-iron casing, casing wear rings, bronze impeller, shaft sleeve, mechanical seal.
    b. Maximum pump casing pressure: 230 PSIG.
    c. Designed so that pump can be serviced without moving motor and without disconnecting piping.
3. Performance:
    a. Each pump shall perform as scheduled and as specified.
    b. Pumps shall not overload at any point on the pump curves.
4. Capacity: As scheduled.

D. Piping, Fittings, Manual Valves, and Piping Specialties:
1. Epoxy phenolic lined steel piping and fittings.
2. Provide isolation valves on suction and discharge from each pump.
3. Provide spring-loaded check valve on discharge from each pump.
4. Supports:
    a. See Section 20 05 29.
    b. Provide supports for the following:
        1) Suction header.
        2) Suction and discharge piping on each pump.
        3) Discharge header.
    c. Support piping independently of pump connections.
    d. Arrange pipe supports to permit field installation of insulation: Section 20 07 00.
5. Pressure gauges on suction and discharge header.
6. Shut-off valves on control sensing lines and gauges.

2.3 VARIABLE SPEED PACKAGED SYSTEM

A. Variable Speed Packaged System: In addition to general packaged system requirements, provide the following:
   1. Variable frequency drives.
   2. Isolation transformers.

B. Electrical Control Panel:
   1. Designed to start and stop pumps and modulate speed to meet system demands.
   2. Monitor system pressure at remote transmitters and send 4-20 mA DC signals via a pair of wires to a receiver/controller in control cubicle.
   3. Receiver/controller: Field programmable.
   4. Start pumps on a drop in system pressure and stop after an adjustable minimum run time.
      a. Provide no-flow probe to control lead pump shutdown.
   5. Start pumps manually and adjust speed automatically or manually using H-O-A switch and manual speed potentiometer for each VFD.
   6. Control sequence enclosure:
      a. High and low system pressure alarms and contacts for remote outputs.
      b. Lead pump selector switch and manual alternation.
      c. Pump sequencing logic.
      d. Transient snubbers on inductive loads in panel.
      e. Receiver/controller.
      f. Interface controls for variable frequency drives.
   7. Provide signal isolating buffers on internal and external 4-20mA circuits where utilized by more than 2 devices.
   8. Remote pressure transmitters:
      a. Self-contained, variable capacitance type.

C. Variable Frequency Drives:
   1. See Section 25 23 00.

2.4 DEMONSTRATION

A. System manufacturer or manufacturer's representative: Provide start-up and adjustment service for packaged pumping system.

B. System manufacturer or manufacturer's representative: Provide a minimum 4 HRS of training for the owner's personnel on the operation and maintenance of the packaged pumping system.

C. System manufacturer: Have factory trained authorized service agency located within 50 miles of project site.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pressure booster system in accordance with manufacturer's recommendations and instructions.

B. Align pump and motor shafts to within manufacturer's recommended tolerances prior to system start-up.

C. Pipe drain lines to floor drain.

D. Provide wiring between pressure transmitters and receiver/controller, (variable speed system only).

END OF SECTION

SECTION 22 13 13
FACILITY SANITARY SEWERS

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. Ductile-iron, gravity sewer pipe and fittings.
   2. Manholes.
   3. Concrete.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Pipe and fittings.

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

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:
   1. 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.
   2. Show system piping in profile. Draw profiles to horizontal scale of not less than 1 IN equals 30 FT and to vertical scale of not less than 1 IN equals 5 FT .Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.

B. Product Certificates: For each type of pipe and fitting.

C. Field quality-control reports.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes according to manufacturer's written rigging instructions.

1.6 FIELD CONDITIONS

A. Interruption of Existing Sanitary Sewerage 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 Architect no fewer than five calendar days in advance of proposed interruption of service.
   2. Do not proceed with interruption of service without Architect's written permission.

PART 2 - PRODUCTS

2.1 DUCTILE-IRON, PRESSURE PIPE AND FITTINGS

A. Push-on-Joint Piping:
   1. Pipe: AWWA C151/A21.51.
   2. Standard Fittings: AWWA C110/A21.10, ductile or gray iron.
   3. Compact Fittings: AWWA C153/A21.53.
   4. Gaskets: AWWA C111/A21.11, rubber, of shape matching pipe and fittings.
   5. Pipe Lining: SewperCoat by Lafarge Calcium Aluminates or approved equal.

B. Mechanical-Joint Piping:
   1. Pipe: AWWA C151/A21.51, with bolt holes in bell.
   2. Standard Fittings: AWWA C110/A21.10, ductile or gray iron, with bolt holes in bell.
   3. Compact Fittings: AWWA C153/A21.53, with bolt holes in bells.
   4. Glands: Cast or ductile iron; with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
   5. Gaskets: AWWA C111/A21.11, rubber, of shape matching pipe, fittings, and glands.
   6. Pipe & Fitting Lining: SewperCoat by Lafarge Calcium Aluminates or approved equal

2.2 MANHOLES

A. Standard Precast Concrete Manholes:
   1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
   2. Diameter: 48 IN 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 IN minimum thickness for floor slab and 4 IN minimum thickness for walls and base riser section; with separate base slab or base section with integral floor.
   5. Riser Sections: 4 IN 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, bitumen or butyl rubber.
   8. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
   9. Steps: ASTM A 615/A 615M, deformed, No. 3 steel reinforcing rods encased in ASTM D 4101, Polypropylene; 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 IN intervals. See Howard County Standard Detail G-5.21.
   10. Grade Rings: Reinforced-concrete rings, 2 to 12 IN 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 IN ID by 8 IN riser, with 4 IN minimum-width flange and 24 IN diameter cover. Include indented top design with lettering “S” cast into cover.
   2. Material: ASTM A 48/A 48M, Class 35 B iron unless otherwise indicated.

2.3 CONCRETE

A. General: Cast-in-place concrete complying with ACI 318, and the following:
   1. Cement: ASTM C 150/C 150M, Type II.
   2. Fine Aggregate: ASTM C 33/C 33M, sand.
   3. Coarse Aggregate: ASTM C 33/C 33M, crushed gravel.
   4. Water: Potable
   5. Portland Cement Design Mix: 3000 psi minimum, with 0.45 maximum water/cementitious materials ratio.

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

B. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4500 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
   1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
      a. Invert Slope: 1 percent through manhole.
   2. Benches: Concrete, sloped to drain into channel.
      a. Slope: 1 percent.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 31 20 00 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details to 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. Install gravity-flow, drainage piping according to the following:
   1. Install piping pitched down in direction of flow, at minimum slope of 2 percent unless otherwise indicated.
   2. Install piping with 10-foot minimum cover.
   3. Install ductile-iron, gravity sewer piping according to ASTM A 746.

3.3 PIPE JOINT CONSTRUCTION

A. Join piping according to the following:
   1. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.
   2. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
   3. Join dissimilar pipe materials with pressure-type couplings.

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

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 2 IN above finished surface in unpaved areas and flush with surface in paved areas, unless otherwise indicated.

3.5 CONCRETE PLACEMENT

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

3.6 CONNECTIONS

A. Connect, gravity-flow drainage piping to building's sanitary building drains specified in Section 22 10 16 "Plumbing Piping."

B. Make connections to existing piping and underground manholes.
   1. Make branch connections from side into existing piping, using “doghouse” manhole type construction per Howard County standard Detail G-5.14.
      a. Use concrete that will attain a minimum 28-day compressive strength of 4500 psi unless otherwise indicated.
   2. 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.

3.7 CLOSING ABANDONED SANITARY SEWER SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
   1. Close open ends of piping with at least 12 IN thick, brick masonry bulkheads.
   2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes: Excavate around manhole as required and use either procedure below:
   1. Remove manhole and close open ends of remaining piping.
   2. Remove top of manhole down to at least 36 IN below final grade. Fill to within 12 IN of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Section 31 20 00 "Earth Moving."

3.8 IDENTIFICATION

A. Comply with requirements in Section 31 20 00 "Earth Moving" for underground utility identification devices. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
   1. Use 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 IN 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 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. Test plastic gravity sewer piping according to ASTM F 1417.
      b. Test concrete gravity sewer piping according to ASTM C 1628.
   7. Manholes: Perform hydraulic test according to ASTM C 969.

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.

END OF SECTION

SECTION 22 33 00
DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Domestic Water Heaters, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Factory testing: Subject tank and elements to hydrostatic test pressure, 150 PCT in excess of working pressure. Certify that components are free of leaks.

B. Manufacturing standard: ASME Pressure Vessel Code.

1.3 SUBMITTALS

A. Product Data:
   1. Water heaters.

B. Contract Closeout Information:
   1. Owner instruction report.
   2. Operation and Maintenance Data.
      a. See Section 01 78 23.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Gas Fired Storage Water Heater:
   1. Base:
      a. Lochinvar.
   2. Optional:
      a. Ruud.
      b. Rheem.
      c. State.

B. Temperature/Pressure Relief Valves.
   1. Base:
      a. Watts.
   2. Optional:
      a. A W Cash.
      b. Wilkins.

2.2 MATERIALS - GENERAL

A. High temperature limits shall prevent delivery of water that is hotter than that selected for delivery from heater.

B. Concrete linings shall comply with MIL-T-12295.

C. Unless indicated otherwise, water pressure drop through heater shall not exceed 10 PSI.

2.3 GAS-FIRED STORAGE WATER HEATER

A. Gas Fired Storage Water Heater:
   1. Factory-assembled, packaged commercial water heater with storage tank, heater section, controls, and other components as indicated.
   2. Completely factory assemble water heater so that installation involves only setting, leveling, anchoring, and connection of piping and electrical services.
   3. Designed for potable water service.
   4. UL listed and AGA certified.
   5. Factory fabricated steel supports.
   6. Provide manufacturer's standard enamel finish.

B. Scheduled Information:
   1. Entering water temperature.
   2. Leaving water temperature.
   3. Recovery capacity.
   4. Gas pressure.
   5. Power: BTUH.
   6. Storage tank capacity.

C. Storage Tank:
   1. Labeled ASME Code construction with minimum working pressure of 150 PSIG.
   2. Vertical, floor mounted.
   3. Provide two 4 IN handhole cleanouts.
   4. Steel outer jacket with undercoat and baked enamel finish.
   5. Glass lined steel tank with anode rods.
   6. Insulation: Minimum 1-1/2 IN thick fiberglass, minimum.
   7. Brass drain valve.

D. Atmospheric Burner Heater Section:
   1. Removable.
   2. Natural gas.
   3. Electronic, intermittent ignition.
   4. Gas pressure regulator.
   5. Flame inspection port.

E. Controls:
   1. Control leaving water temperature within 5 DEGF of selected temperature.
   2. Adjustable leaving water temperature range: 110-180 DEGF.
   3. High-temperature limit with adjustable set point.
   4. Low-water cutoff.
   5. Upper and lower thermostats.

F. Other Components:
   1. Temperature/pressure relief valve.
   2. Temperature gauge.
   3. Barometric draft regulator.

2.4 TEMPERATURE/PRESSURE RELIEF VALVES

A. Temperature/Pressure Relief Valves.
   1. AGA and ASME-approved, tight-shutoff, self-closing, bronze-bodied.
   2. Threaded inlet and outlet.
   3. Test lever.
   4. Capacity: Same power as water heater. See schedule.
   5. Relief setting: 210 DEGF/150 PSIG unless otherwise required by code.

PART 3 - EXECUTION

3.1 GENERAL

A. Install units in accordance with manufacturer's instructions.

B. Install units to allow complete access for servicing including removal of heater sections.

C. Set thermostat so heater will deliver scheduled leaving water temperature.

3.2 PARALLEL PIPING MANIFOLD

A. Pipe groups of heaters serving the same system in parallel:
   1. Provide equal-distance water-piping manifolds so that pressure drops through each heater branch are identical.
      a. Equal-distance manifolds:
         1) Cold-water manifold: Developed distances are equal between each heater's cold-water inlet and common tee that splits cold-water flow to heaters.
         2) Hot-water manifold: Developed distances are equal between each heater's hot-water outlet and common tee that combines the hot-water flow from heaters.
         3) Hot-water recirculation manifold: Developed distances are equal between each heater's cold-water inlet and common tee that splits recirculation-water flow to heaters.
      b. Equal developed distances include equal quantities of fittings and valves.
      c. Connect heaters' inlets and outlets to straight-through ports of common tees. Tees' branch ports are the common ports.

END OF SECTION

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SECTION 22 42 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Plumbing Fixtures, as indicated, in accordance with provisions of Contract Documents.

B. Definitions:
1. Aerator: Device that mixes room air with faucet's water stream.
2. Ledge mounted faucet: Faucet with body mounted on top of faucet ledge and covered by faucet housing or single escutcheon.
3. Bottom-mounted faucet: Faucet with body mounted beneath faucet ledge; each penetration is covered by single escutcheon.
4. Semi-cast: Fittings, return bends, and nuts are cast brass. Waste arms and wall bends are tubular.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Manual Valve Standards:
1. See Section 20 05 23, for valves labeled "V-__".

B. Design and Installation Standards:
1. ANSI Z358.1: Standard for Emergency Eyewash and Shower Equipment.
2. ASSE 1016: Individual Thermostatic Pressure Balancing, and Combination Pressure Balancing and Thermostatic Control Valves for Individual Fixture Fittings.
3. ASSE 1017: Temperature Actuated Mixing Valves for Hot Water Distribution Systems.
4. NSF standard: Comply with NSF 61: “Drinking Water System Components-Health Effects”, for fixture materials that will be in contact with potable water.

C. Accessibility Manufacturing and Installation Standards:
1. Americans with Disabilities Act (Public Law 101-336).
2. ANSI-A117.1, current edition.
3. Local authorities.
4. State authorities.

1.3 SUBMITTALS

A. Product Data:
1. Assemble submittals by mark number. Include sufficient information to verify compliance with descriptions.
2. Where model numbers differ from descriptions, submit to meet description requirements:
   a. Electric water coolers.
   b. Emergency fixtures.
   c. Hose bibbs.
   d. Hose reels.
   e. Lavatories.
   f. Mixing valves.
   g. Showers.
   h. Sinks.
   i. Urinals.
   j. Wall hydrants.
   k. Water closets.
   l. Undersink protective covers.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
      a. See Section 01 78 23.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Electric Water Coolers and Drinking Fountains:
   1. Base:
      a. Halsey-Taylor.
   2. Optional:
      a. Elkay Manufacturing.
      b. Haws Corporation.
      c. EBCO Manufacturing (Oasis).
      d. Sunroc.

B. Sensor Operated Faucets:
   1. Base:
      a. Sloan Valve.
   2. Optional:
      a. Chicago Faucet.
      b. Hydrotek.

C. Single Lever Mixing Faucets:
   1. Base:
      a. American Standard Plumbing.
   2. Optional:
      a. Chicago Faucet.
      b. T&S Brass & Bronze Works.

D. Two Handled Faucets:
   1. Base:
      a. American Standard Plumbing.
   2. Optional:
      a. Chicago Faucet.
      b. T&S Brass & Bronze Works.
      c. Delta Commercial.
      d. Crane Plumbing.
      e. Eljer Plumbingware.
      f. Kohler.

E. Molded Stone, Precast Terrazzo, Fiberglass Reinforced Polyester Fixtures:
   1. Base:
      a. Fiat.
   2. Optional:
      a. Creative Industries Terrazzo Products.
      b. Stern and Williams.
      c. Swan.
      d. Mustee & Sons, EL.

F. Stainless Steel Fixtures:
   1. Base:
      a. Elkay Manufacturing.
   2. Optional:
      a. Just Manufacturing.
      b. Southern Kitchens.

G. Vitreous China Fixtures:
   1. Base:
      a. American Standard Plumbing.
   2. Optional:
      a. Eljer Plumbingware.
      b. Kohler.

H. Fixture Carriers:
   1. Base:
      a. Wade.
   2. Optional:
      a. Watts/Ancon.
      b. Jonespec.
      c. Josam.
      d. J R Smith.
      e. Zurn Industries.

I. Flow Control Devices:
   1. Base:
      a. Same as installed faucet or shower head.

J. Flushometer Valves:
   1. Base:
      a. Sloan Valve.
   2. Optional:
      a. Coyne & Delany.
      b. Zurn Industries.

K. Hose Bibbs:
   1. Base:
      a. Chicago Faucet.
   2. Optional:
      a. Acorn Engineering.
      b. Delta Commercial.
      c. Crane Plumbing.
      d. Croker West.
      e. Sloan Valve.
      f. Speakman.
      g. T&S Brass & Bronze Works.
      h. Woodford Manufacturing.

L. Hose Reels:
   1. Base:
      a. Chicago Faucet.
   2. Optional:
      a. T&S Brass & Bronze Works.

M. Thermostatic Mixing valves:
   1. Base:
      a. Symmons.
   2. Optional:
      a. Lawler Manufacturing.
      b. Leonard Valve.
      c. Powers.

N. Tempering Mixing valves:
   1. Base:
      a. Powers.

2. Optioinal:
    a. Watts.
    b. Leonard.

O. Shower Drains:
1. Base:
    a. Wade.
2. Optional:
    a. Watts-Ancon.
    b. Jonespec.
    c. Josam.
    d. J R Smith.
    e. Zurn Industries.

P. Wall Hydrants:
1. Base:
    a. Wade.
2. Optional:
    a. Watts-Ancon.
    b. Jonespec.
    c. Josam.
    d. J R Smith.
    e. Woodford Manufacturing.
    f. Zurn Industries.

Q. Water Closet Seats:
1. Base:
    a. Beneke.
2. Optional:
    a. Bemis.
    b. Centoco.
    c. Church.
    d. Olsonite.
    e. Sperzel.

R. Undersink Protective Covers:
1. Base:
    a. Truebro.
2. Optional:
    a. McGuire.

2.2 MATERIALS

A. Construct or equip fixtures with air gap or anti-siphon devices to prevent siphoning non-potable water into potable water supply system.

B. Piping exposed in finished areas including fittings and trim:
1. See Section 22 10 16.

C. Dimensions:
1. Dimensions are Nominal.
2. Multiple dimensions:
    a. First dimension: Side-to-side.
    b. Second dimension: Front-to-back.
    c. Third dimension: Top-to-bottom.

D. Manufacture accessible fixture assemblies to meet requirements of accessibility standards.

E. Faucets - General:
   1. Following general conditions apply unless detailed otherwise in specific descriptions:
      a. Renewable cartridges with integral seats (or renewable seats and stems).
      b. Materials:
         1) Brass, bronze, copper, stainless steel, ceramic.
         2) Plastic components are not acceptable.
      c. Finish:
         1) Chrome.
      d. Gooseneck spouts:
         1) Discharge at least 5 IN above rim of fixture.
      e. Electric, sensor-operated faucets:
         1) Mount transformer and control panel in concealed but accessible location.
         2) Coordinate with Electrical and Casework contractors.
      f. If mixing valve is not included in faucet description, provide a tempering, under-counter mixing valve. Mechanical mixing valves shall not be used.
      g. Comply with NSF 61- "Drinking Water System Components – Health Effects" for fixture materials that will be in contact with potable water.

F. Lavatory Fixtures - General:
   1. Following general conditions apply unless detailed otherwise in specific descriptions:
      a. Vitreous china and enameled, cast-iron fixtures:
         1) Color: White.
         2) Overflows: Integral.
      b. Stainless steel fixtures:
         1) Finish: Softsatin.
         2) Type: 302 (18-8) or 304 (18-8).
         3) Thickness: 20 GA.
         4) Sound deadening that covers complete underside of bowl.
      c. Provide integral faucet ledge with holes:
         1) Coordinate hole quantities, locations, and centerings with faucet types indicated in fixture descriptions.
         2) Provide exact number of holes necessary.
            a) Use of faucet hole covers is not acceptable.

G. Mixing Valves - General:
   1. Following general conditions apply unless detailed otherwise in specific descriptions:
      a. Materials:
         1) Brass, bronze, copper, stainless steel, ceramic.
         2) Thermostatic mixing valves:
            a) Thermostat may contain plastic parts.
         3) Escutcheon may be pot metal.
      b. Finish of exposed surfaces:
         1) Chrome.
      c. Hot/cold color coding.
      d. Coordinate number of ports with trim indicated in fixture descriptions.
         1) Four-port valves:
            a) If diverter spout is indicated in fixture description, provide built in choke.
            b) If external diverter valve is indicated in fixture description, provide without choke.
      e. Comply with NSF 61- "Drinking Water System Components – Health Effects" for fixture materials that will be in contact with potable water.
      f. Tempering Type Mixing Valve:
         1) ASSE 1016 Type: T/P.
         2) Integral checks and service stops on inlets.
         3) Inlet screens: stainless steel.
         4) Adjustment: adjustable locking type.

5) Connections:
    a) 3/8 IN.
6) Example:
    a) Powers model e480.

g. Thermostatic Mixing Valves:
    1) ASSE 1017 compliant.
    2) Renewable thermostatic and pressure-balance elements.
    3) Compensates for changes in both temperature and pressure.
    4) Integral checks and service stops.
    5) Temperature control with built-in shut off; opens from cold to hot.
    6) Single lever handle.
    7) Adjustable, temperature-limit stops.
    8) "OFF-COLD-HOT" marking in block type letters minimum 7/32 IN high.

2. Mixing Valve Trim - General:
    a. Cabinets:
        1) Stainless steel construction.
        2) Hinged doors:
            a) Removable when in the open position.
            b) Hinge on side.
        3) Size cabinets to hold valve and accessories as required in each description.
    b. Thermometers:
        1) 3-1/2 IN dial.
        2) Hermetically sealed.
        3) Bimetal element.
        4) Range: Minus 0 to 140 DEGF.
        5) Construction: Welded stainless steel.
        6) White-faced, three-color dial.
    c. Vacuum breakers and valves:
        1) See "Faucets, general" in Article 2.01.

3. Semi-cast P-traps and Continuous Wastes:
    a. P-trap:
        1) Semi-cast:
        2) 1-1/4 or 1-1/2 IN NPS cast brass return bend with clean out.
        3) 17 GA x 1-1/4 or 1-1/2 IN OD copper tube tailpiece.
        4) Nuts: Cast brass.
    b. Continuous Waste:
        1) Semi-cast:
        2) 1-1/2 IN NPS cast brass tee.
        3) 17 GA x 1-1/2 IN OD copper tube tailpieces.
        4) Nuts:
            a) Cast brass.

H. Shower Heads - General:
    1. Following general conditions apply unless detailed otherwise in specific descriptions:
        a. Nozzle designed to prohibit liming and clogging.
        b. Body:
            1) Material: Brass.
                a) Hand-held shower-head body may be plastic.
            2) Finish: Chrome.
                a) Hand-held shower-head body may be white.
        c. Internal components:
            1) Foul resistant.

I. Sink Fixtures - General:
    1. Following general conditions apply unless detailed otherwise in specific descriptions:
        a. Vitreous china: White.

b. Stainless steel:
   1) Finish: Softsatin.
   2) Type: 302 (18-8) or 304 (18-8).
   3) Sound deadening that covers complete undersides of each bowl.
   4) Thickness:
      a) Sink depth less than or equal to 10 IN: 18 GA.
      b) Sink depth greater than 10 IN: 16 GA.
c. Molded stone and terrazzo:
   1) Marble chips in reinforced Portland cement.
      a) 7-day compressive strength:
         (1) 3000 PSI.
      b) Exposed surfaces:
         (1) Ground smooth, grouted and sealed to resist staining.
   2) Drain body opening: Integrally cast.
   3) Color:
      a) As selected from manufacturer's standard line by Architect.
d. Enameled cast-iron:
   1) Color: White.
e. Countertop sinks:
   1) Self-rimming.
f. Provide integral faucet ledge with holes:
   1) Coordinate hole quantities, locations, and centerings with the following:
      a) Faucets and trim indicated in fixture descriptions.
      b) Hot-water dispensers.
      c) High-purity water faucets.
   2) Provide exact number of holes necessary.
      a) Use of faucet hole covers is not acceptable.

2.3 ELECTRIC WATER COOLERS

A. Electric Water Coolers – General:
   1. Following general conditions apply unless detailed otherwise in specific descriptions):
      a. Self contained, refrigeration units.
         1) Capacity based on 90 DEGF room temperature, 80 DEGF inlet-water temperature, and 50 DEGF drinking-water temperature.
         2) Air cooled condensing units.
            a) 115V.
            b) Hermetically sealed compressor.
      b. Bubbler drain-pan: Stainless steel.
      c. Stainless steel: Type 304 with satin finish.
      d. Chrome-plated, brass bubbler.
         1) Bubbler guard may be plastic and need not be chrome-plated.
      e. Stream regulator mounted inside cabinet or in bubbler. Regulator shall maintain constant stream height while line pressure varies between 30 and 90 PSI.
      f. Certified lead free as defined by the Safe Drinking Water Act.

B. EWC-1, Accessible, facing forward, dual-level:
   1. Fixture:
      a. Wall hung, surface-mounted, dual-level. Self closing push bars on front and sides. Refrigeration unit mounted in cabinet behind and below bubble drain pan. Provide high unit with bottle filling station.
      b. Minimum Capacity: 7.5 GPH.
      c. Cabinet finish: Acrylic enamel on 20 GA steel.
         1) Color selected by Architect.
         2) Halsey Taylor HTHB-HAC8BLSS-WF.
      d. Fixture carrier: Hanger-plate type.

2.4 EMERGENCY FIXTURES

A. Emergency Combination Shower/Eyewash - General:
   1. Following general conditions apply unless detailed otherwise in specific descriptions:
      a. See also general comments for Emergency Showers and Emergency Eye/face Washes.
      b. 1-1/4 IN galvanized stanchion with floor flange.
      c. 1-1/4 IN, cold-water supply.
   2. 1-1/4 IN waste outlet.
         1) No additional waste piping required.
      b. Eye/face wash valve operated by foot pedal and push handle.
      c. Shower valve: rough chrome-plated brass, 1 IN, stay open, activated by pull handle.
      d. Eye/face wash valve: stay open valve with hand and foot operation.
      e. Provide eye/face wash supply line strainer with removable element.
      f. Eye/face wash dust covers: Fall off when water flows.
      g. Mixing Valves: In compliance with current editions of ANSI standard z358.1 (American National Standard for Emergency Eyewash and Shower equipment) and ASSE standard 1016 (American Society for Sanitary Engineering).
   3. EC-1, Emergency Combination Shower and Eye Wash:
      a. Fixture:
         1) Shower: Stainless steel deluge type showerhead with, 1 IN inlet, brass stay open ball valve, and stainless steel triangle pull handle.
         2) Eye/face wash: stainless steel bowl, automatic volume controls in twin spray heads.
         3) Example: Speakman SE-603-SSH.
      b. Mixing Valve, thermostatic:
         1) Exposed valve, Leonard TM-850.
         2) Operating parameters:
            a) Flow control range: 3-64 GPM.
            b) Minimum flow at 30 PSI: 20GPM.
            c) Minimum flow at maximum pressure drop of 10 PSIG: 29 GPM.
            d) Output temperature range: 60-90 DEGF.
               (1) Maintain output temperature range to a minimum flow of 3 GPM.
            e) HW supply temperature: 90 DEGF.
            f) Supply pressure range: 40-80 PSIG.
            g) Mixing valve bypass: cold water bypass if valve should fail.
         3) Mounting bracket: Wall mount.

B. Emergency Showers – General:
   1. Following general conditions apply unless detailed otherwise in specific descriptions:
      a. Valve: rough chrome-plated brass, 1 IN, stay open.
      b. Pull handle: rigid, stainless steel.
      c. 1 IN cold-water supply.
      d. Mixing Valves: In compliance with ANSI standard z358.1-1998 (American National Standard for Emergency Eyewash and Shower equipment) and ASSE standard 1016 (American Society for Sanitary Engineering).
   2. ES-1, Emergency shower, wall lever activation:
      a. Fixture:
         1) Mounting: Showerhead concealed flush with ceiling. Valve located in wall mounted recessed stainless steel cabinet operated by pull down lever.
         2) Shower head: Deluge type; chrome-plated brass.
            a) Example: Speakman SE-237.
      b. Mixing Valve, thermostatic:
         1) Exposed valve, Leonard TM-850.
         2) Operating parameters:
            a) Flow control range: 2-72 GPM.
            b) Output temperature range: 60-95 DEGF.

c) HW supply temperature: 95 DEGF.
d) Supply pressure range: 40-80 PSIG.
e) Mixing valve bypass: cold water bypass if valve should fail.
3) Mounting bracket: Wall mount.

C. Emergency Eye/Face Washes – General:
1. Following general conditions apply unless detailed otherwise in specific descriptions:
a. Stay open valve operated by push handle.
b. 1/2 IN, cold-water supply.
c. Aerated spray.
d. Supply-line strainer with removable element.
e. Dust covers: Fall off when water flows.
2. EW-1, Emergency eye/face wash, wall mounted:
a. Fixture:
1) Wall mounted. Stainless steel bowl. Mounting brackets. Automatic volume controls in twin spray heads. 1-1/4 IN OD tailpiece.
a) Example: Speakman SE-400.
b. Trim:
1) P-trap: Chrome, 1-1/4 IN or 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/4 IN or 17 GA x 1-1/2 IN OD copper tube trap arm.
c. Mixing Valve, thermostatic:
1) Exposed valve, Leonard TA-350.
2) Operating parameters:
a) Flow control range: 2-10 GPM.
b) Output temperature range: 60-95 DEGF.
c) HW supply temperature: 95 DEGF.
d) Supply pressure range: 40-80 PSIG.
e) Mixing valve bypass: cold water bypass if valve should fail.
3) Mounting bracket: Wall mount.
3. EW-2, Emergency eye/face wash, deck mounted swing arm type:
a. Fixture:
1) Countertop-mounted, 90 degree swing type. Mounting brackets. Automatic volume controls in twin spray heads. Through the counter chrome sleeve for handle. Verify right or left hand configuration is required. Install in such manner as not to interfere with sink faucet.
a) Example: Speakman SEF-572.
b. Mixing Valve, thermostatic:
1) Exposed valve, Leonard TA-350.
2) Operating parameters:
a) Flow control range: 0.5-8 GPM.
b) Output temperature range: 60-95 DEGF.
c) HW supply temperature: 95 DEGF.
d) Supply pressure range: 40-80 PSIG.
e) Mixing valve bypass: cold water bypass if valve should fail.
3) Mounting bracket: Wall mount.

2.5 FIXTURE CARRIERS

A. Fixture Carriers:
1. Application:
a. This paragraph describes carriers for wall hung valves and wall hung fixtures except water closets.
b. See Water Closet article for closet carriers.
2. Carriers consist of uprights, floor anchors, and fixture supports:
a. Fixture-support types are concealed-arm, exposed-arm, hanger-plate, and clinical-service-sink.
b. Include associated hardware.

3. Materials:
    a. Coated cast iron.
    b. Steel.
4. Weight of construction: Institutional.
5. Uprights: Rectangular structural steel.
6. Floor anchors:
    a. Non-adjustable cast-iron floor anchors bolted to uprights; or steel-plate floor anchors integrally welded to uprights.
    b. 4-hole anchoring to floor.
7. Concealed-arm fixture supports:
    a. Header couplings:
        1) Vertically adjustable with horizontally adjustable cross tie.
        2) Integral pipe sleeves.
    b. Secure arms to pipe sleeves with threaded or set-screw connections.
    c. Hardware for vitreous china fixtures:
        1) Leveling screws for four corners of fixture.
        2) Non-slip devices to lock fixture into place on arms.
    d. Hardware for cast-iron fixtures:
        1) Threaded eye bolts with leveling hardware.
    e. For flat-slab fixtures requiring set out from wall, provide 2 IN chromed wall escutcheons.
8. Hanger-plate fixture supports:
    a. Bolted attachment to uprights.
    b. Drilled/slotted to match fixture.
    c. Hardware for attaching fixture.
    d. Provide in adequate size and quantity to anchor fixture at every anchoring point on the fixture.
9. Clinical-service-sink fixture supports:
    a. Two heavy-duty hanger plates, one with cast-iron waste-outlet coupling.
    b. Hardware for attaching fixture and waste piping.
10. Match lengths, mounting locations, and sizes to fixture requirements.

2.6 HOSE BIBBS

A. Hose Bibb – General:
1. Following general conditions apply unless detailed otherwise in specific descriptions:
    a. Material: Brass.
    b. Finish: As indicated.

B. HB-1, Polished Brass Hose Bibb with Vacuum Breaker:
1. Fixture:
    a. 1/2 IN IPS male inlet, adjustable / removeable wall flange, lever handle, 3/4 IN garden hose outlet.
        1) Model: T&S Brass B-0718.
2. Vacuum breaker:
    a. Garden hose vacuum breaker, 3/4 IN female garden hose inlet & male outlet.
        1) Model: T&S Brass B-5550-10.

2.7 HOSE REELS

A. HR-1, Concealed Installation:
1. Fixture:
    a. Painted, retractable hose reel without cover. 35 FT of 3/8 IN ID rubber hose. Self-locking/releasing hose bumper on guide arm with multiple possible mounting positions. Mountable on wall or structure above ceiling. Self closing hand-held valve, insulated handle, stay open ring, straight spray head with rubber bumper. 0.75 GPM flow control.
        1) Chicago Faucet 536.

2.8 LAVATORIES

A. L-1, Lavatory, Oval, Electric, Sensor:
   1. Fixture:
      a. 22 x 19 IN oval, Countertop, vitreous china.
         1) American Standard Plumbing Elisse Petite 0410.021.
   2. Faucet:
      a. Electric sensor operated, ledge mounted, 4 IN centerset faucet, integral spout, faucet mounted sensor, aerator.
         1) Sloan ETF-600.
      b. Mixing valve:
         1) Provide tempering mixing valve with checkstops.
         2) Valve shall be mounted under lavatory.
   3. Trim:
      a. Supplies: Chrome, 3/8 IN OD, soft copper tube, loos -key stops, escutcheons.
         1) Model.
      b. Grid drain: Chrome, 1-1/4 IN cast brass with 17 GA x 1-1/4 IN OD copper tube tailpiece.
      c. P-trap: Chrome, 1-1/4 IN or 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/4 IN or 17 GA x 1-1/2 IN OD copper tube trap arm.

B. L-2, Lavatory, Oval, Electric, Sensor, Accessible:
   1. Fixture:
      a. 22 x 19 IN oval, Countertop, vitreous china.
         1) American Standard Plumbing Elisse Petite 0410.021.
   2. Faucet:
      a. Electric sensor operated, ledge mounted, 4 IN centerset faucet, integral spout, faucet mounted sensor, aerator.
         1) Sloan ETF-600.
      b. Mixing valve:
         1) Provide thermostatic mixing valve with checkstops.
         2) Valve shall be mounted under lavatory.
   3. Trim:
      a. Supplies: Chrome, 3/8 IN OD, soft copper tube, loose key stops, escutcheons.
         1) Model.
      b. Grid drain: Chrome, 1-1/4 IN cast brass with 17 GA x 1-1/4 IN OD copper tube tailpiece.
      c. P-trap: Chrome, 1-1/4 IN or 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/4 IN or 17 GA x 1-1/2 IN OD copper tube trap arm.

2.9 MIXING VALVES

A. MV-2, exposed valve without cabinet:
   1. Mixing valve:
      a. Thermostatic, exposed valve.
         1) Symmons 7-700A.
      b. Operating Parameters:
         1) Flow control range: 0-25 GPM.
         2) Output temperature range: 65-115 DEGF.
         3) HW supply temperature: 115 DEGF.
         4) Supply pressure range: 40-80 PSIG.
   2. Mixing-valve trim:
      a. Volume-control and shut-off valve: In-line, flush-mounted.
      b. Thermometer: Exposed.
      c. Atmospheric vacuum breaker: Exposed.
   3. Provide wall mounting bracket.

B. MV-3, exposed valve without cabinet:
   1. Mixing valve:
      a. Thermostatic, exposed valve.
         1) Symmons 7-1000A.
      b. Operating parameters:
         1) Flow control range: 0-45 GPM.
         2) Output temperature range: 65-115 DEGF.
         3) HW supply temperature: 115 DEGF.
         4) Supply pressure range: 40-80 PSIG.
         5) Provide wall mounting bracket.
   2. Mixing-valve trim:
      a. Volume-control and shut-off valve: In-line, flush-mounted.
      b. Thermometer: Exposed.
      c. Atmospheric vacuum breaker: Exposed.
   3. Provide wall mounting bracket.

2.10 SHOWERS

A. See Article 2.01 MATERIALS - GENERAL

B. Shower fixtures (built up), general:
   1. Drain body: Integrally cast stainless steel or chrome-plated brass. Provide for elastomeric or minimum 1-1/2 IN deep lead/oakum connection.
   2. Strainer: removable stainless steel.
   3. Tiling flange, integrally cast:
      a. Coordinate with ceramic-tile work.
      b. Provide at sides where ceramic tile walls abut receptor: Coordinate with Division 09.

C. SH-1, Vandal resistant shower, ceramic-tile:
   1. Fixture:
      a. Drain body for ceramic-tile shower base. Material: Coated cast iron. 10 IN diameter flashing collar. Reversible flashing clamp with seepage openings and tapped opening for strainer body. Threaded strainer body. 6 IN square, secured, satin nickel bronze, removable strainer. Provide flashing around drain.
         1) Wade W-1100.
   2. Mixing valve:
      a. Thermostatic, exposed valve. Flow control range: 0-2.5 GPM. Output temperature range: 65-115 DEGF. HW supply temperature: 115 DEGF. Supply pressure range: 40-80 PSIG. Provide wall mounting bracket.
      b. Escutcheon and handle material: Chromium plated brass.
         1) Symmons 7-200A.
      c. Volume-control and shut-off valve: In-line, flush-mounted.
   3. Mixing-valve trim:
      a. Volume-control and shut-off valve: In-line, flush-mounted.
      b. Thermometer: Exposed.
   4. Mixing-valve cabinet:
      a. Flush-mounted with lockable, hinged door.
   5. Shower trim:
      a. Shower heads: Vandal-resistant, fixed head, through-the-wall back plate, 30-degree spray angle, tamper-proof adjustable spray.
         1) Symmons 4-295.

2.11 SINKS

A. See Article 2.01 MATERIALS – GENERAL

B. S-1, Single bowl, wrist blades and gooseneck:
   1. Fixture:
      a. 22 x 19 x 7.5 IN, Countertop, stainless steel, single-bowl, 3-1/2 IN outlet.
         1) Elkay Lustertone LR-2219.
   2. Faucet:
      a. Bottom-mounted, 8 IN spread, two 4 IN wristblades, 5 IN reach fixed gooseneck.
         1) American Standard Plumbing Heritage 6832.000.
   3. Trim:
      a. Supplies: Chrome, 3/8 IN OD, soft copper tube, loose key stops, escutcheons.
         1) Model.
      b. Chrome plated brass grid drain for 3-1/2 IN outlet with 17 GA x 1-1/2 IN OD copper tube tailpiece.
         1) Model.
      c. P-trap: Chrome, 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/2 IN OD copper tube trap arm.
         1) Model

C. S-2, Single bowl, wrist blades and gooseneck, accessible:
   1. Fixture:
      a. 25 x 19.5 x 10.5 IN, Wall Hung, stainless steel, single-bowl, 3-1/2 IN outlet.
         1) ElkayEWS2520W6C.
   2. Faucet:
      a. Wall-mounted, 8 IN spread escutcheon, dual-wrist blade mixing, 5 IN gooseneck spout.
         1) Elkay LK940GN05T6H.
   3. Trim:
      a. Supplies: Chrome, 3/8 IN OD, soft copper tube, loose key stops, escutcheons.
         1) Model.
      b. Chrome plated brass grid drain for 3-1/2 IN outlet with 17 GA x 1-1/2 IN OD copper tube tailpiece.
         1) Model.
      c. P-trap: Chrome, 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/2 IN OD copper tube trap arm.
         1) Model

D. S-3, Double bowl, wrist blades and gooseneck:
   1. Fixture:
      a. 33 x 21 x 8 IN, Countertop, stainless steel, double-bowl, 3-1/2 IN outlets.
         1) Elkay Lustertone LR-3321.
   2. Faucet:
      a. Bottom-mounted, 8 IN spread, two 4 IN wristblades, 8 IN diameter swing gooseneck.
         1) Chicago Faucet 201-AGN8AE3-317.
   3. Trim:
      a. Supplies: Chrome, 3/8 IN OD, soft copper tube, loose key stops, escutcheons.
         1) Model.
      b. For each compartment provide chrome plated brass drain body with chrome plated brass removable basket strainer, neoprene stopper, with chrome plated metal slide post for 3-1/2 IN outlet with 17 GA x 1-1/2 IN OD copper tube tailpiece.
         1) Model.
      c. Continuous waste assembly, Chrome: Cast brass, 1-1/2 IN tee, cast brass nuts, 17 GA x 1-1/2 IN OD copper tube tailpieces. Coordinate style with disposal and dishwasher when present.
         1) Model.

d. P-trap: Chrome, 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/2 IN OD copper tube trap arm.
    1) Model.

E. S-4, Single bowl, dual lever control, swivle spout:
    1. Fixture:
        a. 36 x 24 x 14 IN, Floor Mount, stainless steel, single-bowl, 3-1/2 IN outlets, centered faucet hole.
            1) Elkay WNSF81362.
    2. Faucet:
        a. Wall-mounted, 8 IN spread escutcheon, dual-lever mixing, 8 IN cast swing spout.
            1) Chicago Faucet 445-ABCP.
    3. Trim:
        a. Supplies: Chrome, 3/8 IN OD, soft copper tube, loose key stops, escutcheons.
            1) Model.
        b. Provide chrome plated brass drain body with chrome plated brass removable basket strainer, neoprene stopper, with chrome plated metal slide post for 3-1/2 IN outlet with 17 GA x 1-1/2 IN OD copper tube tailpiece.
            1) Model.
        c. Continuous waste assembly, Chrome: Cast brass, 1-1/2 IN tee, cast brass nuts, 17 GA x 1-1/2 IN OD copper tube tailpieces. Coordinate style with disposal and dishwasher when present.
            1) Model.
        d. P-trap: Chrome, 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/2 IN OD copper tube trap arm.
            1) Model.

F. S-5, Double bowl, dual lever control, swivel spout:
    1. Fixture:
        a. 45 x 27.5 x 45 IN, Floor Mount, stainless steel, double-bowl, 3-1/2 IN outlets, centered faucet hole.
            1) ElkayWNSF82422.
    2. Faucet:
        a. Wall mounted, 8 IN spread escutcheon, dual-lever mixing, 8 IN cast swing spout. .
            1) Chicago Faucet 445-ABCP.
    3. Trim:
        a. Chrome grid drain for 3-1/2 IN outlet with 17 GA x 1-1/2 IN OD copper tube tailpiece.
            1) Model.
        b. For each compartment provide chrome plated brass drain body with chrome plated brass removable basket strainer, neoprene stopper, with chrome plated metal slide post for 3-1/2 IN outlet with 17 GA x 1-1/2 IN OD copper tube tailpiece.
            1) Model.
        c. Continuous waste assembly, Chrome: Cast brass, 1-1/2 IN tee, cast brass nuts, 17 GA x 1-1/2 IN OD copper tube tailpieces. Coordinate style with disposal and dishwasher when present.
            1) Model.
        d. P-trap: Chrome, 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/2 IN OD copper tube trap arm.
            1) Model.

2.12 SINKS, MOP

A. See Article 2.01 MATERIALS – GENERAL

B. MSB-1:
   1. Fixture:
      a. One-piece, molded-stone, floor-mounted basin, DN80 3 IN brass or stainless steel drain body, removable dome strainer, vinyl or stainless steel bumper guards on sides not adjacent to wall.
         1) Fiat MSB-2424, 24x24 IN.
   2. Faucet:
      a. Wall mounted, combination service-sink fitting, two handles, fixed spout, integral vacuum breaker, 3/4 IN hose threads, adjustable wall brace, pail hook, flanged female adjustable arms with integral stops.
         1) Chicago Faucet 897.

2.13 SINKS, SERVICE

A. See Article 2.01 MATERIALS - GENERAL

2.14 SINKS, UTILITY

A. US-1:
   1. Fixture:
      a. 24 x 20 x 14 IN, molded-stone tub, self-leveling tapered white baked enamel steel legs, 2 IN outlet.
         1) Fiat FL-1.
   2. Faucet:
      a. Ledge-mounted, chrome plated, 4 IN centerset, two handles, 5 IN swing spout with integral vacuum breaker and 3/4 IN hose thread connection.
         1) Chicago Faucet 891 with L5VBJKCP spout.
   3. Trim:
      a. Supply pipes: 3/8 IN OD, soft copper tube, loose key stops, escutcheons.
         1) Model.
      b. Grid drain, 2 IN cast brass, 1-1/2 IN OD tailpiece.
         1) Model.
      c. P-trap, 1-1/2 IN semi-cast with cleanout.
         1) Model.

2.15 SPARE PARTS

A. Provide two of each type of renewable cartridge, stem, and seat.

2.16 URINALS

A. Urinal fixtures, general (Following general conditions apply unless detailed otherwise in specific descriptions):
   1. Fixture material: White vitreous china.
   2. Spud material: Brass.
   3. Floor-mounted fixtures: Provide bolt caps with retainers for exposed bolts.
   4. Nominal flush volume: 4 Liters per flush 1.0 GPF.

B. UR-1, Sensor, 120 volt:
   1. Fixture:
      a. Wall hung, blowout, 1-1/4 IN top spud, 2 IN outlet, privacy shields, integral trap.
         1) American Standard Plumbing Lynbrook 6601.012.
      b. Fixture carrier: Hanger-plate type.

2. Flushometer valve:
   a. Chrome finished brass, 12 IN tall, battery-powered, sensor-operated diaphragm type with battery back-up, manual override feature, integral vacuum breaker, flush connection and spud coupling for 1-1/4 IN top spud, 1 IN screwdriver back-check angle stop. Match flush volume to fixture requirements.
      1) Sloan 186-1.0-ES-S.

C. UR-2, Accessible, Sensor, 120 volt:
   1. Fixture:
      a. Wall hung, blowout, 1-1/4 IN top spud, 2 IN outlet, privacy shields, integral trap.
         1) American Standard Plumbing Lynbrook 6601.012.
      b. Fixture carrier: Hanger-plate type.
   2. Flushometer valve:
      a. Chrome finished brass, 12 IN tall, battery-powered, sensor-operated diaphragm type with battery back-up, manual override feature, integral vacuum breaker, flush connection and spud coupling for 1-1/4 IN top spud, 1 IN screwdriver back-check angle stop. Match flush volume to fixture requirements.
         1) Sloan 186-1.0-ES-S.

2.17 WALL HYDRANTS

A. Wall hydrants, general (Following general conditions apply unless detailed otherwise in specific descriptions):
   1. Materials: Type M copper, bronze, cast brass.
   2. Finish of exposed parts: Satin nickel.
   3. Integral, self-draining vacuum breakers.
   4. Key operated volume control/stop.
   5. Automatic draining, non-freezing.
   6. Nylon seats.
   7. Modular face/box.
   8. Renewable cartridges with integral seats (or renewable seats and stems).
   9. 3/4 IN inlet.
   10. 3/4 IN hose-thread outlet.

B. WH-1:
   1. Fixture:
      a. Single temperature, exposed face.
         1) Wade W-8600.

2.18 WATER CLOSETS

A. See Article 2.01 MATERIALS - GENERAL

B. Fixture carriers for wall hung water closets:
   1. Carriers consist of drainage fitting, faceplate, foot supports, closet coupling, and associated hardware.
   2. Style:
      a. Adjustable:
         1) Capable of being installed to accept accessible and standard-height closets at each carrier by adjusting only the face-plate position.
      b. Floor anchored.
   3. Material: Coated cast iron.
   4. Weight of construction: Institutional.
   5. Extension:
      a. When distance between carrier and closet exceeds manufacturer's recommended distance, provide longer closet coupling, longer fixture studs, and additional foot supports.
   6. Provide anchor foot assembly for single carriers.
   7. Closet couplings: Cast iron.

8. Hardware:
   a. Provide hardware to assemble carrier and to mount fixture to carrier.
   b. Match hardware to fixture requirements.
9. Finish on exposed parts: Chrome unless indicated otherwise in fixture description.

C. Water-closet fixtures, general (Following general conditions apply unless detailed otherwise in specific descriptions):
   1. Wall hung closets: Provide fixture carriers.
   2. Close-coupled tanks:
      a. Provide closet supplies: 3/8 IN OD, chromed, soft copper tube, loose key stop, escutcheon.
      b. Provide anti-siphon, brass ballcocks.
      c. Flush handles: Chrome.
   3. Floor-mounted closets: Provide bolt caps with retainers.
   4. Bowls: Elongated.
   5. Color: White.
   6. Fixture material: Vitreous china.
   7. Spud material: Brass.
   8. Spud size: DN40 1-1/2 IN.
   9. Nominal flush volume: 6 Liters per flush 1.6 GPF.

D. Water-closet Seats, General:
   1. Solid plastic.
   2. Color: White.
   3. Resistant to scratching, stains, chemicals, and cleaning agents.
   4. Elongated-bowl style.
   5. Stainless steel hinge pins, bolts, and hardware.
   6. Check hinges.

E. WC-1, Public wall hung, Sensor, 120 volt:
   1. Fixture:
      a. Wall hung, siphon jet, top spud.
         1) American Standard Plumbing Afwall 2257.103.
   2. Flushometer valve:
      a. Chrome finished brass, 12 IN tall, 120 volt, sensor-operated diaphragm type with manual override feature, integral vacuum breaker, flush connection and spud coupling for 1-1/2 IN top spud, 1 IN screwdriver back-check angle stop with tamper proof screws. Match flush volume to fixture requirements.
         1) Sloan 111 ES-S.
   3. Seat:
      a. Open-front seat without cover.

F. WC-2, Public wall hung, Sensor, 120 volt, accessible:
   1. Fixture:
      a. Wall hung, siphon jet, top spud.
         1) American Standard Plumbing Afwall 2257.103.
   2. Flushometer valve:
      a. Chrome finished brass, 12 IN tall, 120 volt, sensor-operated diaphragm type with manual override feature, integral vacuum breaker, flush connection and spud coupling for 1-1/2 IN top spud, 1 IN screwdriver back-check angle stop with tamper proof screws. Match flush volume to fixture requirements.
         1) Sloan 111 ES-S.
   3. Seat:
      a. Open-front seat without cover.

2.19 UNDERSINK PROTECTIVE COVERS

A. Undersink protective covers, vinyl:
   1. Material: Molded closed cell vinyl.
   2. Minimum thermal conductivity at mean temperature:
      a. $k \leq 1.17$, 75 DEGF.
   3. Attachment method: Reusable snap clips or seamless pre-wrapped.
   4. Service: Covers to cleanouts and valves to be removable without damage to clips.

PART 3 - EXECUTION

3.1 GENERAL

A. Install fixtures in first class manner with proper connections to water, drainage and vent systems.

B. Install fixtures at manufacturer's suggested height unless noted otherwise.

C. Install fixtures in accordance with manufacturers' instructions.

D. See that proper grounds are set to form a secure base and an absolutely rigid setting for each fixture.

E. Provide guards and boxing as may be required to protect fixtures against damage from operations of other trades.

F. Where pipes penetrate walls, floors, or ceilings, conceal penetrations with chrome escutcheons or stainless steel plates.

G. Connect exposed traps and supply pipes for fixtures and equipment to rough piping systems at wall, unless otherwise specified.

H. Where plumbing fixtures abut to walls, floors, and countertops, seal with silicone sealant: See Section 07 92 16.

I. On flushometer valves with pipe supports, mount pipe support to wall two-thirds of flush-valve height above fixture spud.

J. Provide undersink protective covers on water supply and waste lines exposed beneath accessible fixtures.

3.2 FIXTURE CARRIER LEVELING

A. Level fixture carriers by shimming floor anchors with steel washers of varying thicknesses.

3.3 ACCESSIBLE FIXTURES

A. Install accessible fixture assemblies to meet requirements of accessibility installing standards

3.4 WATER CLOSET FIXTURE CARRIERS

A. Install each carrier to accept accessible and standard-height water-closet installations so that future change from one height to the other can be accomplished by adjusting only the position of the face plate.

3.5 ADJUST AND CLEAN

A. Valves with adjustable temperature-limit stop: Adjust stop to deliver maximum 110 DEGF.

B. Remove dirt from fixtures, fittings and traps.

C. Secure escutcheons against wall.

END OF SECTION

SECTION 22 61 13
LABORATORY AIR SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Laboratory Air System, as indicated, in accordance with provisions of Contract Documents.

B. This section includes the equipment requirements for the compressed Laboratory Air (LA) system:
1. Air compressors.
2. Air receivers.
3. Air dryer/filter skids.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Laboratory air system components shall be furnished by a single supplier.

B. Laboratory air system components shall provide compressed air of Class 2 quality, in accordance with ISO 8573.

1.3 RELATED WORK

A. Refer to other Mechanical Specification Divisions for general and special mechanical requirements.

B. Work of other Mechanical Specification Divisions:
1. Welding and brazing requirements.
2. Insulation.
3. Plumbing systems.
4. Pipe hangers and supports.
5. Piping and equipment identification.
6. Process piping systems.

1.4 SUBMITTALS

A. Product Data:
1. Performance data.
2. Physical dimensions and weight data.
3. Vibration and acoustical data.
4. Piping diagrams, and field connections.
5. Electrical and controls wiring data, and field connections.

B. Contract Closeout Information:
1. Warranty.
2. Owner instruction report.
3. Operation and Maintenance Data.
    a. See Section 01 78 23.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Air Compressors:
1. Base:
    a. Kobelco.

2. Optional:
   a. Atlas Copco.

B. Air Receivers:
   1. Base:
   2. Optional:
      a. Hanson Tank.
      b. Silvan Industries.
      c. Manchester Tank.

C. Air Dryers and Filters:
   1. Base:
      a. Zeks.
   2. Optional:
      a. Atlas Copco.
      b. Pneumatic Products.
      c. Deltech.
      d. Gardner Denver.

2.2 AIR COMPRESSOR

A. Positive-displacement, two-stage, water cooled, rotary screw air compressor capable of delivering 100 percent oil-free air.

B. Assembly Includes:
   1. Air compressor.
   2. Drive motor.
   3. Intercooler.
   4. Aftercooler.
   5. Lubrication system.
   6. Regulation and control system.
   7. Inlet air filter and silencer.
   8. Sound attenuation cabinet.
   9. Moisture separators with automatic drains.
   10. Pressure relief valves.
   11. Aftercooler check valve.
   12. Base frame.
   13. Internal wiring.
   14. Piping.

C. Noise shall be 80 dBA or less at 3 FT measurement from compressor unit.

D. Water Cooled Compressors:
   1. Cooling water conservation system.
   2. Chilled water is available for compressor cooling.
   3. Contractor shall provide an automatic control valve and approved temperature sensor to throttle cooling water as required.
   4. Provide automatic tight shutoff valve to stop water flow on compressor failure/shutoff.
   5. Valve and actuator shall be industrial quality equal to Fisher.
   6. Intercooler and aftercoolers shall be ASME coded and stamped.
   7. Aftercooler shall be sized to cool discharge air to within 20 degF of leaving water temperature.

E. Separate Direct Drive Lubrication System:
   1. Pre-lubricated bearings and timing gears.
   2. Lubricate for 15 seconds before startup and continue to be lubricated for at least 20 seconds after shutdown.
   3. Provide for accurate measurement of oil level while compressor is in operation.

F. Inlet Filter Silencer:
   1. Dry type on compressors.
   2. Design for 125 percent of compressor's expected capacity in SCFM.

G. Antifriction Bearings:
   1. AFBMA L10 life of 120,000 hours minimum.
   2. Regreasable while running via installed grease fittings.
   3. Factory greased with wide temperature range, rust-inhibiting grease.
   4. Provide details concerning motor shaft to compressor connection, including shaft seals.
   5. Shaft seal:
      a. Spring-loaded carbon ring cooled by oil during operation.
      b. Provide gravity fed oil reservoir to provide lubrication in the event of a power failure coast down.
      c. Provide access covers for each bearing chamber and oil reservoir.

H. Motors:
   1. Basic requirements applicable to motors that are provided and installed under this Section are set forth in Section 20 05 00.

I. Control System:
   1. Integral to compressor package.
   2. Provide manual and automatic operation and be equipped with a fused disconnect switch capable of being padlocked in the off position.
   3. Compressor local panel and control devices shall be skid mounted and factory wired.
   4. Adjustable timer for loading delay to prevent excessive starts.
   5. Automatic shutoff of compressor during periods of low demand and excessive idling to conserve energy.
   6. 120 V, 60 Hz, by others.
   7. Incorporate safety devices to shut down unit and require manual reset in event of:
      a. High oil temperature.
      b. High first and second stage discharge air temperature.
      c. Motor overload.
      d. Low-oil pressure.
      e. High-bleedoff air pressure.
      f. Low-discharge pressure switch.
      g. High-high discharge pressure switch.
      h. High second stage inlet air temperature.

J. Compressor Local Panel:
   1. House within NEMA 12 enclosure.
   2. UL labeled for use as an industrial control panel.
   3. Include the following instruments:
      a. Intercooler air pressure gauge.
      b. First- and second-stage discharge air pressure gauge.
      c. Oil pressure gauge.
      d. Intake filter differential pressure gauge.
      e. First and second stage discharge air temperature gauges and lights.
      f. Low oil pressure light.
      g. Hour Meter:
         1) Running time
         2) Loaded time
   4. Auto-operation light.
   5. Power on light.
   6. Motor overload light.
   7. Unload/normal toggle switch.
   8. Reset/start push button.
   9. Stop push button.

10. High-oil temperature light.
11. High bleedoff air pressure light.
12. High discharge water temperature switch and gauge.
13. Hand off auto switch, in auto accept a run contact from BMCS.
14. Use push to test indicating lights.
15. Second-stage inlet air temperature gauge and light.
16. Output for connection of common trouble alarm to the Owner control system.

K. Factory wire components to motor starters and control panels.

L. Accessories:
   1. Automatic drain traps:
      a. Electric stainless steel drain valve assembly, ASCO CDVA 120 V, 60 Hz, or equal.
      b. Power to be provided by Vendor via prewired skid system.
      c. Automatic drains:
         1) Controlled by a field adjustable timer located in local control panel.
   2. Pressure safety relief valves:
      a. ASME coded for Section VIII air service.
      b. Safety valves shall be capable of relieving the total rated capacity of compressor at set pressure of 150 PSIG.
   3. Permanently attached stainless steel identification name plates shall be supplied with each equipment unit and components.

2.3 AIR RECEIVER

A. Provide steel air receivers as shown on Drawings.

B. Receivers:
   1. shall be suitable for a maximum working pressure at the top tangent line, of 10 PCT or 25 PSIG above the highest normal operating pressure, whichever is greater, and shall be furnished with ASME stamp and certification papers.
   2. Internally lined with a combination epoxy and polyamide-type resin.
      a. Plasite 7133 or approved equal.
      b. Receiver exterior shall be sandblasted, primed and painted with machinery enamel.

C. Floor Mounted Receivers:
   1. Steel support legs or skirt, designed for bottom of tank 12 IN above floor.
   2. Size in accordance with applicable seismic zone.

D. Accessories:
   1. Manway.
   2. Flanged inlet and outlet nozzles.
   3. NPT drain nozzle:
      a. Include an automatic electric stainless steel condensate drain valve assembly with timer (ASCO CDVA, 1/2 IN, 120V, 60 Hz or equal) for each receiver.
   4. NPT relief valve nozzle:
      a. Include an ASME pressure relief valve on each receiver, capable of relieving the total system rated capacity at the set pressure of 150 PSIG.
   5. NPT pressure gauge nozzle:
      a. Include a pressure gauge, with isolation valve, with 0-150 PSIG range.
   6. Lifting lugs.
   7. EPDM nozzle gaskets.

E. Nameplates:
   1. Supply receiver with a 316L stainless steel equipment identification label mounted on a raised flat surface permanently attached to receiver.

F. Spare Parts:
   1. Provide one spare gasket for manways and nozzles.

2.4 AIR DRYER

A. Packaged System:
   1. Skid mounted, complete with interconnecting tower piping, valve manifold, filter units, and control wiring.
   2. The air dryer unit shall be packaged ready for an air inlet, air outlet, and single-point electrical power connection.
   3. The dryer package shall include a particulate pre-filter, coalescing pre-filter, and particulate after-filter on the skid fully piped and valved.

B. Dual Tower, Heated Regenerative Desiccant Dryers:
   1. External heater and process air shall be used to regenerate the dryer.
   2. Mount heater externally to desiccant bed and shall have an inconel sheath.
   3. Thermally insulate heater and associated purge piping.
   4. Maximum purge volume:
      a. 7 PCT for heated dryer package of inlet airflow.

C. Air Dryers:
   1. Mount with two chambers on common baseplate.
   2. Include valves, controls, and wiring necessary for complete system operation.
   3. Regeneration shall use dry outlet air.
   4. Initiate regeneration by dewpoint of outlet air, with an in-bed capacitance type moisture sensor and control system.

D. Dryer Package:
   1. Design for drying compressed air from a saturated condition at 100 DEGF and 100 PSIG to a design dew point of -40 DEGF.
   2. Do not exceed design dew point of the distributed air.

E. Air Dryer Vessels:
   1. ASME code stamped for 150 PSIG, designed in accordance with Section VIII, Division 1, and stamped by the code inspector.
   2. Design in accordance with state and federal codes, including ANSI, NEMA, NEC, and ISA.

F. Dryer System:
   1. Design with a maximum pressure drop of 5 PSI at rated flow, temperature, and pressure.

G. Exhaust Muffler:
   1. During purge, regeneration, and dry gas sweep, the air noise shall not exceed 80dBA at 3 FT measurement.

H. Dryer:
   1. Separate desiccant fill and drain ports.
   2. Locate such that dryer piping does not have to be disturbed for desiccant change.

I. Dryer Skid Mounted Air Filters:
   1. Provide three valve bypass piping, such that any filter element can be safely serviced while dryer is in operation.

J. Unit shall include separate tower pressure gauges with isolation valves, separate ASME code-rated safety relief valves, separate tower temperature gauges, and stainless steel diffuser screens to protect the desiccant at the inlet and discharge of each tower.

K. Dryer Control Panel:
   1. Automatically alternate towers for regeneration in such a manner as to provide an uninterrupted air supply without any downstream pressure fluctuations.
      a. The pressures in both desiccant chambers shall be equalized prior to changeover.
   2. Single point power connection.
      a. If required, provide a control voltage transformer.
      b. A power interruption shall not result in the interruption of air flow through the dryer.

c. 480V/60HZ/3 for heated air dryer.
d. 120 VAC for heatless air dryer.
3. Changing of a tower from a drying mode to regeneration mode shall be accomplished with switching valves.
a. Carbon steel bodies, stainless steel internals, and Teflon seats and seals.
b. Rated for 500,000-cycle life.
4. Switching valves shall be controlled by a four-way solenoid valve which directs dry air to the air cylinder on the control valve.
5. Provide dryer with purge/ regeneration control system to minimize regeneration cycles and maintain outlet dew point at or below specified requirement.
6. Local dryer control panel:
a. NEMA 12, UL listed.
b. Include indication of following:
1) Power on.
2) Left chamber depressurizing.
3) Right chamber depressuring.
4) Left chamber heating.
5) Right chamber heating.
6) Left chamber repressurizing.
7) Right chamber repressurizing.
8) Inlet valve malfunction.
9) Exhaust valve malfunction.
10) Dryer inlet pressure.
11) Dryer outlet pressure.
12) Left chamber pressure.
13) Right chamber pressure.
14) Moisture indicator.
15) Heater on.
16) Adjustable heater thermostat.
7. Indicating lights shall be push-to-test.
8. Fail safe valve control mode to assure continuous supply of compressed air.
9. Provide optional controls to allow Owner to reduce purge air volumes in low flow applications.
10. Provide output for connection of common trouble alarm to the Owner control system.

2.5 AIR FILTERS

A. Pre-filter and Coalescing Pre-filter:
1. Located upstream of air dryer.
2. After filter:
a. Mounted downstream of dryer to capture desiccant or other particulate before they pass downstream.

B. Particulate Pre-filter:
1. 1.0 micron rating.

C. Coalescing Pre-filter:
1. 5.0 micron rating, 5 ppm(w) oil carryover.

D. Particulate After-filter:
1. High efficiency, 0.01 micron rating.
2. High temperature for heated air dryer applications.

E. Filter Elements:
1. Filter media compatible with mineral or synthetic oils.
2. Provide double O-ring seals.
a. Elastomeric.
b. Seal filter element to filter housing.

3. Support media inside and out.
4. Coalescing element:
    a. Rigid perforated sleeve for structural strength and an outer drain layer to permit oil and water to drain to bottom of element and not re-enter into air stream.

F. Filter Housings:
1. Aluminum construction, corrosion-resistant lining, side or bottom drain port to suit installation.
2. Housing shall be made so elements can be replaced without removing housing from piping.
3. Pressure rating: 300 PSIG.
4. Provide with integral differential pressure indicator.

G. Accessories:
1. Coalescing filters shall have electrical solenoid drain valve with adjustable timer for sequential operation.
2. Provide two sets of each filter cartridges, one installed in each housing for start-up, and one spare shipped with units.

2.6 VIBRATION ISOLATION

A. Vibration Isolation:
1. See Section 20 05 50.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Install equipment as indicated on Drawings and in strict accordance with manufacturers written instructions.

B. Install equipment on vibration isolation bases where specified elsewhere in the construction documents.

END OF SECTION

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SECTION 22 63 13
SPECIALTY GAS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Specialty Gas Systems, as indicated, in accordance with provisions of Contract Documents.

B. Systems Include:
   1. Inert cylinder or dewar source systems:
      a. Nitrogen (N2)
      b. Specialty Gas (SG) – owner defined
   2. Products:
      a. Gas panels.
      b. Specialty gas piping and valves.

C. Completely coordinate with work of other trades.

1.2 RELATED WORK

A. Refer to Mechanical Specification Divisions for the following:
   1. Pipe hangers and supports.
   2. Piping and equipment identification.
   3. Laboratory equipment.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Equipment drawings, showing materials of construction, features, and installation details.
   2. Submit piping system routing drawings and details prior to any material installation.

B. Product Data:
   1. Valve cut-sheets indicating materials of construction, leak rates, surface finish, testing and quality assurance procedures prior to ordering valves. Comprehensive reliability data (leak rate vs. service time) shall be provided.
   2. Manufacturer’s preshipment cleaning and packaging procedures for tube, fittings, and valves, along with samples thereof, prior to ordering. Identify chemicals to be used in the cleaning procedures. Describe cleaning procedures in detail. Cleaning procedures shall comply with or exceed specified requirements.
   3. Catalog information pertaining to automatic tube butt-welding system proposed for use.
   4. A definitive plan for the provision of a temporary clean room facility to be used on the site for prefabrication of sections of piping system in preparation for installation.
   5. Installation Quality Control and Field Quality Assurance procedures for review and approval by Owner prior to start of piping system fabrication.

C. Contract Closeout Information:
   1. Operations/Maintenance Manuals:
      a. Submit for Owner’s use, complete operating and maintenance manuals that describe proper operating procedures, maintenance and replacement schedules, component parts list, and closest factory representative for components and service.
      b. See Section 01 78 23.

1.4 PACKING AND SHIPPING REQUIREMENTS

A. Deliver products with manufacturer's quality assurance documentation stating, materials composition; mill test reports; certification of conformance report; testing and compliance with leak rate specifications.

B. Gas cabinets, gas panels, valve manifold boxes, regulators, and gauges shall be cleaned, packed, and shipped per manufacturer's standard procedures.

C. Piping:
   1. Piping ends shall be sealed with 1.75 MIL Aclar 33C wrap and low residue clean room tape under purged Nitrogen or Argon, then protected with hard plastic end cap.
   2. Double bag piping in heat sealed 6-mil polyethylene bags.
   3. Pipe shall be properly supported to prevent distortion during shipment.

D. Fittings:
   1. Immediately double package upon completion of cleaning operation each fitting separately in heat-sealed polyethylene bags purged with 0.01 um absolute filtered Nitrogen or Argon.

E. Valves:
   1. Supplied by manufacturer in a cleaned condition in accordance with approved procedures and individually double packaged in heat-sealed polyethylene bags purged with 0.01 um absolute filtered Nitrogen or Argon for shipment.

PART 2 - PRODUCTS

2.1 INERT GAS PANELS – AUTOMATIC SWITCHOVER

A. Acceptable Manufacturers:
   1. Base:
      a. Matheson - SwitchPro.
   2. Optional.
      a. Air Products.
      b. Praxair.

B. Inert gas panel design is based on a self contained, manifold package consisting of a sheet metal panel with piping and fittings, flex hoses, filters, sensing devices, purifiers, and mounting hardware for safe automatic delivery of non-hazardous gases to process use points.

C. Inert gas panel assemblies are designed for cylinder gas pressure regulation and control of 2 inert gas cylinders, one in use and one in standby.

D. Assemblies are designed for isolation of gas cylinders for cylinder changeover and new cylinder purge.

E. Inert gas panels shall have provisions for auto switchover to standby gas cylinder, allowing continuous, uninterrupted delivery of gas.

F. Piping:
   1. Refer to tubing and device requirements in this specification section.
   2. All piping, piping manifolds, and piping components shall meet the following as a minimum:
      a. The final outlet isolation valve shall have a 1/2 IN female VCR fitting on its outlet side.

G. Control System:
   1. Controllers: Inert gas panel controllers shall be of modular design allowing for easy maintenance and modification, including the following:
      a. Stand-alone capabilities to allow independent operation without the gas management system.
      b. History of events retention during loss of communication with the gas management system and automatic upload of process data when communications are restored.
      c. Easily removed or replaced for maintenance.
      d. Configurable from the gas management system and locally at the controller.
      e. Remote interface capabilities for communications link to gas management system.
      f. Local lockout of non-emergency remote control functions.
      g. User programmable parameters.

2. The inert gas panel controllers shall activate automatic shutdown on the following conditions:
    a. Overpressure downstream of regulator (regulator diaphragm failure).
    b. Excess gas flow.
    c. Detection of seismic activity per local, state and federal regulations.
3. The inert gas panels shall activate local audible/visual alarms on the following conditions:
    a. Low process cylinder pressure or weight.
    b. Low purge cylinder pressure.
    c. Auto shutdown/remote shutdown.
4. The inert gas panel controllers shall be fail safe by interrupting gas supply and closing all supply valves in the event of loss of electrical power or pneumatic pressure.
5. Each inert gas panel controller shall include:
    a. Independent alarm and shutdown capability through hardwired systems from external control signals.
    b. Externally mounted emergency stop buttons.

H. Electrical:
1. Inert gas panels shall be designed to operate on 120 VAC.
2. Provide RFI protection and/or shielding from RF interference a distance of one foot from the controllers from sources listed below:
    a. Two-way radio (walkie-talkie) transmission: 900 MHz, up to 4 watts energy output.
    b. Orbital Welding Equipment: 1 to 10 MHz, up to 25 kV voltage output.
3. Single grounding point shall be provided per equipment.

I. Instrumentation:
1. All wetted instrument elements shall be cleaned for high purity gas service, prior to installation. CFC based cleaners are not allowed.
2. All pressure transducers shall be gauge type. Pressure transducers shall be provided to monitor the following points as a minimum:
    a. Process gas; high pressure side.
    b. Process gas; delivery pressure.
    c. Vacuum pressure side.

2.2 INERT GAS PANELS – SINGLE CYLINDER

A. Acceptable Manufacturers:
1. Base:
    a. Matheson PAN-5100.
2. Optional:
    a. Air Products.
    b. Praxair.

B. Inert gas panel design is based on a self-contained, manifold package consisting of a sheet metal panel with all piping and fittings, flex hoses, filters, sensing devices, purifiers, and mounting hardware for safe automatic delivery of non-hazardous gases to the process use points.

C. Inert gas panel assemblies are designed for cylinder gas pressure regulation and control of 1 inert gas cylinder.

D. Piping:
1. Refer to tubing and device requirements in this specification section.
2. All piping, piping manifolds, and piping components shall meet the following as a minimum:
    a. The final outlet isolation valve shall have a 1/2 IN female VCR fitting on its outlet side.

E. Electrical:
1. Single grounding point shall be provided per equipment.

F. Instrumentation:
   1. All wetted instrument elements shall be cleaned for high purity gas service, prior to installation. CFC based cleaners are not allowed.

2.3 PRESSURE REGULATOR

A. Acceptable Manufacturers:
   1. Base:
      a. Tescom
   2. Optional:
      a. APTech.

B. Internal surfaces shall be 316L stainless steel electropolished to a 10 Ra average finish. Connection shall be VCR with pure nickel seal welded to the regular body by the manufacturer.

C. Regulator:
   1. 316L stainless steel body, Kel-F81, valve seat, 316 stainless steel diaphragm, stem, and seal disc.

D. Operating temperature minus 40 DEGF to 140 DEGF with a maximum rated inlet pressure of 3,500 PSIG and outlet pressure as required by process tool. Regulator shall incorporate an adjustable stop allowing a maximum outlet pressure to be limited to any valve between the maximum rated valve and 50 PCT of the maximum valve.

E. All regulators shall be 100 PCT inboard leak tested and certified to $1x10^{-9}$ am cc/sec. using helium.

F. Two pressure gauges shall be provided, 1 upstream and 1 downstream connected directly to regulator.

2.4 PRESSURE GAUGES

A. Acceptable Manufacturers:
   1. Base:
      a. Span.

B. Provide 2 IN dial face, mirror backed gauge with 316L stainless steel bourdon tubes, stainless steel movement, and VCR female gland connection with pure nickel gasket.

C. Mounting connection shall be bottom mounted.

D. Gauges shall be factory cleaned as stated herein and certified to meet a helium test $1x10^{-9}$ am cc/sec.

2.5 HIGH PURITY VALVES

A. Valves:
   1. Packless bellows or diaphragm type rated at 150 PSI minimum, provided with 316L stainless steel bodies, Kel-F seats, integral purge ports upstream and downstream of seat with VCR fitting caps, stainless steel bellows or diaphragm.
   2. Manufacturer shall use 60 DEGC hot DI water to clean for ultra high purity gas valves and ship to site in sealed, unopened, double polyethylene bags.
   3. Valve tube extensions shall be of the same heat number as piping material. Provide valves with the extensions sufficiently long to allow orbital welding with the following weld heads.

Pipe Size	Head Size
1/4 IN through 1/2 IN	3/4 IN (AMI 750)
3/4 IN through 1-1/2 IN	1-1/2 IN (AMI 1500)
2 IN through 2-1/2 IN	2-1/2 IN (AMI 2500)
3 IN	4 IN (AML 4000)

2.6 CLEANED-FOR-OXYGEN-SERVICE TUBING

A. Acceptable manufacturers:
   1. Tubing and butt weld fittings:
      a. Base:
         1) Cardinal.
      b. Optional:
         1) Valex.
         2) Advanced Micro Finish.
   2. Weld fittings from machined stock:
      a. Base:
         1) Microfit by Swagelok.
      b. Optional:
         1) Minibutt Weld by Parker.
         2) Mini Butt Weld (E series) by HTC.
   3. Compression fittings:
      a. Base:
         1) Swagelok by Swagelok.
      b. Optional:
         1) Let-Lok by HTC.
         2) A-Lok by Parker.
   4. Face seal fittings (used for purge assemblies and purge ports):
      a. Base:
         1) VCR by Swagelok.
      b. Optional:
         1) Vacuseal by Parker Hannifin.
         2) Face seal by HTC (E series greater than or equal to 1/2 IN OD, U series for others).

B. Carrier tubing:
   1. All tube shall be produced from ASTM Grade TP 316L (UNS S31603) stainless steel raw material. Tubing sized smaller than 1/2 IN shall be seamless; 1/2 IN and larger may be seamless or welded seam.
   2. Tubing shall be bright annealed at the producing mill in a dry hydrogen atmosphere (dew point <40 degrees Celsius) or vacuum annealed (10 micron HG) to a Rockwell 90 Rb maximum hardness.
   3. Elemental sulfur content shall be in the range of 0.005 to 0.017 percent.
   4. Interior surface finish shall have a minimum 180-grit finish or less than 30 Ra.
   5. "Clean-for-oxygen service" shall mean tubing free of visible contamination, which includes visible stains, discoloration, and pitting. The cleaning process shall meet NFPA 99, CGA 4.1, and ASTM G-93-88.
   6. Provide piping within a given size with the same heat number. Provide certification and test method used as part of tubing submittal.
   7. Seamless piping shall conform to the following:

			Permissible Variation		
Size (Inches)	ASTM No.	Wall Thickness	Diameter (Inches)	Ovality (Inches)	Wall Thickness (%)
1/2	A632	0.035	+0.004/-0.000	N/A	10 PCT
3/8	A632	0.035	+0.004/-0.000	N/A	10 PCT
1/2	A269	0.049	+/-0.005	+/-0.010	10 PCT
3/4	A269	0.065	+/-0.004	+/-0.010	+20 PCT-0 PCT
1	A269	0.065	+/-0.006	+/-0.010	+20 PCT-0 PCT
2	A629	0.065	+/-0.008	+/-0.010	+22 PCT-0 PCT
2-1/2	A269	0.065	+/-0.008	+/-0.010	+22 PCT-0 PCT
3	A269	0.065	+/-0.008	+/-0.010	+22 PCT-0 PCT

C. Fittings:
1. All fittings and components shall be equal in all respects to tubing specified above. This includes, but is not limited to, quality, properties, cleanliness, packaging, shipping, inspection, and quality assurance.
2. Tees: Compression “Swagelok” stainless steel fittings with silver plated front ferrule. Alternatively, tees may be fabricated by the drawn or pulled tee method, or using milling equipment to notch or drill the joining parts.
3. Elbows: Compression “Swagelok” stainless steel fittings with silver plated front ferrule. Alternately, manufactured long radius type with wall thickness and heat number the same as piping, or field bending of elbows is allowed with minimum 10x-tube diameter radius bends.
4. Welding: TIG welding method. Welds shall be flush and contain no pits or crevices. A smooth radii shall be present at the connection on both the ID and OD surfaces after final finishing. No undercutting of the external weld bead shall be allowed. Concavity of the external weld bead in excess of 10 percent of the wall thickness is not permitted. Wall thickness variations from the nominal value shall not exceed plus or minus 10 percent.
5. All manufactured components shall be cleaned after manufacturing and shall meet NFPA 99, CGA 4.1, and ASTM G-93-88.

2.7 CLEANED-FOR-OXYGEN-SERVICE VALVES

A. Acceptable manufacturers:
1. Mains and branches valves:
   a. Base:
      1) Whitey.
   b. Optional:
      1) Evans.
      2) PBM.
      3) SAES/Parker.

B. Valves:
1. Three piece ball type rated at 150 PSI minimum, provided with 316L stainless steel body and ball, reinforced PTFE seats, integral purge ports upstream and downstream of seat with VCR fitting caps. Stainless steel Swagelok mechanical fitting on valve outlet with cap.
2. Manufacturer shall use 60 DEGC hot DI water to clean for ultra high purity gas valves and ship to site in sealed, unopened, double polyethylene bags.

C. Leak test: For the outboard and across the seat test, pressure to 150 PSI with helium. There shall be no detectable helium with the contents of the bag using a helium detection device. Valves shall be tested for compliance with a leak rate not exceeding $1x10^{-9}$ $atm.cm^3/sec.$ across the seat.

D. Finish: Gas wetted surfaces shall be the same as for tubing.

E. Quality assurance: Delivered to Project with appropriate manufacturer's quality assurance documentation stating testing and compliances with leak rate specifications. Submit test and cleaning methodology to Owner and Engineer for review prior to shipment of valves. Traceability by heat lot of tube extensions will be required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install specialty gas equipment and devices where indicated on the Drawings and in accordance with the manufacturer's instructions.

B. Provide onsite testing, adjustment and demonstration of all installed equipment as required for complete and satisfactory operation.

C. Testing and adjustments shall be made by a factory certified technician, per certification procedure approved by the Owner's representative.

3.2 QUALITY ASSURANCE

A. The Owner has the option to provide its own and/or retain an independent third party Quality Assurance Representative (QAR) to monitor and inspect the installation of all process piping systems.

B. The Owners General Responsibilities:
1. Verify that all required examinations and testing have been completed and to inspect the piping and installation to the extent necessary to be satisfied that it conforms to all applicable examination requirements of applicable codes, engineering design and specifications.
2. Have access to any place where work concerned with the piping installation is being performed. This includes manufacture, fabrication, assembly, erection, examination, and testing of the piping. Owner shall have the right to audit any examination, to review all certifications and records necessary to satisfy applicable codes, design and owner specifications.
3. Maintain daily Quality Control Logs of work in progress, plus discrepancies.
4. Establish tracking, (paper document & PC based) for systems installation progress, analytical testing and systems buyoff.
5. Verify purge gas pressure and flow at the source and runs.
6. Assure that only approved materials are installed.
7. Observe installation methods and technologies to assure conformance to the manufacturer's installation instructions and project specifications.
8. Monitor cleanliness conditions of work area and tools.
9. Observe worker's daily performance.
10. Inspect and sign-off orbital weld joints.

C. The Owner's QAR has the right to select tube joints, which may be removed from installed systems or fabrication for random quality check inspections.

D. The Owner's QAR is authorized to stop work, via the General Construction Manager, when nonconforming work is observed or results of testing indicate improper installation.

E. If the Owner's QAR selects work for removal or testing which is subsequently found to be acceptable to the Owner, the Owner shall bear all costs associated with the removal, cleaning, re-cleaning, testing, re-testing, and installation of the removed or tested work. However, if the work is subsequently found to be unacceptable to the Owner per Design, Local Codes, manufacturer's installation requirements and/or specifications, the installer shall bear all said costs.

F. Daily Quality Control Provisions: (Piping Installer):
   1. Workers are to check in with signature.
   2. Provide a suitable caged material authorization point. Unused materials are to be returned daily.
   3. Maintain a daily log.

3.3 QUALITY ASSURANCE OF RECEIVED MATERIALS

A. Upon receiving any high purity process piping components, a visual inspection of the packaging shall be made to ensure all parts are double bagged and/or nitrogen purged and free from defects.
   1. Any parts having defective packaging shall be removed from inventory, and the part tagged DEFECTIVE. Tag and remove rejected material(s) from the approved materials area.
   2. A visual inspection shall be made on the components themselves after the packaging is removed to verify no contamination, discoloration, incomplete electropolishing, or any other cosmetic defects are detected on the part prior to installation.

B. Piping Samples: 6 IN long, taken from actual piping to be used for the Project, for each diameter involved and subjected to specified electropolishing/cleaning procedure. Randomly cut samples from 5 pieces or 10 PCT, whichever is greater, of random tubing lengths of approximately 20 FT-0 IN for examination. As a minimum, for 10 PCT of the material being inspected, a sample coupon shall be taken from the middle section for inspection. The lot shall be accepted if there are zero unacceptable samples from a given lot based upon surface anomalies, ovality and wall thickness. If there is one rejection in a lot, another 10 PCT will be sampled and any further rejections will result in rejection of the lot.

C. Fitting Acceptance: After fabrication, randomly select 5 pieces or 10 PCT (whichever is greater) of fittings from the lot for examination. The lot shall be accepted if there are zero unacceptable samples from a given lot. If there is one rejection in a lot, another 10 PCT shall be sampled and any further rejections will result in rejection of the lot.

3.4 WELDING EQUIPMENT AND TOOLS

A. Provide welding equipment and supplies which are needed to perform the work including but not necessarily limited to: power supply, properly sized welding heads, remote controls, collets, voltage regulators, surge suppressers and tack welders.

B. Properly maintain and care for welding equipment during the construction period.

C. Automatic orbital welders shall be used for all welding. While tubing is under dynamic purge, TIG welders may be used for skin tacking on tubing 3/4 IN and larger. Welders shall be certified for TIG as for orbital welding, per Paragraph 3.6 of this Section. All TIG tack welds must be 100 PCT consumed by the orbital weld.

D. Provide new, unused tubing cutters and wheels, de-burring tools, facing tool bits, for UHP piping system fabrication and installation, keep separate from other tools, and label or tag for "UHP SS PIPING ONLY".

E. At the start of each shift and as needed, clean tools and facilitating materials; i.e. tubing cutters and wheels, de-burring, facing, collets, bits, tape measure blades, purge PFA hose(s) and purge / facing hose connections, e.g. Teflon® / nylon ferrules. This includes any tool and/or facilitation component that has direct contact with UHP tube, fittings or UHP components. Clean with a mixture of 70 PCT DI and 30 PCT IPA and dry with filtered Argon or Nitrogen.

3.5 CLEANED-FOR-OXYGEN-SERVICE FACILITIES

A. All prefabrication work (including cutting, facing, bending, and welding) shall be performed in a Class 100,000 Clean Area and free from normal construction traffic. While cleaning may not be required after cutting, all possible care shall be taken to ensure spool piece remains free from contamination.

B. If a fabrication piece becomes contaminated, the QAR may require the piece to be cleaned using DI water.

C. The Clean Area shall be divided into two areas:
   1. "Prep area" for receiving and cutting tube for either subassembly work or direct installation in the tubing system in the field.
   2. "Subassembly area" for welding subassemblies of tube, valves, fittings, gauges, etc., for installation in the field. This area shall also be used for rinsing and cleaning of cutoff tube segments.

D. The Clean Area areas shall be equipped with pass-through windows with two sets of windows, one exterior and one interior, to permit transfer of materials with minimum impact to the air quality in the Clean Area.

E. All personnel entering the Clean Area shall only enter through the prep area (an emergency exit door shall be provided in the subassembly area). "Sticky" mats shall be used outside the main entrance. Immediately upon entering the Clean Area, all personnel shall don gloves, hair nets, and facial hair nets.

F. Provide filtered nitrogen (from a cryogenic source), high-purity, welding grade argon, and DI water.

G. Provide coordination with the Contractor for domestic water and power connection locations.

H. The Clean Area shall be of sufficient size to permit welding a fitting or valve on to the end of a 20 foot length of tube. The exhaust end of the tube may extend into the prep area during the weld operation in the subassembly area.

3.6 SHOP OR FIELD FABRICATION

A. Tubing used for connecting the various gases to the gas distribution system for welding, purging, and testing operations, and all purge, weld, test valves, lines, manifolds, etc. to be of the same quality as the system being constructed.
   1. For continuous field purging of installed runs and finished subassemblies, use electropolished SS tubing from the purge source valve to the .01um metal sintered filtered purge port connection. For shop or field spool fabrication, installer may use pre-cleaned PFA tubing with a filter at spool point of connection, however, PFA tubing cannot be longer than 20ft. in length. When not in use, purge lines must be capped under flow, or maintain a 5 cfh trickle/dynamic argon purge.

B. In addition to approved procedures and provisions stipulated in the Owner approved, installer’s "Field Quality Assurance Program" the following shall apply:
   1. Conduct qualification tests for the welding equipment and the welding operators prior to the start of system fabrication. All testing is subject to approval by the Owner's QAR.
   2. Submit a duplicate of the manufacturer's published operating instructions for the use of the welding equipment to the Owner's QAR for review and approval. Submit equipment weld-ability sample joints, for all sizes, to the Owner's QAR/QC for inspection prior to fabrication.
   3. Each welder shall be qualified by the installer’s QC with the Owner's field QAR present. The orbital butt-welding equipment and operator shall perform operations and qualifications in accordance with the approved equipment manufacturer's published information and written procedures. An approved weld joint shall be made by each welder for each material and wall thickness to be welded.

4. Each welder shall coupon in with two coupons at the beginning of each shift and coupon out at the end of each shift. In addition, replacement of weld heads, modification of weld heads, welder maintenance, or power interruptions will require a re-coupon. Starting and ending coupons must support all welds performed during the shift. The operator shall cut the coupons a minimum of 3/8 IN from the weld center to allow good visual inspection of the tube I.D. and heat-affected zone. At the time of coupon in or out, the coupon(s) heat number and purge flows must match the material being fabricated and/or installed. All coupons shall be logged with coupon number.
5. Each weld machine shall have a daily log sheet to verify machine setup, daily weld-head calibration, correct purge setup and coupon inspections. Logs shall be on cleanroom approved paper while working in a cleanroom environment. The welder and installer's QC must inspect and sign-off the log daily. Random inspection signoffs will be done by the Owner. Copies of logs shall be transmitted to Owners QAR for project archiving.
6. For installer and Owner QC viewing, weld coupons shall be dated and left with the weld machine. Store coupons in a protective poly-bag for the duration of the project.
7. All ink markings when measuring, cutting, bending, etc. must be removed from material prior to welding and/or installation.
8. Provide weld map of each system showing machine, welder, and weld head numbers. Update weld maps at the end of each shift.
9. Rejected Weld Criteria. Criteria for rejection of a weld are as follows:
    a. No visible Heli-arc tacks on the tube ID or OD after orbital welding.
    b. No undercut or profile defect causing the wall thickness to fall below that of the parent metal.
    c. Concavity / Convexity exceeds 10 PCT of the tube wall thickness.
    d. Penetration and bead width must be uniform throughout the entire weld, plus or minus 0.008 in.
    e. Bead meander must not exceed 25 PCT of the bead width.
    f. There should be no unusual inclusion or porosity when viewed with the unaided eye.
    g. Misalignment exceeds 10 PCT of the wall thickness.
    h. Tube OD color should be at a minimum.
    i. Tube I.D. color (haloing in heat effected area) should be at a minimum, no color is preferable.
10. The Owner's QAR reserves the right to suspend welding operations, for noncompliance with specified Owner approved procedures or standards.
11. The Owner's QAR reserves the right to request removal of any system welds deemed substandard or otherwise unacceptable. If, after removal, the weld proves to be substandard, installer will pay for replacements. If the weld is acceptable, the Owner will pay for replacement. Orbital weld inspections shall be based upon the above criteria.
12. For field bent tubing, if there is any kind of deformation of the tubing during bending, discard the bender immediately and replace the tubing.
13. Only one VCR gasket is to be used at one time VCR gaskets shall not be reused. Tighten VCR connection per manufacture recommendations.
14. VCR clamps shall be used on all valves and/or components that are not base-mounted and directly connected to each another.
15. Any VCR connected line or spool that transfers radial torque to valves and/or components shall have VCR clamps.
16. Support all UHP SS piping with plastic molded cush-clamps or approved equal. Support and hanger requirements shall be per Mechanical Specification Divisions.

C. Provide QC personnel to perform required inspections, testing and documentation while adequately monitoring all shop and field activities. Inspections shall include minimum bore scoping of 90 PCT of tubing sections. The Owner may provide full-time quality assurance representative(s) (QAR) relative to installation of the UHP piping system. QAR services shall be the responsibility of the Owner.

D. Upon acceptance of components and after having opened the package, maintain a minimal 5CFH Argon purge, or while under dynamic purge, seal the ends using plugs or caps until just prior to installation. Plugs and caps shall be either compression type with a PFA, Nylon ferrule or VCR on tubing up to and including 1 IN.

E. Maintain a continuous 0.01um metal sintered filtered Grade 6 Argon gas purge, minimum 99.9 PCT pure with verification from the Argon supplier, on piping system segments during cutting, facing, fabrication and installation. Purging based upon time and flow is acceptable up to 1-1/2 IN OD piping. For pipe greater than 1-1/2 IN, a portable hand held oxygen monitor reading ppm level is required. Purge O2 readings shall not exceed 10 ppm prior to welding.

F. For field QC verification, O2 monitors shall have copies of manufacturer's calibration requirements along with calibration log sheet(s) noting the calibration date, including the name of calibrator. Log and OEM sheets shall remain with the O2 monitor(s) at all times. Logs will be turned over to the Owner for project archiving.

G. Cut and face pipe using orbital cutter and facing tools, keeping pipe under purge during cutting and facing operations to keep pipe clean of any metal particles. Keep tools sharp and replace before "mushrooming" occurs.

H. Welding:
   1. Place a clean flow restrictor over the end of a piping segment for purging.
   2. A purge-base standard for line sizes 1/4 IN up to 1-1/2 IN OD; a minimum flow of 10 CUFTH for two minutes, per 1/8 IN diameter, per 20 FT length is required.
   3. 4 IN and larger diameter tube or pipe will require a non-shedding purge diffuser for adequate ID gas coverage.
   4. For accelerated purging, thus decreasing purge time requirements; increase the CFH on line sizes 1/4 IN up to 1-1/2 IN to the following:

      *Based upon 20 FT. linear footage

Tube O.D Diameter	Tube I.D. Flowrate	Purge Time
.250	15 CUFTH	2 Min.
.375	15 CUFTH	2.5 Min.
.500	20 CUFTH	3 Min.
.750	20 CUFTH	3.5 Min.
1.00	20 CUFTH	4 Min.
1.50	20 CUFTH	6 Min.

Purge Restrictor Size:

Tube O.D. Diameter	Orifice Size
3/8 IN and smaller	1/8 IN
1/2 IN up to 1-1/12 IN	1/4 IN
2 IN	3/8 IN
4 IN to 6 IN	1/2 IN
8 IN and larger	3/4 IN

   5. Once installation of a piping segment has begun, continue the inner Argon gas purge without interruption. As a minimum, adhere to the following purge requirements:
      a. Whenever possible, utilize systems in-line isolation valve purge ports for continuous purging.

b. It is important to consider the piping system layout when establishing the purge. The best method is to establish the purge at the source and fabricate the piping from this point to the point of use. Establishing the purge at one location also minimizes disturbances in the purge system.
c. For system overnight and/or weekend purging and for work left over from one shift to another, a plug or cap with no greater than 1/8 in. OD opening shall be placed over the purge restrictor with a minimum 10CFH continuous flow, or provide isolation valve and cap with piping sections maintained under positive pressure.
d. Make certain that purge exhaust flows are sufficiently vented to prevent build-up of inert gas in areas of possible gas entrapments, e.g. low elevation containment pit/basement and/or confined space areas. Since these gases are considered to be an asphyxiant, in certain cases, inert gases my need to be vented outside of building. For all areas in question, contact the Owner for review and approval.
e. Whenever possible, use isolation valve purge ports for continuous and shock purging. If ports aren't available, for line sizes 1-1/2 IN and larger, weld-on purge caps are required. For smaller sizes, compression purge caps can be used.
f. For continuous pipe runs 2 IN or larger, with vertical heights of 2ft. or greater, "shock purge" horizontal runs prior to installing vertical transition piping spool(s).
g. To prevent component failures due to metal shavings etc., prior to the installation of components and/or valves, a shock purge must first be done on the line the valve or component is installing to.

6. Provide flow meter to monitor all purges.

3.7 INSTALLATION OF FITTINGS, VALVES, AND COMPONENTS:

A. All components and fittings shall be installed by trained personnel using clean techniques and welding practices consistent with the tubing installation procedures described in this Specification.

B. Compression Fittings: Compression fittings are not permitted in the cleaned-for-oxygen-service gas systems, except for capping the unused ends of smaller valves and the sealing of outer containment lines, if shown on the Drawings.

C. Mechanical Joint Fittings:
1. Mechanical joint fittings in Hydrogen systems are only allowed inside a vented and monitored Valve Manifold Box, or on connection to the Hydrogen Tank in an exterior, and open to atmosphere gas pad location.
2. Mechanical fittings may only be used for connection of gauges, sensors, purge ports, etc., that require frequent removal and/or replacement for calibration or service. Except for gauges and purge ports, the location and intended use of all mechanical fittings shall be submitted and approved by the Contractor prior to purchase. Mechanical fittings shall be precleaned for cleaned-for-oxygen service and sealed in nitrogen-purged plastic bags prior to shipment.
3. Protect gland faces from damage when making trial connections by using unplated nickel gaskets to verify piping configurations. Never touch the surfaces of the glands or the gaskets.
4. Make sure faces of sealing surfaces are clean and that no visible signs of contamination are present. If contamination exists, remove with a Alpha-Wipe and then blow off with purge gas.
5. Make all necessary rotational alignments prior to tightening finger tight. Do not permit the faces of the sealing surfaces or the gasket to rotate during the tightening process.
6. Finger tight must be achieved, so gently wiggle the fitting or tubing alignment while continuing to ensure finger tightness.
7. Gland surfaces must be parallel and tubing axis must be in line when making up final connections. It is very important that both sides of the connection have good centerline (axial) alignment before the connection is made.

8. Bulkhead Joints: Fittings for pass-through of the tubing into an enclosure or equipment housing shall be a mechanical bulkhead compression union, 316 stainless steel, bored-through, nylon-ferruled compression fittings of the size appropriate to the outside diameter of the process gas tubing. The tubing shall pass directly through the fitting with no connections or welds. Alternatively, a VCR bulkhead fitting may be used.

D. Manual Valves:
   1. Valves shall be located to allow space to operate the valve handle and connect to purge ports after installation in the field.
   2. Valves shall be installed using clean techniques and welding practices consistent with this document.
   3. All valves shall be cycled five times after being welded to pipe segment, while in the subassembly area, and while under purge. Cycling shall be the process of gently turning to the full open position and then back to the full closed position.
   4. Caps on valve extensions for future connection shall be welded for pipe diameters greater than or equal to 3/4 inch and Swagelok compression fittings with silver-plated stainless front ferrules (factory degreased and cleanroom packaged) for pipe diameters less than 3/4 inch. This only applies to systems which are going to be extended within 1 month, otherwise they shall be welded. Purge and fill end cavity with argon after installing caps.

3.8 GROSS LEAK TEST – (PRESSURIZATION TEST)

A. A gross leak test shall be performed by the Installer on all new or repaired process piping installations.

B. Prior to beginning the gross leak testing, the Contractor, Installer, and Owner shall complete a walk-through of the entire system to verify that the drawings and diagrams have been followed for the fabrication and installation of said lines. During the walk-through, verify craftsmanship (plumb / square / uniformity), as well as verifying that pipe supports, pipe labeling and analytical tags are in place.

C. Use 0.01 um metal sintered filtered and regulated Argon for pressurization of the piping systems.

D. Maintain the system at static pressure of 150-PSIG minimum, (200-PSIG maximum) for a period not less than 24 HRS.

E. Test pressure gauges to be non-particulating, mirrored background with 1psi graduation.

F. Any loss of pressure (- 1PSIG) indicates a leak in the piping system.

G. Locate the leak(s) using approved Helium Leak Detector and approved leak detection procedures, repair the leak, re-pressurize the line, and restart the check.

   Note: Do not use liquid for leak detection.

H. If there is no pressure loss, allow the test to remain for 24 HRS from the first initial reading. The results of any checks that are made must be documented. All testing to be witnessed and signed-off by the Owner. Test documentation shall be turned over to the Owner for project archiving.

I. When outer containment piping is installed in the piping system, provide gross leak testing as stated above on all containment piping.

J. Upon completion of the Gross Leak test procedure, recharge the line to 10 PSI with 0.01 um metal sintered filtered and regulated Argon, then close all valves starting at the farthest point from the Argon source. When the line is sealed, maintain the system in this condition until the Shock Purge process is performed.

K. If UHP Specialty Gas lines (single or coaxial) are designated as spare lines for future use, if lines are not connected to isolation valves per design, but terminate outside of exhausted valve boxes, cabinets and/or inert panels. Install permanent end of line UHP valves with UHP 0 to 30psi pressure gauges for 10psi inert static pressure monitoring. Valves with gauges shall be placed on spare lines within the gas bunker areas.

3.9 SHOCK PURGE

A. A shock purge (sometimes referred to as a pulse purge) shall be performed by the Installer on all new or repaired process piping installations using approved purge procedures.

B. The purge shall consist of a minimum 100 PSI, 10-cycle (one minute per cycle) purge flow, starting from the valve closest to the source and proceeding downstream through mains, branch lines, and equipment isolation valves.

C. Use 0.01 um metal sintered filtered and regulated Argon for purging of the piping systems.

D. The Argon must not come from an existing house or bulk gas system source, unless approved by the Owner.

E. On lines sizes 1-1/2 in. and larger: Midway through the system's shock purging 10-cycle sequence, piping walls must be moderately tapped, using a non-destructive / non-dimpling type rubber mallet. Line tapping is required throughout the entire line system.

F. Never allow the purge pressure to drop below 5 PSIG or reach atmospheric pressure when cycle purging line.

G. Upon completion of the shock purge cycling, and before turning the line over for acceptance testing, recharge the line to 10 PSIG with .01um filtered Grade 6 Argon, closing all valves starting at the farthest point from the Argon source. When the line is sealed, maintain the system in this pressure condition until Acceptance Testing is performed.

H. Prior to any testing, hang white, cleanroom approved, “Gas line Installation and Qualification Tags”.

I. Tag Placement:
1. All end-of-mains / branches and equipment isolation valves.
2. All gas lines prior to entering exhausted gas box or equipment enclosures.
3. All gas lines exiting component / valve exhausted gas box enclosures.
4. All gas lines prior to inert manifold panels and lines exiting inert panels.
5. All source gas lines exiting a gas cabinet.

J. Tag Format:
1. White lettering on black background

GAS LINE INSTALLATION
AND QUALIFICATION TAG
Line Number: ____________________
Installed By: _____________________
Date: ________
Gross Leak Tested by: _____________
Date: ________
Shock Purged by: _________________
Date: ________
Helium Leak Checked by: ___________
Date: ________
Particle Checked by: _______________
Purity Tested by: __________________
Date: ________
*** Please Do Not Remove***
White lettering on red background.

2. Fill out tags with a Black Sanford Sharpie pen.
   A. Note: The installer(s) performing the tasks to sign-off applicable tag sections as installation or testing is COMPLETED.

3.10 PIPING SYSTEM IDENTIFICATION

A. Colors will be used to identify the characteristic hazards of the contents.

B. Labeling to be completed by the end of every workday.

C. The Owner will provide specific line numbering for all specialty gases. Numbering will denote source supply and all distribution transitions. Specific line-number label placement shall be adjacent to legend pipe labels and arrows.

D. Labeling is to be consistent with Mechanical Specification Divisions.

E. Labeling Legend(s) shall be provide by the Owner.

3.11 ANALYTICAL TESTING AND CERTIFICATION

A. Testing Steps: All new or repaired process piping shall be tested by the Owner before the materials or work can be accepted as certified and/or placed into service. The Owner shall test and qualify in the following sequence:
   1. Particulate Testing
   2. Helium Leak Testing
   3. Purity Testing

B. Final analytical testing will be performed by an Owner supplied testing organization independent of the installer.

C. Certification is performed by recording test data and completing required documentation when tested materials pass each testing step.

D. Prior to beginning analytical testing and certification steps, Owner will verify that piping and components have been gross leak checked, shock purged, and the Gas Line Installation and Qualification Tag has been filled in correctly.

E. Owners OAR must observe all tests.

3.12 PARTICULATE TEST

A. Approved particulate test shall be performed by the Owner before the materials or work can be accepted as certified.

B. Prior to beginning particulate testing the Owner will verify that piping and components have been gross leak checked, shock purged, and the Gas Line Installation and Qualification Tags in place.

C. Particle Testing – Minimum General Requirements:
   1. The particle test of the gas line must cycle a volume of gas through the line and measure the amount of particles in that volume. The test cycle consists of charging the line to line pressure no less than 30 PSI and then discharging the line through an approved laser gas particle counter.

D. Particle Testing – Minimum Documentation Requirements:
   1. Document the particle counts that accumulate during the cycle purge and stabilization period.
   2. All particle documents including counts from components that fail the particle testing specifications shall be transmitted to the Owner for review.

E. For a line or component to meet qualification requirements, particle must be less than 10 counts at .2um per purge cycle for minimum 5 consecutive sample intervals.

F. If a component fails to qualify after the maximum 20 sample intervals, cycle purge the component and re-perform the particle testing. If the component fails to qualify the second attempt schedule time for replacement of the component.

G. If a line fails, cycle purge the line. If a line fails to qualify after the second attempt, the line shall be tested in segments to isolate the failure. The segment shall then be repaired / replaced. Particle testing shall resume on that line as well as for the entire system (combined segments).

H. Owner shall have the right to be present and witness the particulate testing operation.

I. If a particle count reveals that a sampled point does not comply with specifications, Owner will retest said point. If a second testing of that point also indicated noncompliance, Owner shall determine the extent of the segment in the system to be removed and replaced as a result of noncompliance. The installer shall be held responsible for all costs incurred in performance of corrective action taken, including costs associated with re-testing of the system until acceptable. No waiving of testing allowed.

J. Upon successful completion of the particle test procedure, recharge the line to 10 PSI with Argon, closing all valves starting at the farthest point from the Argon source. When the line is sealed, maintain the system in this pressure condition until the Helium Leak Testing is to be performed.

K. Confirm all testing data has been recorded accurately and complete required certification documentation.

3.13 HELIUM LEAK TEST – CARRIER TUBING

A. An approved Helium leak test shall be performed by the Owner before the materials or work can be accepted as certified. Testing includes double containment lines.

B. Prior to beginning Helium Leak testing, Owner will verify that piping and components have passed the analytical particle test, and the Gas Line Installation and Qualification Tag has been filled correctly.

C. Use 0.01 um metal sintered filtered and regulated Helium for pressurization of the piping system between 90 - 100 PSIG.

D. The piping system must hold static pressure for a period not less than 24 HRS after initial pressurization. Any loss of pressure indicates a leak in the piping system.

E. Locate all leaks using an approved Helium Leak Detector, and approved helium leak detection procedures.

Note: <u>Do not use liquid</u> for leak detection.

F. The installer must repair all leaks. If lines require cutting, insertions and re-welding, the line must again be shock purged and all testing repeated.

G. Upon successful completion of the Helium Leak Testing, recharge the line to 10 PSI with 0.01 um metal sintered filtered and regulated Argon; closing all valves, starting at the farthest point from the Argon source. When the line is sealed, maintain the system in this condition until the Purity Test is to be performed.

H. Confirm all testing data has been recorded accurately. Complete required testing/certification documentation and transmit to the Owner.

3.14 PURITY TEST - CARRIER TUBING

A. An approved purity test shall be performed by the Owner before the materials or work can be accepted as certified.

B. Prior to beginning Purity testing; Owner will verify that piping and components have passed all prior testing and the Gas Line Installation and Qualification Tags have been filled in correctly.

C. Perform flow purge to evacuate all Helium from source to point of use using 0.01 micron filtered and regulated Nitrogen or Argon.

D. Test equipment to be used for analytical purity testing must be approved for use.

E. Moisture, 02, CO, CO_2, CH_4: System outlet gas impurities for each constituent shall increase by not more than 20 ppb over the source gas measurement to meet test acceptance specifications. The source gas is targeted at 20 ppb impurities.

F. If a gas analysis reveals that a sampled point does not comply with specifications, in the following paragraph, shock purge and retest said point. If a second testing of that point also indicates noncompliance, the Owner shall determine the extent of the system to be replaced as a result of noncompliance. The procedures to be followed for such remedial action shall be in strict accordance with these specifications. The installer shall be held responsible for all costs incurred in performance of corrective action taken, due to non-compliant piping segments including costs associated with re-testing of the system until acceptable.

G. Purity Level acceptance for UHP Process Piping
1. O_2 <40 PPB MAX w/ delta relative to source <20 PPB
2. H_2O <40 PPB MAX w/ delta relative to source <20 PPB
3. CO <40 PPB MAX w/ delta relative to source <20 PPB
4. CO_2 <40 PPB MAX w/ delta relative to source <20 PPB
5. THC <10 PPB MAX

H. Upon successful completion of the Purity Test, recharge the line to 10 PSI with 0.01 micron filtered and regulated Nitrogen or Argon. Close all valves starting at the farthest point from the Nitrogen or Argon source. When the line is sealed, maintain the system in this condition until the line is to be put into operational service.

I. Confirm all testing data has been recorded accurately and complete required certification documentation.

3.15 LEAVE-BEHINDS

A. Owner is willing to negotiate purchase of equipment at conclusion of construction based on pre-arranged terms. Clean all welding equipment and hand tools used during construction, assure good operating condition, and then turn over to Owner.

END OF SECTION

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SECTION 22 63 21
LIQUID NITROGEN PIPING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Liquid Nitrogen Piping System, as indicated, in accordance with provisions of Contract Documents.

B. Scope of Work includes:
   1. Storage tank(s).
   2. Ambient vaporizer(s).
   3. Vacuum-jacketed liquid nitrogen piping system(s).
   4. Phase separator(s).

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Installer qualifications: Manufacturer, of reputable, established organization regularly engaged in supply and servicing liquid nitrogen piping systems, including providing engineering services.

B. All liquid nitrogen system components shall be furnished by a single supplier.

C. All materials used in the system shall be compatible with the cryogenic service requirements.

D. The system shall be designed to minimize heat gain to the liquid nitrogen and the volume of nitrogen vaporized.

E. Seismic design criteria: See Section 20 05 00.

1.3 RELATED WORK

A. Work by Others shall include;
   1. Liquid nitrogen storage tank(s) shall be supplied and installed by Air Products.
   2. Ambient vaporizer(s) and switching unit shall be supplied and installed by Air Products.
   3. Gaseous pressure control manifold shall be supplied and installed by Air Products.

B. Refer to other Mechanical Specification Divisions for:
   1. General mechanical requirements.
   2. Pipe hangers and supports.
   3. Piping identification.

C. Refer to Electrical Specification Divisions for electrical requirements.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Tank layout, including foundation support drawings and details.
   2. Piping schematics.
   3. Liquid nitrogen piping layout at 1/4 IN scale.

B. Product Data:
   1. Storage tank.
   2. Vaporizer, including performance data.
   3. Pipe and fittings.
   4. Valves.
   5. Accessories and gauges.
   6. Vacuum pump.
   7. Phase separator.

8. Electronic liquid level control console.

C. Contract Closeout Information:
1. Test reports.
2. Operation and Maintenance Data.
3. Local service office and response time for service.

1.5 DELIVERY, STORAGE, AND HANDLING

A. The Manufacturer shall be solely responsible for the adequacy of the preparation for shipment provisions employed with respect to materials and application.

B. Equipment and components shall be completely free of water prior to any shipment preparation.

C. Adequate protection shall be provided against mechanical damage and atmospheric corrosion in transit.

D. All instruments and valves, including auxiliary systems, must be securely mounted and/or supported to eliminate damage during shipment, and storage.

E. Supports and rigging connections shall be provided to prevent damage during lifting or unloading.

F. Protection of Piping Connections:
1. All flange faces shall be protected by securely fastened blind flanges to prevent damage and contamination during shipment.
2. Threaded connections shall be provided with a pipe plug of the same material as the connections. Plugs shall have a hex head. Only 100 PCT Teflon tape shall be used as thread sealant.
3. Opened ends of tubes and pipe shall be capped (taping alone is not adequate) for protection, and double wrapped to minimize contamination.

G. Piping connections between factory-fabricated vacuum jacketed piping spools shall be match marked to agree with the manufacturer’s submitted piping plan drawings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Storage tanks:
1. Base:
   a. Chart / MVE.
2. Optional:
   a. Taylor-Wharton.

B. Ambient vaporizers:
1. Base:
   a. Chart / MVE.
2. Optional:
   a. Thermax.

C. Piping system and components:
1. Base:
   a. Cryotech / Vacuum Barrier Systems.
2. Optional:
   a. Vacuum Barrier Corporation.
   b. Chart / MVE.

2.2 MATERIALS - GENERAL

A. Components used in the liquid nitrogen distribution system shall be products of a single manufacturer and shall be marketed collectively as a system. Materials used in the system shall be compatible with the low temperature service requirements.

B. Field fabrication of major components, or acquisition and use of components from multiple manufacturers is not acceptable.

2.3 STORAGE TANKS

A. Provide liquid nitrogen storage tanks as indicated on the drawings.

B. Tanks shall be designed to 250 PSIG Maximum Allowable Working Pressure.

C. Tanks shall be complete with the following accessories:
   1. Fill, liquid outlet, and vapor outlet connections and piping.
   2. Pressure building coil.
   3. Economizer.
   4. Pressure safety relief valves.
   5. Outer vessel vacuum readout.
   6. Pressure and level indicators.

2.4 AMBIENT VAPORIZERS

A. Provide ambient vaporizers as indicated on the drawings.

B. Vaporizers shall be sized to deliver the ____ SCFM continuous flow for 10 day period before freezing.

C. Vaporizers shall be complete with the following:
   1. 450 PSIG Maximum Allowable Working Pressure.
   2. All aluminum construction.
   3. Inlet and outlet connections.
   4. Supports.
   5. Automatic switchover controls, for multiple vaporizers, with adjustable timed period.
   6. Standard industrial gas service pressure control manifold.

2.5 FLEXIBLE DYNAMIC PIPING SYSTEM

A. General:
   1. Provide a complete flexible dynamic vacuum-jacketed piping system as indicated on the drawings, including pipe, fittings, valves, accessories, and vacuum pump.

B. Double Wall Pipe:
   1. Two concentric, corrugated stainless steel tubes, separated by a Teflon spacer.
   2. The spacer shall be in the form of a ribbon, twisted on its own axis, and wrapped in a helical configuration in the annular space between the two tubes.
   3. The exterior surface of the outer tube shall be coated with a braided outer cover.
   4. The annular space shall be continuously evacuated by a vacuum pump capable of maintaining a dynamic vacuum of 0.01 microns absolute or better.

C. Vacuum Pump:
   1. The vacuum pump shall be an air-cooled oil diffusion pump, two-stage mechanical fore pump, and cooling fan mounted on a compact base.
   2. The pump shall have a continuous vacuum capacity of 0.01 microns absolute or better.
   3. The vacuum pump shall operate with single-phase 110V, 7A, 60 HZ power supply.
   4. Basis of design: Cryotech/VBS Millitorr High Vacuum Pump.

D. Vacuum Gauge:
   1. Digital readout gauge, cabinet mounted, adjustable set point, 0 to 100 millitorr range, 6 FT power cable, 10 FT gauge tube cable. Used in conjunction with a gauge sensing tube.
   2. Basis of design: Cryotech/VBS 906.

E. Valves and accessories:
   1. All valves and accessories shall be suitable for use with the other system components and shall be products of the system manufacturer.

2.6 FLEXIBLE STATIC PIPING SYSTEM

A. General:
   1. Provide a complete flexible static vacuum-jacketed piping system as indicated on the drawings, including pipe, fittings, valves, and accessories.

B. Double Wall Pipe:
   1. Two concentric, corrugated stainless steel tubes, separated by a Teflon spacer.
   2. The spacer shall be in the form of a ribbon, twisted on its own axis, and wrapped in a helical configuration in the annular space between the two tubes.
   3. The exterior surface of the outer tube shall be coated with a braided outer cover.
   4. The annular space shall be evacuated and sealed at the factory.

C. Valves and accessories:
   1. All valves and accessories shall be suitable for use with the other system components and shall be products of the system manufacturer.

2.7 RIGID STATIC PIPING SYSTEM

A. General:
   1. Provide a complete rigid static vacuum-jacketed piping system as indicated on the drawings, including pipe, fittings, valves, and accessories.

B. Pipe and Fittings:
   1. Inner carrier:
      a. The design and manufacturing of the vacuum insulated pipe shall be in accordance with ANSI B31.3 - Chemical Plant and Petroleum Refining Piping and latest applicable addenda for 150 PSI.
      b. Material shall be "INVAR 36 IN or 304 stainless steel, ASTM-A312 pipe, welded or seamless.
      c. Flow rate and size shall be as Indicated on Drawings.
      d. Pipe ends shall be bayonet joints for joining spools and as specified on Drawings at use point(s).
   2. Vacuum jacket:
      a. The vacuum jacket shall be designed in accordance with the ASME Code for Unfired Pressure Vessel, Section VIII for an internal vacuum and external atmospheric pressure with the assembly at ambient temperature.
      b. Material shall be 304 stainless steel, ASTM-A312 welded pipe.
      c. Expansion joints (NOTE: Only required when stainless steel inner carrier is used). Shall be installed in the inner pipe of each spool as required to compensate for the differential rates of expansion and contraction between the inner carrier and jacket pipe.
         1) Material: Type 304 stainless steel with Type 304 stainless steel ends for butt welding.
         2) Design: Normal movement with minimum design as follows:
            a) External pressure: 20 PSI with internal vacuum
            b) Internal pressure: 35 PSI
            c) Cycle life: 5000 cycles
   3. Spacers:
      a. The inner carrier shall be supported within the jacket by a support system designed to absorb thermal loads on the inner pipe when partially or completely filled with product, to minimize heat leakage, withstand loadings (a, b, and c below) during shipping and loading, and (d) during and after installation:
         1) Three "g" load applied vertically downward.
         2) Three "g" load applied vertically upward.

3) Two "g" load applied horizontally, longitudinally, or laterally combined with one "g" load vertically downward.
4) When inner liner is filled with Trichlorethylene, meet uniform building code for Zone 3 seismic requirement or higher. Coordinate with seismic requirements.

4. Laminar Radiation Shielding:
   a. The inner line shall be "super insulated" with a minimum of fifteen alternate layers of aluminum foil and Dexter glass fiber paper.
5. Chemical Gettering System:
   a. Each spool shall have molecular sieve and a hydrogen converter installed in the vacuum annullus for the purpose of removing the majority of vacuum contaminants released by outgassing. The quantity of sorption pumping materials required for each spool section shall be determined by the manufacturer.
6. Evacuation Port:
   a. Each spool shall be equipped with a combination evacuation/relief valve port complete with a Hastings DV-6R vacuum transducer for monitoring the vacuum level without breaking into the vacuum annulus.
      1) Location shall be in an approved location or approximately centered on each spool with consideration to personnel safety, accessibility, and non-interference with other equipment.
7. Manufacturing:
   a. Shall be accomplished through the use of certified welders. Welder's certification to be submitted upon request.
8. Evacuation:
   a. Heat shall be applied during pumping to accelerate outgassing. Minimum temperature shall be 200 DEGF. Spools to be sealed at less than 10 microns.
   b. Means shall be employed on the vacuum pumping system to prevent oil from backstreaming into the spool vacuum space.

C. Valves and accessories:
   1. All valves and accessories shall be suitable for use with the other system components and shall be products of the system manufacturer.

2.8 TRIAXIAL PIPING SYSTEM

A. The triaxial piping system shall be used for tool feed from the phase separator. The inner tube shall carry liquid nitrogen to the use point, and the surrounding annulus shall carry nitrogen in the liquid and vapor form back to the phase separator.

B. The triaxial piping system shall consist of three concentric, stainless steel tubes. The outer two tubes shall be corrugated and shall be separated by a Teflon spacer. The inner tube shall not be corrugated.

C. The spacer shall be in the form of a ribbon, twisted on its own axis, and wrapped in a helical configuration in the annular space between the outer two tubes.

D. The exterior surface of the outer tube shall be coated with a clear PVC heat shrink wrap.

E. The annular space between the outer two tubes shall be continuously evacuated by a vacuum pump capable of maintaining a dynamic vacuum of 0.01 microns absolute or better.

2.9 PIPING FITTINGS

A. The available fittings shall include, but not be limited to, bayonet connections, elbows, crosses, tees, and end terminations.

B. All fittings shall be of dimensions commensurate with the piping to which attached and shall possess the same vacuum insulating qualities.

C. End terminations shall be suitable for the designated individual application, and shall include an end with proper thermal isolation.

D. Where appropriate for dynamic piping system, the end terminations shall have a pump-out port for the maintenance of vacuum.

E. Where appropriate for dynamic piping system, bayonet connections shall contain connections on each vacuum port to which a metal jumper hose can be attached to permit the dynamic vacuum to be continuous around the fitting.

2.10 VALVES

A. All valves shall be suitable for use with the other system components.

B. Manual liquid nitrogen shut-off: Stainless steel, 145 PSI maximum operating pressure, non-rising stem, vacuum jacketed, bayonet connections, manual operation.

C. Automatic liquid nitrogen shut-off: Stainless steel, 145 PSI maximum operating pressure, non-rising stem, vacuum jacketed, bayonet connections, pneumatic operation, solenoid actuated, 115 Volt, 60 Hz.

D. Vacuum shut-off, for dynamic piping system: Brass, 1/4 turn, Teflon seals, Viton o-ring stem seal, integral annullus relief valve, two plugged DN6 female NPT taps, VF-25 flanged end connections.

E. High vacuum solenoid, for dynamic piping system: Brass, continuous duty normally closed solenoid actuator, Viton o-ring seals, 115 Volt, 60 Hz.

F. Back pressure regulating: Stainless steel and brass globe valve assembly, Teflon seats, vacuum jacketed, bayonet connections (liquid nitrogen), VF-25 flanged connections (vacuum).

G. Relief: Stainless steel, NPT end connections.

2.11 PIPING ACCESSORIES

A. All accessories shall be suitable for use with the other system components.

B. Provide pressure gauges suitable for cryogenic service, with a range of 0-200 PSIG. Provide a gauge at each liquid nitrogen supply valve.

C. Provide in-line mechanical float type venting devices, with vent heater, at all high points of the liquid nitrogen piping system, to keep the piping system continuously wetted with liquid nitrogen.

D. Provide safety relief valves in each segment of liquid nitrogen piping that can be isolated by shutoff valves.

E. Provide gas trap assemblies at each liquid nitrogen point of use and end of line, to reduce the liquid losses when the liquid nitrogen is not flowing.

2.12 PHASE SEPARATORS

A. The phase separator shall be a horizontal, vacuum insulated dewar type vessel fabricated of stainless steel and shall include an inlet bayonet connection, an automatic valve, an inlet relief valve, a reservoir relief valve, a vacuum zone valve, and a vent terminating in a male bayonet connection.

B. Provide vacuum pump with digital vacuum readout meter for each phase separator.

C. Separator shall be designed to vent gaseous vapor at the top of the separator to the atmosphere at a pressure of approximately 1 atmosphere.

D. Maximum liquid nitrogen inlet pressure: 150 PSI (10.34 BAR).

E. Outlets:
   1. Phase separator shall have eight (8) liquid outlet connections.

2. Liquid nitrogen shall be dispensable by gravity from the bottom of the separator through the inner tube of the triple wall pipe to the end termination at the point of use. The pressure in this portion of the system shall be approximately equal to the hydrostatic head from the phase separator to the point of use.

F. Controls:
1. Phase separator shall be provided with a complete and functional control system.
2. System shall control supply of liquid nitrogen to the phase separator with a pneumatically operated valve governed by a solenoid valve. The solenoid valve shall respond to electrical signals from a sensor probe in the phase separator to maintain the liquid level at essentially atmospheric pressure.

2.13 ELECTRONIC LIQUID LEVEL CONTROL CONSOLE

A. Used in conjunction with the phase separator to regulate the liquid nitrogen level, and to monitor system vacuum.

B. The liquid nitrogen portion shall contain the following features:
1. "FILLING" Light. Light shall latch ON as the as the liquid level falls through the LOW level setting, and shall latch OFF as the liquid level rises through HIGH level setting.
2. Five liquid level lights as follows: - EMPTY - MIN. LEVEL - LOW LEVEL - HIGH LEVEL - OVERFLOW.
3. OFF/ON switch controlling only this portion of the console.

C. The vacuum portion shall contain the following:
1. Vacuum gauge with adjustable set point.
2. System alarm light set to annunciate when the system vacuum rises above the set point.

D. The console shall incorporate a control circuit to the phase separator fill valve. In the event that the OVERFLOW setting is reached, the control circuit shall disconnect the fill valve until such time as the liquid level drops below the overflow level.

PART 3 - EXECUTION

3.1 FABRICATION

A. Minimize the quantity of connections by making the sections of piping as long as practical while maintaining functionality.

B. To the greatest extent possible, achieve corners by bending the pipe. The arc of the bend shall not be less than the minimum bend radii specified by the piping manufacturer.

C. Design the installation such that the pressure of the liquid nitrogen supply shall not exceed 30 PSI.

3.2 TANK AND VAPORIZER

A. Install the storage tanks and vaporizers in accordance with the manufacturer's instructions.

B. Provide common tank fill connection assembly with fill piping to each tank, as indicated on the drawings.

3.3 PIPING

A. Install the complete system in accordance with the Contract Documents, and the requirements of the system manufacturer.

B. For dynamic piping system, install vacuum pumps on vibration isolation bases, where indicated on the drawings or where directed by the Owners Representative.

3.4 PHASE SEPARATOR

A. Install in the ceiling space where indicated on the drawings, and in accordance with the manufacturers written installation instructions. Install in a level condition. Do not install with obstructions within 3 FEET of the exhaust vent.

B. Install an end trap and bypass ahead of each end termination to permit liquid and gas to return to the phase separator through the annular space between the inner two tubes of the triple wall pipe.

C. Route vent piping to the outside, or as indicated on the drawings.

3.5 VALVES

A. Install high vacuum solenoid valves in the upright position.

B. Install an annulus relief valve on the system side of the vacuum connection.

C. Install a vacuum ball valve on the system side of each annulus relief valve.

3.6 SUPPORTS

A. Provide supports in quantities and types required by the piping system manufacturer.

3.7 TESTING

A. Prior to shipment to the site, factory cold-test the complete system vacuum integrity using liquid nitrogen. Manufacturers shall perform pressure tests on storage tank, vaporizer and phase separator.

B. For dynamic piping system, leak test the installed system with helium and a mass spectrometer to a sensitivity of 1 x 10 -9 standard cubic centimeters of helium per second at each joint.

C. The Owners Representative shall be provided the opportunity to witness any factory testing. Provide the Owner at least 1 week advance notice of any factory testing.

D. Vacuum Retention Test (Static System Only):
   1. Each spool shall be tested over a two day period with the spool isolated from the pump at ambient temperature. The pressure in the annual space shall be measured every 24 HRS and recorded. Spools will be acceptable if:
      a. There is a pressure rise of eight microns or less. A pressure greater than eight microns will require one additional day of vacuum retention. The line shall be considered acceptable if the third day's reading indicated the vacuum is stable.
      b. The maximum stabilized pressure before shipping is 35 microns. (Consult factory for seven day or greater retention).

END OF SECTION

DIVISION 23

HEATING, VENTILATING, AND AIR CONDITIONING

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SECTION 23 08 00
COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 01 91 13 – Commissioning General Requirements

C. Section 25 08 00 – Commissioning of Integrated Automation Systems

D. Section 26 08 00 – Commissioning of Electrical Systems

E. Commissioning Plan

1.2 DESCRIPTION OF WORK

A. The purpose of this section is to specify the Division 23 responsibilities and participation in the commissioning process. All contractors responsible for Division 23 installation or other activities shall have commissioning responsibilities described herein.

B. Work under this contract shall conform to requirements of Division 1, General Requirements, Conditions of the Contract, and Supplementary Conditions. This specification covers Commissioning of HVAC Systems, which are a part of this project.

C. Commissioning shall be a team effort to ensure that all mechanical equipment and systems have been completely and properly installed and function together correctly to meet the design intent. Additionally, system performance parameters shall be monitored and documented for fine tuning of control sequences and operational procedures. Commissioning shall coordinate and document equipment installation, equipment start-up, control system calibration, testing and balancing, and verification and performance testing.

D. The Commissioning Team is defined in Specification 01 91 13 Section 1.3 – Definitions. The mechanical trades represented on the Commissioning Team shall include but not be limited to; sheet metal, pipe and fitting, controls, test and balance, plumbing, chemical treatment and fire protection. The lead person for each trade who will actually perform or supervise the work is to be designated as the representative to the Commissioning Team. Responsibility for various steps of the commissioning process shall be divided among the members of the Commissioning Team, as described in this section.

E. HVAC Contractor(s) are responsible for mechanical system installation, start-up, testing, balancing, preparation of O&M manuals, and operator training as defined in various Division 23 specification sections. HVAC Contractor(s) are responsible for coordination, observation, and verification of commissioning as defined in this section and Section 01 91 13. Neither Section 01 91 13 - Commissioning General Requirements nor Section 23 08 00 – Commissioning of HVAC Systems shall relieve the HVAC Contractor(s) from their obligations to complete all portions of work in a satisfactory and fully operational manner. Furthermore, Section 23 08 00 – Commissioning of HVAC Systems shall not relieve the Electrical Contractor(s) or Controls Contractor(s) from any obligations set forth within Division 1, Division 25, Division 26, including Section 01 91 13 – Commissioning General Requirements.

1.3 DEFINITIONS

A. HVAC Contractor(s): The term HVAC Contractor(s) utilized herein refers to any and all subcontracting companies or venders whom are responsible for the construction or other provisions regarding any of the systems which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 23 of the specifications. Subcontracting parties outside of the scope of the Systems to be Included in Commissioning or outside of the scope of Division 23 are not included.

B. Equipment Manufacturer(s): The term Equipment Manufacturer(s) utilized herein refers to any and all subcontracting companies whom are responsible for the provision of equipment or components which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 23 of the specifications. Equipment Manufacturer(s) shall refer to the direct representative of the maker and/or distributor of the equipment or component being provided. This may include either the actual equipment manufacturer or the supplier thereof, under the provisions that the supplier has a thorough knowledge of the equipment or component and is recognized by the actual equipment manufacturer as being a proper representative.

1.4 SCOPE OF WORK

A. The HVAC Contractor(s) shall be required to Commission all equipment, components and accessories of each of the commissioned systems as outlined within Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning. In order to accomplish a complete commissioning process, the HVAC Contractor(s) shall be required to fulfill all requirements set forth within Specification 23 08 00 Section 1.5 – Roles and Responsibilities. Additionally, the HVAC Contractor(s) shall be required to fulfill all requirements set forth within Specification 01 91 13.

B. Through the Commissioning Process, the HVAC Contractor(s) shall accomplish thorough documentation, organized scheduling and coordination, detailed installation verification, and detailed system functional verification. For this, the HVAC Contractor(s) must cooperate and coordinate with the Commissioning Agent.

1.5 ROLES AND RESPONSIBILITIES

A. In addition to the Commissioning Agent, Owner and System Design Professional(s), the Commissioning Team is comprised of a minimum of one individual to represent each contracting company or venders whom are responsible for the construction or other provisions regarding any of the systems which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 23 of the specifications. See Specification 01 91 13 Section 1.3 – Definitions for the definition of the Commissioning Team.

B. Contracting companies providing members shall include but not be limited to; sheet metal, pipe and fitting, controls, test and balance, plumbing, chemical treatment and fire protection contractors whose responsibilities are defined herein.

C. In addition to all roles and responsibilities defined herein, all HVAC Contractor(s) shall be required to fulfill all requirements described within Specification 01 91 13 Section 1.4 – Roles and Responsibilities.

D. HVAC Contractor(s)
   1. General Requirements:
      a. Include all cost to complete commissioning requirements for HVAC Systems in the contract price. Contractor costs shall be reflected within the Schedule of Values as specified within Specification 01 91 13 Section 2.2 – Schedule of Values.
      b. Ensure cooperation and participation of specialty Contractors and Sub-Contractors.

c. Ensure participation of major Equipment Manufacturers in appropriate start-up, testing and training activities.
d. Attend Commissioning Meetings for construction phase coordination as scheduled by the Commissioning Agent. Additionally, attend the Commissioning Kick-Off Meeting as scheduled by the Commissioning Agent.

2. Commissioning Schedule
   a. Prepare a Preliminary Schedule for HVAC Systems and equipment, including component installation, start-up and checkout, and system start-up. Integrate commissioning activities into this Preliminary Schedule including Pre-Functional and Functional Performance Tests. Coordination of the commissioning activities and their integration into the schedule shall be conducted within the Commissioning Meetings.
   b. Update the Preliminary Schedule and submit a Final Schedule which shall reflect all items within the Preliminary Schedule and shall also include but not be limited to: inspections, O&M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, TAB, and task completion. All Contractor(s) shall integrate schedule activities into one complete Final Schedule which shall be reflected within the Construction Manager's/General Contractor's overall project schedule. The Final Schedule shall be continuously updated throughout the Construction Phase.
3. Submittal Requirements:
   a. Comply with all Submittal requirements as outlined within Specification 01 91 13 Section 2.3 – Submittals.
   b. Comply with all requirements as outlined within Specification 01 91 13 Section 2.5 – Start-Up and Test Reports.
   c. Provide a complete set of O&M manuals to the A/E and the Commissioning Agent.
   d. Provide the following documentation to the Commissioning Agent for the purpose of construction updates:
      1) General construction progress and status reports
      2) Updated Architect, Owner, System Design Professional, and Contractor deficiency logs
      3) Minutes from all construction and coordination meetings not otherwise conducted by the Commissioning Agent
      4) Pre Start-Up and Start-Up procedures
      5) Value Engineering Proposals and a list of all accepted VE items
      6) Pressure Test Reports, Flushing Reports and Start-Up Reports
      7) Construction document changes resulting from mechanical Requests for Information
4. Pre-Functional Checklist Requirements:
   a. Detailed installation verification shall be performed on all installed equipment and systems to ensure that the installations conform to the contract documents, local and applicable codes, and standard practice. This shall be accomplished through the completion of Pre-Functional Checklists. The creation, distribution, completion and maintenance of Pre-Functional Checklists are detailed in Specification 01 91 13 Section 2.4 – Pre-Functional Checklists.
   b. Complete Pre-Functional Checklists on all mechanical equipment and system components installed or provided by the HVAC Contractors(s).
   c. Notify the Commissioning Agent a minimum of two weeks (14 days) in advance, of the time for start of the TAB work.
   d. Notify the Commissioning Agent a minimum of two weeks (14 days) in advance, so that witnessing Equipment and System Start-Up can begin.
   e. Provide written notification to the Commissioning Agent for each system listed in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, that the system installation is complete in its entirety and that the system is fully operational, online, and ready for Functional Performance Testing.

5. Equipment and Systems Start-Up
    a. Perform all initial check-out and start-up procedures as outlined within the specifications and as per the Equipment Manufacturer's recommendations. Provide full documentation of all start-up and check-out procedures and results. Documentation is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist.
    b. Perform all pressure tests, weld tests, vibration analysis and any other system component test required by the specifications requiring a 3rd party test agency. Provide full documentation of all tests procedures and results. Documentation is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist
    c. Perform all Test, Adjustment and Balance requirements for hydronic piping systems and air distribution systems. Submit copies of the TAB Report to all interested and reviewing parties as required by the specifications and to the Commissioning Agent. Also, submit a copy of the preliminary TAB documentation including the TAB Plan, Forms and Report format to the Commissioning Agent for review and approval. The TAB Contractor shall assist as the TAB Report is spot-checked by the Commissioning Agent. See the Specification 23 08 00 Section 1.5 – Roles and Responsibilities, Subsection E for additional TAB Contractor Requirements.
    d. Perform all equipment, system and component cleaning and flushing as required by the specifications and Equipment Manufacturer's recommendations. Provide full documentation of all cleaning and flushing procedures and test results (i.e. pH test results, ect.) Documentation is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist
6. Functional Performance Test Requirements:
    a. Detailed testing shall be performed on all installed equipment and systems to ensure that operation and performance conform to contract documents, local and applicable codes, and standard practice. This shall be accomplished through the completion of Functional Performance Tests. The creation, distribution and completion of Functional Performance Tests are detailed in Specification 01 91 13 Section 2.6 – Functional Performance Tests.
    b. Provide all appropriate equipment and materials as necessary to execute and complete all Functional Performance Tests. Comply with all requirements as outlined within Specification 01 91 13 Section 2.8 – Test Equipment.
    c. Provide appropriate technicians for participation during system verification and functional performance testing. Technicians shall demonstrate system performance to Commissioning Agent including all modes of system operation (e.g. normal, abnormal, emergency, etc.)
    d. Verify all functional performance tests prior to requesting test witness by the Commissioning Agent, demonstrate all Functional Performance test tasks in the presence of the Commissioning Agent and assist the Commissioning Agent in all verification and functional performance tests.
    e. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Commissioning Agent for verification or diagnostic purposes. Typically, TAB Verification shall occur in conjunction with Functional Performance Testing.
    f. Cancellation or delays of any system tests or Functional Performance Testing upon the day of that particular scheduled test, due to lack of preparation or status of installation shall be considered a failed test due to the additional time required by the Commissioning Agent to witness electrical testing. These additional tests shall be treated in accordance with Specification 01 91 13 Section 3.6-A.

7. Training Requirements:
   a. Comprehensive training of O&M personnel shall be performed by the HVAC Contractor(s) and Equipment Manufacturer(s) prior to turnover of the systems to the Owner. Training shall include but not be limited to classroom instruction and hands-on instruction of the installed equipment and systems. Training shall be coordinated by the Commissioning Agent via review and approval of the Contractor(s) Training Plan, Forms and Schedule. Alternately, the Commissioning Agent may provide a Training Plan including all forms for completion by the HVAC Contractor(s).
   b. The Training Schedule is to be coordinated and completed by the HVAC Contractor(s). The Training Schedule is to be updated and maintained as construction progresses. The Training Schedule and all updates shall be coordinated with and approved of by the Owner. A copy of the Training Schedule and all updates shall be provided to the Commissioning Agent.
   c. Contractor(s) responsible for the installation or provision of any piece of equipment or system shall attend, at minimum, the initial training session for that equipment or system.
   d. All Training Documentation shall be assembled and organized in a binder or set of binders. Coordinate with all other Contractor(s) to provide one complete bound Training Record. This requirement shall not be negated, unless other specific complete Project Training Record requirements, encompassing ALL project training documentation, is outlined elsewhere within the specifications.
   e. Contractor to make professional video recordings of all O&M staff training sessions.
8. Close-out Requirements:
   a. Remedy all deficiencies identified during commissioning. Provide all materials, equipment, labor, etc. to accomplish these remedies.
   b. Provide a complete set of Record Documents (As-Built Drawings and Specifications) to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval by the Commissioning Agent.
   c. Provide a Project Training Record to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy of all Project Training Record for review and approval to the Commissioning Agent.
   d. Provide a complete copy of Equipment and System Warranties to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval by the Commissioning Agent.
   e. Provide to the Commissioning Agent, a complete record of Attic Stock as delivered to the Owner and as approved by the Owner.
   f. Contractor to provide CMMS data and MAXIMO documentation to Owner as required by project specifications.

E. Test, Adjust, and Balance Contractor(s):
   1. Comply with all requirements as outlined within Specification 23 08 00 Section 1.5 Sub-Section D – HVAC Contractor(s).
   2. Submit the TAB procedures to the Commissioning Agent and Design Professional for review and acceptance. TAB procedures must include the TAB Plan, TAB Forms and TAB Report Format. These documents must be approved prior to proceeding with the Test, Adjustment and Balance.
   3. Attend the TAB review meeting scheduled by the Commissioning Agent. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the HVAC system.
   4. Issue a statement that TAB work has been completed. Submit through the Contractor(s) a copy of the preliminary version of the Test and Balance Report to the Commissioning Agent and System Design Professional. Submit for review, a Final Version of the Test and Balance Report to the Commissioning Agent and System Design Professional within the amount of time allotted within the Specifications. The Commissioning Agent and Systems Design Professional must both accept the Final TAB Report.

5. The Commissioning Agent shall be provided with a copy of the Test, Adjustment and Balance Report a minimum of two weeks (14 days) prior to the scheduled spot check of the balanced system. The report may be a Preliminary or Final version. A representative of the Test and Balance firm shall be required to assist with the spot check. The Test and Balance firm shall provide calibrated testing equipment as per Specification 01 91 13 Section 2.8 - Test Equipment. Equipment shall be similar in style and type as used to initially perform Test, Adjustment and Balance procedures.
6. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Commissioning Agent for verification or diagnostic purposes.

F. Equipment Manufacturer(s):
1. Comply with all requirements as outlined within Specification 23 08 00 Section 1.5 Sub-Section D – HVAC Contractor(s).
2. Assist in scheduling of training sessions. Provide training of Owner's Maintenance Personnel with adequacy required for full comprehension of equipment and maintenance procedures. Coordinate training with the Commissioning Agent. Training forms for Agenda and Training Record shall be provided by the Commissioning Agent. These forms are to be utilized for all Training Sessions. Manufacturer's standard training forms shall not be accepted as Training Records if Commissioning Forms are provided. Manufacturer standard training forms may be submitted as supplemental information, but the Commissioning Forms must be completed in their entirety.
3. Review installation for Equipment Manufacturer's specific requirements. Verify safeties, limits, relays and all other equipment specific settings are correct. Verify these settings optimize equipment performance and efficiencies.
4. Perform, approve and document all start-up services as outlined within the specifications for each piece of equipment, component and accessory. Perform all standard manufacturer services as outlined on manufacturer supplied forms. Additionally, perform all other requirements specifically called for within the project specifications, not otherwise performed in a manufacturer standard startup service. Provide additional documentation for these services on forms with manufacturer's letterhead.
5. Demonstrate performance of equipment as required within Functional Performance Tests.

1.6 DOCUMENTATION

A. The Commissioning Agent shall oversee and maintain the development of Commissioning Documentation. The Commissioning Documentation shall be kept in three ring binders, and organized by system and sub-system when practical. All pages shall be numbered, and a table of contents page(s) shall be provided. The Commissioning Documentation shall include the following which is to be maintained by the Contractor(s):
1. Start-Up and Check-Out Documentation: Organized and arranged with its associated Pre-Functional Checklist.
2. System and Component tests (i.e. Weld Test Reports, Cleaning & Flushing Reports, etc.): Organized and arranged with its associated Pre-Functional Checklist.
3. Pre-Functional Checklist: Organized and arranged as per provided by the Commissioning Agent. Typically these forms are organized by System and Sub-System and according to the order of standard specifications as outlined by American Institute of Architects (AIA.)
4. Test, Adjustment and Balance Report: The approved Final Report shall be provided to the Commissioning Agent for inclusion into the Final Commissioning Report.
5. Functional Performance Tests: All tests performed by the installing contractors for internal checkout and for witness by the Commissioning Agent shall be kept by the Contractor(s), organized and arranged by System and Sub-System, and turned over to the Commissioning Agent for inclusion into the Final Commissioning Report.
6. Project Training Record: The Training Record shall be provided with a Table of Contents followed by the updated Training Schedule and finally followed by each Training Session Agenda and Record. The Training Session Agenda and Record shall be organized by System and Sub-System.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The appropriate Contractor(s) shall furnish all special tools and equipment required during the commissioning process. A list of all tools and equipment to be used during commissioning shall be submitted to the Commissioning Agent for approval. The owner shall furnish necessary utilities for the commissioning process. Additional test equipment requirements are found in Specification 01 91 13 Section 2.8 – Test Equipment.

2.2 TEST EQUIPMENT - PROPRIETARY

A. 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.

PART 3 - EXECUTION

3.1 GENERAL

A. A pre-construction meeting of all Commissioning Team members shall be held at a time and place designated by the General Contractor. The purpose shall be to familiarize all parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.

B. A Final Commissioning Plan shall be developed by the Commissioning Agent. The HVAC Contractor(s) shall assist the Commissioning Agent in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation in a timely manner. If contractor initiated system changes have been made that alter the commissioning process, the Commissioning Agent shall notify the Owner.

C. The Commissioning Process shall follow the schedule and procedures set forth within the Final Commissioning Plan.

D. The HVAC Contractor(s) shall complete all phases of work so the systems can be started, tested, balanced, and acceptance procedures undertaken. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, and change orders.

E. The HVAC Contractor(s) shall coordinate all Commissioning Activities into the project as required herein and as outlined within the Commissioning Plan. The HVAC Contractor(s) shall complete all required Commissioning and Construction Activities correctly and on schedule.

3.2 PARTICIPATION IN ACCEPTANCE PROCEDURES

A. The HVAC Contractor(s) shall provide skilled technicians to start-up and debug all systems within Division 23. These same technicians shall be made available to assist the Commissioning Agent in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the Commissioning Agent and coordinated by the HVAC Contractor(s). HVAC Contractor(s) shall ensure that the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. System performance problems and discrepancies may require additional technician time, Commissioning Agent time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods, at no cost to the owner, until the required system performance is obtained.

C. The Commissioning Agent reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and willingness to work with the Commissioning Agent. The HVAC Contractor(s) shall provide adequate documentation and tools to start-up and test the equipment, system, and/or sub-system.

3.3 DEFICIENCY RESOLUTION

A. In some systems, miss-adjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the Owner, with input from the contractor and equipment supplier. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the Owner and/or Architect shall have final jurisdiction over any additional work done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Any and all schedule items affected by this work shall be reflected on the Commissioning and Overall Project Schedules.

3.4 ADDITIONAL COMMISSIONING

A. The HVAC Contractor, and associated sub-contractors, shall be responsible for any additional commissioning required as a result of failure of a pre-functional or a functional test. Incomplete or incorrect Pre-Functional Checklists reviewed by the Commissioning Agent shall require an additional inspection to verify the re-completed PFC is complete and accurate. Functional Performance Tests witnessed by the Commissioning Agent which fail, shall require retesting, again witnessed by the Commissioning Agent. These documents must be re-checked or re-witnessed in order for the system to be approved and accepted by the Commissioning Agent.

B. The Commissioning Agent will invoice the Owner for additional time, plus expenses, required to witness any retesting due to failed PFC's or FPT's, and the Owner at his discretion may deduct this cost from the Construction Manager's Application for Payment. It is the HVAC Contractor's responsibility to properly de-bug systems and verify successful system performance prior to inviting the Commissioning Agent to witness the test.

3.5 SEASONAL COMMISSIONING

A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning shall be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. Heating equipment shall be tested during winter design extremes. Cooling equipment shall be tested during summer design extremes with a fully occupied building. Each contractor and supplier shall be responsible to participate in the initial and the alternate peak season tests of the systems as required to demonstrate performance.

3.6 PRE-FUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTS

A. The Commissioning Agent shall be responsible for preparing the Pre-Functional Checklist. The HVAC Contractor(s) shall be responsible for completing their applicable sections. Detailed descriptions of Pre-Functional Checklists are outlined in Section 01 91 13-2.4.

B. The Commissioning Agent shall be responsible for preparing the Functional Performance Tests. The Commissioning Agent and Contractor (s) shall schedule the tests and assemble the commissioning team members who shall be responsible for the tests. Participating contractors, manufacturers, suppliers, etc. shall include all costs to do the work involved in these tests in their proposals. Detailed descriptions of Functional Performance Tests are outlined in Section 01 91 13-2.6.

C. Following is a list of tasks and supporting information that shall be required:
   1. HVAC Contractor(s) - provide the services of a technician(s) who is (are) familiar with the construction and operation of this system. Provide access to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.

D. Documentation and Reporting Requirements
   1. Any contractors with responsibilities related to the equipment to be installed, i.e. mechanical, electrical, TAB, controls, Construction Manager, shall be responsible for completing their related portion of the Pre-Functional Checklist and Functional Performance Test forms and shall sign off on its completion.

E. The Commissioning Agent shall direct and witness the field verification of the Final TAB report. The TAB Contractor shall perform measurements as directed by the Commissioning Agent.
   1. The Commissioning Agent shall select report data for verification at random.
   2. The TAB contractor shall be given sufficient advance notice of the date of field verification. However, they shall not be informed in advance of the data points to be verified. The TAB contractor must use the same instruments (by model and serial number) that were used when the original data were collected.
   3. Failure of an item is defined as:
      a. For all readings other than sound, a deviation of more than 10 percent.
      b. For sound pressure readings, a deviation of 3 decibels. (Note: variations in background noise must be considered).
   4. A failure of more than 10 percent of the selected items shall result in the rejection of the TAB report.

F. If deficiencies are identified during verification, the construction manager must be notified, and action taken to remedy the deficiency. The final tabulated checklist data sheets shall be reviewed by the Design Professional and the Commissioning Agent, to determine if verification is complete, and the operating system is functioning in accordance with the contract documents.

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SECTION 23 11 23
NATURAL GAS PIPING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Natural Gas Piping System, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Piping standards: See Section 20 11 00.

B. Manual valve standards: See Section 20 05 23 (for valves labeled "V-__").

1.3 SUBMITTALS

A. Product Data:
   1. Pressure regulators.

B. Contract Closeout Information:
   1. Test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Pipe wrapping:
   1. Base:
      a. Republic.

B. Pipe field wrap:
   1. Base:
      a. Republic.

C. Pipe stands:
   1. Base:
      a. Miro Industries.

D. Gas Regulators:
   1. Base:
      a. Fisher Regulators.
   2. Optional:
      a. Maxitrol Company.
      b. American Meter Company.

2.2 MATERIALS

A. NATURAL GAS PIPING
   1. Gas piping below ground:
      a. Black steel See Section 20 11 00.
      b. Black steel shall have welded joints, wrapped.
      c. Exposed 1-1/2 IN and smaller: Threaded joints, with malleable iron threaded fittings.
      d. Concealed 1-1/2 IN and smaller: Welded joints, with socket welding fittings.
      e. 2 IN and larger: Welded joints, with butt welding fittings.
   2. Gas piping below ground 5 FT outside the building:
      a. Polyethylene pipe.

   b. Polyethylene shall be socket fittings or fusion fittings.
   c. Concealed 1-1/2 IN and smaller: Fusion welded or socket joints.
   d. 2 IN and larger: Fusion welded.
3. Gas piping above ground:
   a. Black steel.
   b. 2 IN and smaller: welded joints, with socket welding fittings.
   c. 2 IN and smaller, exposed in mechanical rooms or outdoors: Black malleable threaded fittings.
   d. 2 1/2 and larger: Welded joints, with butt welding fittings.
4. Pipe wrapping for black steel piping: Factory installed, Republic X-Tru-Coat.
5. Pipe stands shall consist of a "roller-bearing" pipe support used to support roof-mounted gas pipes:
   a. Pipes rest on a self-lubricating polycarbonate resin roller rod and roller.
   b. The pipe support base shall be made of polycarbonate resin.
   c. The roller rod shall be made of glass-filled nylon, and all metal parts are made of stainless steel.
   d. Pipestand shall provide a minimum of 2 IN of clearance above the roof surface.
6. Pipe field wrap for black steel piping: Republic X-Tru-Tape, 1 IN and less wide.

B. VALVES
1. Ball valves (2 IN and smaller): V-16.
2. Plug valves:
   a. 2 IN and smaller: V-60.
   b. 2-1/2 IN and larger: V-41.
3. Butterfly valves (2 IN and smaller): V-57.

C. GAS PRESSURE REGULATORS
1. Provide gas pressure regulators where the gas supply pressure is higher than the pressure at which the gas utilization equipment is designed to operate.
2. Gas pressure regulators shall be designed for a maximum pressure drop of 0.25 PSIG at maximum flow.Provide at service entrance or as shown on the drawings.
4. Equipment capacities: As scheduled.
   a. Natural gas at 1000 BTUH per CU FT.

PART 3 - EXECUTION

3.1 NATURAL GAS PIPING INSTALLATION

A. Install in accordance with codes, local Gas Company regulations and ordinances.

B. Contact the local gas utility company to cap the existing natural gas service. Remove old piping from building to the main.

C. Provide new service to buildings.

D. Provide new service regulator and meter.

E. Provide gas pressure regulators at every gas burning appliance where inlet pressure is greater than allowable.

F. Vent regulators in accordance with NFPA 54, International Fuel Gas Code, and Authority Having Jurisdiction. For regulators installed inside the building, manhole, or in an enclosed space extend vent piping full size from the regulator to the exterior of the building or provide approved vent limiting devices in accordance with ANSI Z21.80 and CSA 6.22.

G. For regulators installed outside the building provide a full size vent extension that extends a minimum of 12 IN above snow level and then curves down to prevent the accumulation of moisture in the vent outlet and terminate with screened weather cap.

H. All piping running up on the outside of walls shall be secured by pipe standoffs.

I. Gas piping located on the roof shall be mounted on pipe stands and spaced according to the manufacturer's recommendations.

J. Provide shut-off valves, dirt leg, and unions on all appliances and equipment.

K. Provide shut-off valves before every gas pressure regulator.

L. Where flexible connections are required, they shall be CSA approved.

M. Provide an approved permanent tag or label that identifies the pressure upstream of all gas regulators.

3.2 TESTING

A. Before piping is covered, test system in presence of Owners Representative.

B. Perform a 100 PSI air test for 6 HRS without pressure drop.

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SECTION 23 12 00
EMERGENCY GENERATOR FUEL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, tools, equipment, and services for Emergency Generator Fuel System, as indicated, in accordance with provisions of Contract Documents.

B. All components of this system shall be appropriate for exterior use.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Materials standards: Components UL labeled.

B. National Fire Protection Association NFPA-30: Flammable and Combustible Liquids Code.

C. National Fire Protection Association NFPA-31: Standards for Installation of Oil Burning Equipment.

D. UL - 142, aboveground steel tanks for flammable and combustible liquids.

E. UL - 2085, Protected aboveground tanks for flammable and combustible liquids.

F. American Association of State Highway and Transportation Officials (AASHTO) Standard: AASHTO M294 for H-20 surface loading.

G. State and local code requirements.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Tank and piping layout, including supply and return pumps.

B. Project Information:
   1. Tank detailed drawings, including manufacturers test standards.
   2. Supply fuel pump package.
   3. Return fuel pump.

C. Contract Closeout Information:
   1. Operating and maintenance data.
   2. Owner instruction report.
   3. Test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Fuel system components:
   1. Base:
      a. As noted.

B. Fuel tank above ground protected, 6,000 GAL:
   1. Base:
      a. Convault.
      b. Highland Tank.

c. General Industries.
d. Containment Solutions.
e. Envirosafe.

C. Leak detection monitoring systems:
1. Base:
a. Veeder Root.
2. Optional:
a. Pneumercator Inc.
b. Red Jacket Electronics.
c. INCON(Intelligent Controls, Inc.).

D. Tank Accessories:
1. Base:
a. OPW.
2. Optional:
a. EBW.

E. Anti-siphon valve:
1. Base:
a. Preferred Utilities Manufacturing Corp.
b. EBW Inc.
c. OPW Inc.

F. Fuel Transfer Pump Sets.
1. Base:
a. Simplex, Inc.

2.2 ABOVEGROUND STORAGE TANK

A. Concrete Encased Tank:
1. The primary steel tank shall have the following features:
a. Be rectangular in shape and have continuous welds on all exterior seams, manufactured in accordance with UL listing requirements and UL Standard 142.
b. Be pressure tested at 5 psig for 24 to 48 hours.
c. Have "emergency vent" system as per NFPA 30 Code requirements.
2. The protected and insulated tank shall have a thru-tank leak detector tube to allow for physical checkup and monitoring capability between the primary and the secondary containment.
3. The primary steel tank shall be pressurized at 5 psig during concrete encasement.
4. The outer surface of the primary steel tank shall be covered by a minimum of 1/4 IN thick Styrofoam insulation panels.
5. The secondary containment shall consist of a 30 Mil thick High-Density Polyethylene membrane enclosing the steel tank and insulation material.
6. The primary steel tank and the secondary containment shall be encased in 6 IN of monolithic reinforced concrete, with minimum design strength of 4,000 and 5,000 psi at 28 days depending on the tank size. The concrete design shall include the following for long-term durability: air entrainment, water reducing admixture, and steel reinforcement. Concrete encasements with seams will not be approved.
7. No steel or insulating material shall come in contact with the concrete or other corrosive material.
8. All openings shall be from the top only.
9. All exposed metal with the exception of stainless steel must be powder coated to inhibit corrosion.
10. The protected and insulated tank shall have a coated concrete exterior to resist weather and reflect sunlight.
11. The protected and insulated tank shall have two (2) bolts for connecting grounding conductors for lightning protection in accordance with NFPA 780.

B. Double-Wall Steel Tank:
   1. Provide a factory-assembled unit that includes a primary storage tank and an integral factory-fabricated secondary containment. Tank assembly shall be in accordance with NFPA 30 and be designed and manufactured for a rectangular installation. Primary storage tank shall be factory-welded steel that conforms to UL 142. Tank assembly shall be mounted on the tank manufacturer's standard UL listed support skid that elevates the tank assembly above the underlying concrete slab a minimum of 12 inches. Tank assembly shall have lifting lugs that allow tank relocation.
   2. The secondary containment reservoir shall be the factory-fabricated steel type that fully-encloses the primary storage tank. The containment reservoir shall conform to UL 142. The interstitial space between the primary tank and the containment reservoir shall be both pressure testable and verifiable. The entire tank assembly shall conform to UL 2085. Tank assembly shall bear the UL 2085 label as a protected tank. The primary storage tank shall be supported within the containment reservoir with steel tank saddles, or other similar supports, fabricated and installed by the tank manufacturer.

2.3 TANK ACCESSORY EQUIPMENT

A. Standard Vent: The standard 2” vent shall be equipped with an aluminum updraft vent cap with wire screen.

B. Emergency Vents: Emergency vents shall be equipped with aluminum vents sized to open at 1/2 oz pressure to provide the required capacity.

C. Direct Read Level Gauge: Tank shall be equipped with a direct reading level gauge with an aluminum housing. The level gauge shall be readable from ground level.

D. Inspection Port Adapter Cap: Tank shall be equipped with a 4 IN adapter and lockable cap for inspection and manual gauging of fuel level. Gauge port shall be accessible from steps or ladder.

E. Overfill Prevention Valve: The tank shall have an overfill prevention valve installed in the fill pipe. The valve shall close automatically at 90% of tank capacity. The valve shall incorporate a drop tube extending to within 6 IN of the tank bottom. Valve shall be rated for pressurized fuel delivery. An automatically actuated solenoid valve in the fill pipe may be provided as an alternative.

F. Access Steps and Ladders: Tank shall be equipped with access steps/ladder to top of tank. Steps shall be of welded steel construction with prime and finish paint of industrial enamel. Steps and ladders shall be designed to conform with OSHA requirements. Steps shall include non-skid tread surfaces, handrails, platforms, and kickplates as required for OSHA compliance.

2.4 VALVES

A. Anti-siphon valve: Full size, NFPA and UL approved:
   1. Provide on fuel supply line at connection to tank.

B. Overfill prevention valve:
   1. Materials:
      a. Valve and valve body: Aluminum.
      b. Hardware: Stainless Steel.
      c. Plastic Parts: Acetal.
      d. Float: Nitrile rubber closed cell foam.

C. Foot valve(s):
   1. Type: Single poppet.
   2. Type: Double poppet.
   3. Size: Same size as suction line.
   4. Material: Zinc plated cast iron.
   5. Cap and suction stub adaptor: Bronze.

6. Gasket: Buna N.

D. Oil pressure relief valves.

E. Ball valves 2 IN and smaller): V-16.

F. Gate valves:
   1. 2 IN and smaller: V-2.
   2. 2-1/2 IN and larger: V-3.

G. Plug valves:
   1. 2 IN and smaller: V-60.
   2. 2-1/2 IN and larger: V-41.

H. Check valves:
   1. 2 IN and smaller: V-27.
   2. 2-1/2 IN and larger: V-28.

I. Valve standards: Section 20 05 23.

2.5 FUEL OIL PIPE AND FITTINGS

A. Steel pipe and fittings: Refer to Section 20 11 00.

B. Provide pipe supports as required so that no weight bears on tank, pump site, or generator day tank.

2.6 TANK LEVEL MANAGEMENT AND LEAK DETECTION SYSTEM

A. Tank monitoring and leak detection system:
   1. Provide a system with combined inventory control, in-tank leak detection, and interstitial leak sensing capabilities.
   2. Modular design system: Allow it to be configured according to the needs of the site.
   3. Veeder-Root TLS-350.

B. Wall mounted console:
   1. Communications: capable of tie-in to Owners Building Automation System (BAS).
      a. Monitoring: alarm signals local and to BAS.
   2. 2-line, 24-character liquid crystal display for viewing of all inventory, leak detection and alarm information.
   3. 24-button front panel keyboard with control and alpha-numeric functions for programming, operating and reporting.
   4. Three front panel LEDs to provide a visual indication of power-on, warning and alarm conditions.
   5. An internal audible warning and alarm indicator.
   6. Intrinsically safe.
   7. UL listed.
   8. RS-232 communications interface module.
   9. 4-relay output module programmable to alarm limits and capable of actuating external alarm devices.
   10. 4-input in-tank probe module compatible with standard capacitance probes and/or magnetostrictive probes.
   11. Line detector control module compatible with a line leak detector kit that performs a positive displacement volumetric line test.

C. Capacitance or magnetostrictive probes with built in diagnostics:
   1. Leak detection capability of 0.1 GPH.

D. Single cable interstitial sensing elements capable of detecting fuel or water:

E. Line leak detection:
   1. Single line-leak module for each line to be monitored.

F. Operating capabilities: Ability to monitor inventory in tank and produce a combination of automatic and manual reports which include the following information:
   1. Fuel volume.
   2. Fuel weight.
   3. Water height.
   4. Fuel temperature.
   5. Ullage.
   6. Temperature compensated fuel volume.
   7. Last inventory increase amount.
   8. Last in-tank leak test result.
   9. Time and date.
   10. Tank identification.
   11. Fuel identification.
   12. 90 percent Ullage.

G. Provide programmable alarm limits to warn of:
   1. Leaks.
   2. Overfills.
   3. High level.
   4. High water.
   5. Low inventory.
   6. Thefts.
   7. Low level set at 200 gallons.
   8. Provide a set of dry contacts to signal alarm condition to Building Automation System (BAS).

H. Provide the ability to perform both automatic and manually activated leak detection tests.

2.7 PUMPING SYSTEMS

A. Supply pump system: Automatic duplex pump controller and duplex pumps.
   1. Duplex pumps: Consist of two pumps, motors and accessories in Type 3R enclosure.
      a. Direct drive, positive displacement, hydraulic gear type with pressure loaded mechanical shaft seal.
      b. Insert appropriate pump and motor data.
      c. Motors: Dripproof, NEMA type B, continuous duty at 40 DEGC, 1800 RPM.
         1) 450 GPH at 40 PSI.
         2) 3/4 Hp.
         3) 460 V.
         4) 3 Phase.
         5) 60 Hertz.
      d. Pump pressure relief valve, adjustable type, vented back to tank.
      e. Pump inlet fuel strainer, 60 mesh.
      f. Pump shutoff ball valve.
      g. Pump motor starter, full voltage type, non-reversing, with overload relay and circuit breaker.
      h. Control relays and control power transformer as required to operate pump motor starter from day tank control contacts.
   2. Duplex pump controller: Function to alternate operation of each pump on successive starts.
      a. Provide pump running indicators for each pump.
      b. Provide pump fail alarm indicator and output contacts.
      c. Provide mode control switch and control logic for automatic operation as:
         1) Pump 1 lead/pump 2 lag.
         2) Pump 2 lead/pump 1 lag.
         3) Both run.

B. Return pump system: Automatic single pump controller and pump.
   1. Single pumps: Consist of one pump, motor and accessories in Type 3R enclosure.

a. Direct drive, positive displacement, hydraulic gear type with pressure loaded mechanical shaft seal.
b. Insert appropriate pump and motor data.
c. Motors: Dripproof, NEMA type B, continuous duty at 40 DEGC, 1800 RPM.
1) 675 GPH at 40 PSI.
2) 3/4 Hp.
3) 460 V.
4) 3 Phase.
5) 60 Hertz.
d. Pump pressure relief valve, adjustable type, vented back to tank.
e. Pump inlet fuel strainer, 60 mesh.
f. Pump shutoff ball valve.
g. Pump motor starter, full voltage type, non-reversing, with overload relay and circuit breaker.
h. Control relays and control power transformer as required to operate pump motor starter from day tank control contacts.

2. Single pump controller:
a. Provide pump running indicator for pump.
b. Provide pump fail alarm indicator and output contacts.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Assemble equipment, piping, controls and connections.

3.2 TANK INSTALLATION

A. Install tank and anchor on concrete foundation per manufacturers recommendations:
1. Contractor shall be trained by the tank manufacturer, the state or other approved agency.
2. Tank shall be installed and tested according to current installation instructions provided with the tank.

3.3 PIPING INSTALLATION

A. Pitch piping toward tank at 1/8 IN in 10 FT.

B. After welding and testing, coat or wrap fittings and joints.

3.4 TANK CLEANING

A. Before tank is filled, pump accumulated water and condensate from tank.

B. Mop tank dry.

C. After tank has been properly dried, place in tank a dose of fuel treatment.
1. 1 gallon of treatment for each 5,000 gallons (1 to 5000 parts) of fuel tank capacity.
2. Follow exact requirements and recommendations of dose manufacturer.

3.5 TESTING

A. After piping has been installed, temporarily cap vent piping, pipe joints and tank connections.

B. Test with maximum of 5 PSI air, using soap suds on joints.

C. Test connections and prove tight at operating pressure.

END OF SECTION

SECTION 23 21 13
HYDRONIC PIPING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Hydronic Piping Systems, as indicated, in accordance with provisions of Contract Documents.

B. Systems and Products Included:
1. Systems:
   a. Chilled water piping.
   b. Condensate and cooling coil drain piping.
   c. Process cooling water piping.
   d. Condenser water piping.
   e. Heating water piping.
   f. Make-up water piping.
   g. Water treatment system piping.
2. Products:
   a. Air vents.
   b. Expansion tanks.
   c. Flow switch wells.
   d. Pressure and temperature test stations, combination.
   e. Air Eliminators and Dirt Separators.
   f. Strainers.
   g. Valves.
   h. Water flow measurement devices.
   i. Water treatment system.

C. Work installed but not furnished:
1. Automatic valves: Furnished in Division 25.
   a. Provide fittings and reducers required for installation of automatic valves.
2. Electronic flow measurement devices: Furnished in Division 25.

D. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Piping standards: Section 20 11 00.

B. Manual valve standards: Section 20 05 23 (for valves with "V" prefix).

1.3 SUBMITTALS

A. Product Data:
1. Air vents.
2. Expansion tanks.
3. Pressure and temperature test stations, combination.
4. Air Eliminator and Dirt Separators.
5. Strainers.
6. Valves, constant flow control.
7. Valves, manual.
8. Valves, pressure reducing.
9. Valves, pressure relief.
10. Water flow measurement devices.
11. Water treatment system.

B. Contract Closeout Information:
   1. Operation and Maintenance Data for items requiring operational instructions or periodic maintenance such as: air vents, constant flow control valves, pressure relief valves, triple duty valves, water flow measurement devices, water treatment system, etc.
   2. Field test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Automatic High Capacity Air Vents:
   1. Base:
   2. Optional:
      a. Armstrong International.
      b. Hoffman Specialty.
      c. Metraflex.
      d. Thrush.

B. Automatic Low Capacity Air Vents:
   1. Base:
   2. Optional:
      a. Armstrong International.
      b. Bell & Gossett, ITT.
      c. Hoffman Air & Filtration Systems.
      d. Taco.
      e. Thrush.

C. Manual Air Vents:
   1. Base:
   2. Optional:
      a. Crane Valves.
      b. Jenkins.
      c. Johnston.
      d. OIC.
      e. Powell.
      f. Stockham Valves & Fittings.

D. Expansion Tanks:
   1. Base:
   2. Optional:
      a. Armstrong Pumps.
      b. Bell & Gossett, ITT.
      c. Taco.
      d. Thrush.

E. Pressure/Temperature Test Stations, Combination P/T Plug.
   1. Base:
      a. Pete's Plug by Peterson Equipment Company.
   2. Optional:
      a. Fairfax.
      b. P/T Plugs and Flex Connectors by Sisco.
      c. Super Seal.

F. Air Eliminator and Dirt Separators:
   1. Base:
   2. Optional:
      a. Armstrong International.
      b. Bell & Gossett, ITT.

c. Spirotherm.
d. Taco.

G. Strainers, Air Separator/Strainers:
1. Base:
2. Optional:
a. Armstrong Machine Works.
b. Bell & Gossett, ITT.
c. Taco.
d. Thrush.

H. In-line Wye Strainer and Valve Combination Strainers:
1. Base:
a. Griswold Controls.
2. Optional:
a. Flow Design Inc.
b. Nexus Valve.

I. Single Basket and Tee Strainers:
1. Base:
a. Hoffman Specialty, ITT.
2. Optional:
a. Armstrong Machine Works.
b. Keckley, OC.
c. Metraflex.
d. Mueller Steam Specialty.
e. Spence Engineering.
f. Spirax Sarco.
g. Tate.
h. Victaulic of America.

J. Suction Diffuser Strainers:
1. Base:
2. Optional:
a. Armstrong Pumps.
b. Bell & Gossett, ITT.
c. Mueller Steam Specialty.
d. Taco.
e. Victaulic of America.

K. Constant Flow Control Valves:
1. Base:
a. Flow Design Inc.
2. Optional:
a. Griswold Controls.
b. Nexus Valve.

L. Water Pressure Reducing Valves:
1. Base:
a. Bell & Gossett, ITT.
2. Optional:
a. Armstrong Pumps.
b. Conbraco.
c. Taco.
d. Watts Control Valves.
e. Thrush.

M. Water Pressure Relief Valves:
   1. Base:
      a. Bell & Gossett, ITT.
   2. Optional:
      a. Armstrong Pumps.
      b. Farris.
      c. Taco.
      d. Teledyne Farris Engineering.
      e. Thrush.

N. Water Flow Measurement Devices:
   1. Base:
   2. Optional:
      a. Hyspan.
      b. Data Industrial.
      c. Dynasonics.
      d. Gerand Engineering.
      e. Victaulic of America.

O. Water-treatment-system cleaning chemicals:
   1. Base:
      a. Oakite Products.
   2. Optional:
      a. Mitco.
      b. Diversey Water Technologies.

P. Water Treatment System Chemical Feeders:
   1. Base:
      a. Calgon-Vestal.
   2. Optional:
      a. Diversey Water Technologies.
      b. Mitco.
      c. Nalco.

2.2 MATERIALS

A. Pipe And Fittings
   1. Pipe and fittings - General:
      a. The following are not permitted:
         1) Plain end, pressure fit type fittings.
         2) Hole cut mechanical tee or saddle fittings.
   2. Fittings: galvanized where galvanized piping is used.
   3. Chilled water piping, above grade:
      a. Copper, type L, with soldered joints, and wrought copper or cast brass fitting.
         1) Optional fittings:
            a) Mechanical groove-end fittings and couplings may be used for sizes 2-1/2 IN and larger.
            b) Ring seal crimped fitting system: 2 IN and smaller where approved by authority having jurisdiction.
      b. Black steel.
         1) 2 IN and smaller: Threaded joints, with cast iron or malleable iron threaded fittings.
         2) 2-1/2 IN and larger: Welded joints.
         3) Grooved couplings and fittings may be used for chilled water piping.
      c. Inside fan plenums (and piping from coil connections to piping headers inside and outside of plenums):
         1) Copper, type L, with soldered joints, and wrought copper or cast brass fittings.
         2) Black steel, with grooved couplings and fittings.

3) Galvanized steel, with grooved couplings and fittings.
4) T-drilled, Type L copper with brazed joints.

4. Condensate and cooling-coil-drain piping:
   a. Copper, type M or L, and soldered joints.
   b. Galvanized steel with cast iron drainage type fittings.
5. Condenser water piping: Same as chilled water piping.
6. Heating water piping, above grade:
   a. Copper, type L, with soldered joints, and wrought copper or cast brass fittings.
      1) Optional fittings:
         a) Ring seal crimped fitting system: 2 IN and smaller where approved by authority having jurisdiction.
   b. Black steel, with welded joints.
      1) For 2-1/2 IN and larger: Use butt welding fittings.
      2) For 2 IN and less: Use socket welding fittings, 2000 PSI class, malleable or cast iron threaded fittings.
      3) Weld-o-let or thread-o-let type fittings may be used in lieu of tees for branch connections, provided main is one size larger than takeoff. Couplings or half couplings are not acceptable except for non-flow connections such as thermometers or gauges.
7. Make-up water piping:
   a. Same as system served.
8. Water treatment system piping:
   a. Same as system served.

B. Air Vents
1. High Capacity, automatic:
   a. 300 PSI rated test pressure, minimum.
   b. Maximum working pressure: 150 PSIG.
   c. Maximum temperature: 212 DEGF.
   d. Body and cover material: Cast iron, ASTM-A126, Class B.
   e. Seat material: Stainless steel-T303, ASTM-A276 or Viton.
   f. Float and float arm material: Stainless steel-T304, ASTM-A240.
2. Low Capacity, automatic:
   a. 150 PSI rated, minimum.
   b. Maximum working pressure: 100 PSIG.
   c. Maximum temperature: 212 DEGF.
   d. Cast bronze, chrome plated, body with renewable valve and seat.
   e. Synthetic rubber disc.

C. Expansion Tanks
1. Tanks, expansion (air-elimination system):
   a. Pre-pressurized diaphragm type.
   b. Size: As scheduled.
   c. Rated pressure: 125 PSIG.
   d. Rated operating temperature: 240 DEGF, minimum.
   e. Precharge pressure: Same as scheduled minimum operating pressure.
   f. Bladder: Heavy duty butyl, removable for inspection.
   g. ASME constructed and stamped.

D. Flow Switch Wells
1. Flow switch wells:
   a. Install 1 IN thread-o-let for flow switch installation.
   b. Provide 1 IN nipple and cap.

E. Pressure And Temperature Test Stations, Combination
   1. Pressure/temperature test station, combination:
      a. Station to receive either a 1/8 IN OD temperature or pressure probe.
      b. Fitting: Solid brass, 1/4 IN NPT, with 2 valve cores of neoprene (maximum 200 DEGF at 500 PSI) or Nordel (maximum 275 DEGF at 500 PSI).
      c. Provide extension at locations with pipe insulation. Extension length shall match or exceed insulation thickness.
      d. Provide with color coded and marked cap with gasket, rated at 1000 PSI at 140 DEGF.
   2. Pressure and temperature test kit:
      a. Range: 0-100 PSI, 0-230 FT WG.
      b. 1/8 IN OD probe and 5 IN stem pocket testing thermometers.
         1) Provide 1 for chilled water: 25-125 DEGF.
         2) Provide 1 50-500 DEGF for hot water.
      c. No. 500 gauge adapter with 1/8 IN OD probe.
      d. Protective carrying case.

F. Air Eliminators and Dirt Separators
   1. Air eliminators and dirt separators:
      a. Coalescing type air eliminator and dirt separator.
      b. Shell: Fabricated Steel.
      c. Seals: Viton.
      d. Removable stainless steel or copper wound air/dirt collection medium.
      e. An integral full port float actuated brass venting mechanism shall be installed at the top of the venting chamber.
      f. Design pressure: 150 PSIG.
      g. NPT tappings for vent and blowdown connections.
      h. Air Removal Efficiency: 100 PCT free and entrained air and 99.6 PCT dissolved air.
      i. Dirt Removal Efficiency: 80 PCT of all particles 30 microns and larger within 100 passes.
      j. Removable lower head to facilitate removal of internal assembly for inspection

G. Strainers
   1. Strainers, air separator/strainers:
      a. ASME code construction.
      b. Removable stainless steel air collector tube.
      c. NPT tappings for vent and blowdown connections.
      d. Stainless steel strainer with 3/16 IN diameter perforations.
         1) Free area: Not less than 5 times cross sectional area of connecting pipe.
      e. Working pressure: 125 PSIG at 350 DEGF.
   2. Strainers, in-line wye strainer and valve combination:
      a. One piece configuration consisting of O-ring union, P/T plug, blow down and ball valve with handle.
      b. Strainer valves 1-1/4 IN and smaller: Limit passage of particles larger than 500 microns.
      c. Strainer valves 1-1/2 IN and larger: Limit passage of particles 1000 microns and larger.
      d. Bronze body construction with threaded or sweat connections.
         1) Internal parts: Brass and stainless steel.
         2) Ball valve:
            a) Ball and stem: 316 stainless steel.
            b) Port size: standard.
            c) Blowout proof stems.
            d) Reinforced Teflon (PTFE) seats.
            e) Teflon (PTFE) seals.
            f) Adjustable packing.
            g) Extended necks and stems that isolate moving valve parts from insulation.

e. Provide valves with unions to allow field exchange of internal components without removing valve body from pipeline.
f. Provide metal ID taps permanently marked to show direction of flow, strainer mesh and model number.
3. Strainers, single-basket type.
a. Screwed or flanged.
b. Body: Cast iron, flanged ends, bolted access cover.
c. Coating: Rust inhibiting.
d. Working pressure, non shock: 150 PSIG.
e. Screens: Bronze, monel or stainless steel.
1) 2 IN and less: 3/64 IN perforations.
2) 2-1/2 IN and larger: 1/8 IN perforations.
4. Strainers, suction diffusers:
a. Angle cast iron body type with inlet vanes and combination diffuser-strainer-orifice cylinder.
b. Provide with disposable 16 mesh strainer for system start-up.
c. Orifice cylinder with 3/16 IN diameter openings.
1) Designed to withstand pressure differential equal to pump shutoff head (maximum ______ PSI).
2) Free area equal to 5 times cross-section area of pump suction opening.
d. Vane length: Not less than 2-1/2 times pump suction opening.
1) Provide with adjustable support foot to carry weight of suction piping.
5. Strainer, tee-pattern type.
a. Grooved ends.
b. Body: One-piece ductile iron casting conforming to ASTM-A536 or malleable iron conforming to ASTM-A47.
c. Coating: Rust inhibiting.
d. Working pressure rating: 300 PSI.
e. Basket screen: 304 stainless steel 0.041 IN wire in a woven No.6 mesh wire screen with 0.126 IN opening.
f. Vertical down flow or horizontal flow.
g. Cleaning access through blank end cap.
6. Strainers, wye:
a. See Section 20 05 19, Piping Specialties.

H. Valves
1. Constant flow control valves:
a. Factory calibrated, direct acting, automatic pressure compensating.
b. Control flow rates within 4 PCT of flow rating over operating pressure differential range.
1) Set flow rating to match the maximum flow required by device served.
c. Pressure differential range:
1) 2-32 PSID.
d. Threaded-brass or copper-sweat body with stainless-steel internal parts.
e. Provide a metal identification tag with chain for each installed valve.
1) Identify valve model number, rated GPM, direction of flow, and differential pressure range.
f. Provide with integral unions to allow field exchange of internal components without removing valve body from pipeline.
g. Provide as indicated.
2. Manual valves:
a. Angle valves:
1) 2 IN and smaller: V-17.
2) 2-1/2 IN and larger: V-18.

b. Balancing valves:
   1) 2 IN and smaller: V-64.
   2) 2-1/2 IN to 12 IN: V-65.
   3) 8 IN and larger:
      a) Plug valve: V-37 with memory stop.
      b) Provide venturi waterflow measuring device.
   4) Ball type balancing valves/circuit setters shall not be used.
c. Isolation valves (Ball valves):
   1) 2 IN and smaller: V-13 or V-14.
d. Isolation valves (Butterfly valves):
   1) 2 IN and smaller: not used.
   2) 2-1/2 IN and larger: V-33 or V-35.
e. Boiler blowdown valves: Plug, globe, angle and check.
   1) Rated for 250 PSIG and 400 DEGF.
f. Boiler feedwater valves: Plug, globe, angle and check.
   1) Rated for 250 PSIG and 400 DEGF.
g. Check valves, pump discharge:
   1) 2 IN and smaller: V-25 or V-26.
   2) 2-1/2 IN and larger: V-28, V-29, or V-30.
h. Check valves, other:
   1) 2 IN and smaller: V-25.
   2) 2-1/2 IN and larger: V-28 or V-29.
i. Isolation valves (Gate valves):
   1) 2 IN and smaller: not used.
   2) 2-1/2 IN and larger: V-3.
j. Globe valves:
   1) 2 IN and smaller: V-6 or V-7.
   2) 2-1/2 IN and larger: V-8.
k. Plug valves:
   1) 2 IN and smaller: V-36.
   2) 2-1/2 IN and larger: V-37.

3. Pressure reducing valves:
   a. Water type, diaphragm operated with low inlet pressure check valve and built-in strainer.
   b. Construction:
      1) Body: Brass.
      2) Diaphragm: EPT.
      3) Check valve: Rubber.
      4) Seat: Brass.
      5) Stem: Brass with Buna N insert.
      6) Strainer: Brass.
   c. Maximum working pressure: 100 PSIG.
   d. Adjustable pressure range: 25-60 PSIG.
4. Pressure relief valves, water:
   a. ASME-approved, tight-shutoff, self-closing.
   b. 2-1/2 IN and less: Screwed.
   c. 3 IN and larger: Flanged.
   d. Ten percent over pressure.
   e. Test lever.
   f. Capacity: Same BTUH as equipment served. See schedules.
   g. Relief setting: 125 PSIG unless indicated otherwise**.**

I. Water Flow Measurement Devices
   1. Differential water pressure meter:
      a. Portable type with 6 IN round dial, 270 degree indication.
      b. Range: 0-100 IN WG as specified.

c. Provide purge valves and hoses, minimum of 20 FT.
d. Meter assembly rated at 250 PSI and 250 DEGF.
e. Arrange tubing for multi-station measurement.

2. Venturi waterflow measuring device:
   a. Accuracy: Plus/minus 1 PCT at design flow.
   b. Maximum pressure drop: 0.8 FT.
   c. Provide safety shut-off valves, sensing taps, nipples and quick connection couplings.
   d. Identify with metal tag on chain indicating:
      1) Size.
      2) Location.
      3) GPM.
      4) Meter reading for GPM specified.
   e. Sizes 1/2 IN through 2 IN brass, screwed.
   f. Sizes 2-1/2 IN and over steel, flanged or butt welded.

2.3 WATER TREATMENT SYSTEM

A. Water Treatment System Cleaning Chemicals:
   1. Alkaline:
      a. Oakite 62, 162, 24, 77.
   2. Acid:
      a. Oakite 32.

B. Water Treatment-system chemical feeders:
   1. Pot type feeders constructed for operating pressure of 150 PSI.
   2. Capacity of feeders: 3 GAL minimum.

2.4 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 GENERAL

A. Install in accordance with Section 20 11 00 and Section 20 05 00.

B. Connect equipment.

3.2 PIPE AND FITTINGS

A. Do not insulate or conceal piping until testing is completed.

3.3 AIR VENTS

A. Automatic Air Vents:
   1. Provide shut off valve ahead of vent.
   2. Provide copper relief line from valve to drain or drip pan.
   3. Provide at locations indicated on equipment and piping schematic drawings.

B. Air vents, manual:
   1. Vents shall prevent air binding in systems.
   2. Vent valves:
      a. Provide at trapped high points of closed cooling and heating piping systems.
      b. Provide at coil headers in air handling units unless an automatic air vent is indicated at that location on equipment or piping schematic drawings.
   3. Coin operated vents:
      a. May be used in lieu of vent valves at coil headers for terminal units with piping connections 1-1/4 IN and smaller.

3.4 FLOW SWITCH WELLS

A. Provide flow switch wells at following locations:
   1. Condenser water supply line to each chiller.
   2. Chilled water return line to each chiller.

3.5 PRESSURE AND TEMPERATURE TEST STATIONS, COMBINATION

A. Provide at locations indicated on equipment and piping schematic drawings.

3.6 AIR ELIMINATORS AND DIRT SEPARATORS

A. Provide at locations indicated on equipment and piping schematic drawings.

3.7 STRAINERS

A. Provide full line size strainers ahead of control valves (motor operated), regulating valves, pumps, and as indicated.

B. Provide strainer types as indicated:
   1. Condenser water: Single-basket or tee type.
   2. Chilled water: Single-basket, tee, or wye type.
   3. Heating water: Single-basket, tee, or wye type.

C. Connections to suit piping.

D. Provide blow-down valves:
   1. Strainers 6 IN and larger: 1-1/2 IN blow-down valve.
      a. Pipe blow down to drain.
   2. Strainers 2 to 5 IN: 1 IN blow-down valve with 3/4 IN hose end connection.
   3. Strainers 1-1/2 IN and smaller: 1/2 IN blow-down valve with 3/4 IN hose end connection.

3.8 VALVES

A. Heating and cooling pipe risers:
   1. Provide isolation valves at main feed points to risers.
   2. Provide isolation valves at branch take-offs from risers.

B. Install pressure relief valves on heat exchangers' piping between exchanger and isolation valves.

C. Provide drain piping at pressure relief valves and valves with test levers.
   1. Extend piping to within 6 IN of floor.

D. System Drains: See Section 20 05 19.

E. 3-valve Manifold:
   1. Provide at each differential pressure sensor.
   2. Coordinate locations and quantities of sensors with Controls Contractor.

3.9 WATER FLOW MEASUREMENT DEVICES

A. Provide as indicated.

3.10 WATER TREATMENT SYSTEM

A. Mount chemical feeder across balance valve on pump discharge of systems.
   1. Chilled water system.
   2. Heating water system.

3.11 CONDENSATE DRAINS

A. Pipe condensate drains for all equipment (i.e. air handling units, fan coil units, and route as indicated on plans.

3.12 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.13 TESTING

A. Test heating and cooling piping upon completion of a section or of entire system.
   1. Test hydrostatically to pressure not less than 50 PCT in excess of maximum pressure to which pipe will ordinarily be subjected, but in no case less than 150 PSI for 1 hour minimum without pressure drop.
   2. Repair or replace leaks or defective pipe disclosed by tests.
   3. Repeat tests until piping indicates tight.

3.14 CLEANING OF CHILLED AND HEATING WATER SYSTEMS

A. Do not valve in or operate system pumps until after system has been cleaned.

B. At system completion, make temporary connection to domestic water system, and flush system until clear water is visible from drain connection.
   1. Drain system after flushing.

C. At project completion, clean systems:
   1. Thoroughly flush system with a recommended hot solution (160-180 DEGF) of alkaline cleaning chemical to remove oil and grease that may be present.
      a. Thorough flushing includes eliminating air from system.
      b. Drain systems, and rinse completely with clean water.
      c. Measure and record volume of each system for purpose of chemical treatment.
   2. Add water and acid solution, and circulate through systems as recommended by manufacturer to remove rust and scale.
      a. Circulate solution through systems at a minimum velocity of 10 FPS.
      b. Drain systems, and rinse completely with clean water.
         1) Rinse system at a minimum velocity of 10 FPS.
   3. Check drain water for pH level.
   4. If drain water is acidic, neutralize system by thoroughly reflushing with alkaline-type material as indicated above.

D. After cleaning is complete, and just before start-up, clean strainers.

3.15 START-UP

A. After cleaning is complete, and water pH is acceptable to manufacturer of water treatment chemicals, add manufacturer-recommended amount of chemicals to systems.

B. Provide monthly testing for the first six months after start-up to verify that the correct chemical concentrations are present in each system.

END OF SECTION

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SECTION 23 21 23
HVAC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for HVAC Pumps, as indicated, in accordance with provisions of Contract Documents.

B. Types Included:
   1. Single suction pumps.
   2. In-line pumps.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Standards:
   1. Hydraulic Institute Standards: HI1983, 14TH Edition.
   2. Hydraulic Institute Engineering Data Handbook: HI979, First Edition.

1.3 SUBMITTALS

A. Product Data:
   1. Pumps:
      a. Include curves.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Letter stating extra material has been delivered.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Single suction, heating, cooling and condenser water pumps:
   1. Base:
      a. Bell & Gossett, ITT.
   2. Optional:
      a. Allis-Chalmers, ITT.
      b. Armstrong Pumps.
      c. Buffalo Forge.
      d. Byron-Jackson.
      e. Chicago Faucet.
      f. Dunham-Bush.
      g. Goulds Pumps.
      h. Sulzer Pump (Paco).
      i. Peerless Pump.
      j. Taco.
      k. Weil Pump.

B. Flexible pump couplings (suitable for use with VFDs):
   1. Base:
      a. Dodge Regupol.
      b. TB Woods.

C. In-line pumps:
   1. Base:
      a. Bell & Gossett, ITT.
   2. Optional:
      a. Allis-Chalmers, ITT.
      b. Aurora.
      c. Buffalo Forge.
      d. Goulds Pumps.
      e. Peerless Pump.
      f. Taco.
      g. Weil Pump.
      h. Ingersoll Dresser Pumps.

D. Pumps and drives by same manufacturer.

2.2 MATERIALS

A. Single Suction Pumps
   1. Pumps, heating, cooling and condenser water: Centrifugal, single stage, single suction, horizontal type, with vertically split casing, end suction and top vertical discharge with electric motor drive.
      a. Capacity: As scheduled, with continuously dropping head capacity curve from zero to maximum flow.
      b. Motor coupling: Close coupled, or flexible coupled as indicated.
      c. Provide coupling guard for flexible couplings.
      d. Mount pump and drive on common base.
      e. Base: Cast iron or steel plate with raised lip and drain connections.
   2. Pumps, single suction centrifugal:
      a. Case: Cast iron, 125 LB ANSI standard flanged connections, hydrostatically tested at minimum 150 PSIG.
      b. Fit case with vent and drain valve.
      c. Impeller: Bronze, enclosed type with volute vent plug.
      d. Shaft: Forged alloy steel.
      e. Shaft sleeves: Stainless steel.
      f. Mechanical seal: Ceramic on carbon.
      g. Bearings: Grease lubricated, ball or roller type.
   3. Pump motor drives: Constant speed, squirrel cage induction, 40 DEGC, drip-proof, AC, ball bearing, non-overloading.
      a. Nameplate horsepower ratings: Not less than maximum required pump input brake horsepower at pump capacities from zero to maximum.
      b. See Section 20 05 00.
   4. Pump couplings, flexible: Dodge Para-Flex.
      a. Taper-Lock bushings keyed to shaft.

B. In-Line Pumps
   1. In-line pumps, heating water: Centrifugal, single stage, for installation in vertical or horizontal piping.
      a. Capacity: As scheduled.
      b. Capable of being serviced without disturbing piping connections.
      c. Pump body: Class 30 cast iron, standard flange connections.
         1) Rated working pressure: 175 PSI.
         2) Provide with gauge ports at nozzles and vent and drain ports.
      d. Impeller: Non-ferrous material, enclosed type.
         1) Dynamically balanced, keyed to shaft and secured by locking capscrew or nut.
      e. Provide internally-flushed mechanical seal with ceramic seal seat.
      f. Non-ferrous shaft sleeve to cover wetted area under seal.
      g. Oil lubricated bronze journal and thrust bearings.

h. Flexible coupling.
i. Motor: Constant speed, squirrel cage induction, 40 DEGC, drip-proof, non-overloading.

2. In-line pumps, heating and cooling water: Centrifugal, close-coupled, single stage, bronze fitted, vertical mount.
   a. Capacity: As scheduled.
   b. Capable of being serviced without disturbing piping connections.
   c. Pump body: Cast iron with 125 PSI ANSI drilled flanges.
      1) Rated working pressure: 175 PSI.
      2) Provide with gauge ports.
   d. Impeller: Non-ferrous material, enclosed type.
      1) Hydraulically and dynamically balanced.
      2) Keyed to shaft and secured by locking capscrew.
   e. Provide internally-flushed mechanical seal with ceramic seal seat.
   f. Non-ferrous shaft sleeve to cover wetted area under seal.
   g. Motor: Open drip-proof enclosure with regreaseable ball bearings.

2.3 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 GENERAL

A. Install pumps according to manufacturer's recommendations and as specified.

3.2 BASE MOUNTED PUMP INSTALLATION

A. Set floor mounted horizontal pump on concrete base.

B. Level and bolt down.

C. Fill entire base with non-shrinking grout.

D. After pump base grouting is complete, align pump and each driver accurately to provide out of alignment of not over 0.004 IN in both axial and angular planes.
   1. After alignment, pin pump and motor to base with taper pins using minimum of 3 pins each.

E. Connect to piping system as indicated.

3.3 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

END OF SECTION

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SECTION 23 25 16
COOLING TOWER TREATMENT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, tools, equipment, and services for Cooling Tower Treatment System, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Water Treatment Vendor qualifications:
   1. Regularly engaged in providing the type and quality of service specified for 10 years.
   2. Associated with a laboratory facility with a full time PhD laboratory directory.
   3. ISO 9002 certified.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Schematic piping and chemical equipment layout.
   2. Identify connection points to condenser/cooling tower water piping system.

B. Product Data:
   1. Cooling tower treatment system components.

C. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Chemical feed pumps:
   1. Base:
      a. Neptune.
   2. Optional:
      a. Pulsafeeder.
      b. Advantage Controls.

B. Side Stream Filtration:
   1. Base:
      a. PEP.
   2. Optional:
      a. Lakos.

2.2 MATERIALS

A. Cooling Tower Treatment System
   1. Cooling tower water treatment system:
      a. Prefabricated, integrated electronic control system for cooling tower water circuit to monitor and control total dissolved solids, corrosion inhibitors, and biocides.
   2. Controller: Microprocessor based type for use in recirculating cooling tower water systems.
      a. Accurately control level of total dissolved solids (TDS) in terms of electrolytic conductivity.
      b. Provide a programmable 28 day biocide timer for accurate addition of algaecide.

c. Provide for proportional feed of inhibitor, and/or dispersant chemicals based upon make up water as measured by a contacting head water meter.

3. Main control panel and accessories:
   a. Housed in a NEMA Type 4X enclosure:
      1) Hinged key lock door with viewing window.
      2) 8 FT, 3-wire power cord with molded plug.
      3) Provide minimum of three (3) 115V, 1 Ph, 60 Hz receptacles located on enclosure for electrical connection and control of chemical pumps.
      4) Prewired for ease of installation.
   b. Provide an external combination mounted flow switch with transparent sight tube.
      1) Disable control outputs upon loss of water flow to prevent chemical feeding.
      2) Provide complete with 3/4 IN connections and combination conductivity and temperature electrode.
   c. Keypad or remote control: Access all measurements and setpoints through chemical resistant key pad or remote.
      1) Security code to prevent unauthorized access.
   d. Utilize microprocessor technology.
   e. Menu driver programs.
   f. Liquid crystal display (LCD).
   g. Provide temperature corrected measurements by reading water temperature and adjusting conductivity values according to known temperature curve.
      1) Range: 32-212 DEGF with an adjustable high alarm.
   h. Provide real-time clock.
   i. Conductivity monitor:
      1) Provide linear measurements of full range.
      2) Provide two scales for selection of high and low in field to assure accurate measurements.
      3) Provide increments of 1 microohm/cm with adjustable hysteresis.
      4) Provide bleed-off control in following manner:
         a) Standard operation-controller actuates a bleed off solenoid valve when dissolved solids level is exceeded by trip point.
         b) Provide an adjustable bleed limit timer to prevent excessive bleed off.
         c) An alarm contact shall close when timer has timed out.
   j. Biocide operation:
      1) Provide a secondary bleed off timer to lower conductivity in system prior to biocide feed.
      2) Lock out cooling water bleed-off during biocide feed period.
   k. Chemical feed control: Provide three timers that are capable of operating in one of following field programmable modes.
      1) Counter-timer-chemical feed proportioned to make-up water rate.
         a) Controller shall send low voltage signal to a contacting head water meter.
         b) Low voltage signal will ensure long contact life.
         c) Water meter shall read in gallons.
   l. Alarms:
      1) Provide alarm LEDs with silence button for high and low conductivity, 10-60 minute bleed-off, chemical feed limit timers, and chemical drum level. Provide remote output relay to indicate alarm condition to Building Management and Control System(BMCS) specified under Division 25.
   m. Controller operating data history:
      1) Retain in memory all operating data for following parameters:
         a) Standard memory shall allow acquisition and storage of all analog inputs for a one-week period.
         b) A three (3) hour minimum, maximum average of all conditions shall be stored for a one-week period.
         c) A minute-by-minute account of operating conditions shall be available for latest three-hour period.

n. Electrode: Combination temperature and conductivity type.
    1) Quick disconnect.
    2) Supplied in flow switch assembly.
o. Ph monitor:
    1) Sensor for monitoring purposes only.
    2) Acid shall not be used to control pH.
p. Remote communication:
    1) Provide internal modem to perform the following functions:
        a) Access Real-time system values.
        b) Change operating parameters.
        c) Controller diagnostics.
        d) Obtain history files.
        e) Alarm condition notification.

4. Impulse water meter:
    a. General:
        1) Measure in gallons.
        2) Sized to meter peak make up rates.
        3) Equipped with an electrical contacting register.
        4) Totalize flow at main control panel.
    b. Provide at following locations:
        1) Cooling tower make up line.
5. Provide PVC injection nozzles with corporation stop to inject chemical into main circulating water line.
    a. Pressure rating: 100 PSI
    b. Size: 3/4 IN NPT.
    c. Quantity: Three (3).
6. Provide chemical feed pumps operated by a 115V, 60 cycle, single PH motor.
    a. Provide separate stroke and stroke frequency setting capabilities.
    b. Positive displacement type pump
        1) Provide with anti-siphon/pressure relief valve installed on pump head which provides anti-siphon protection and aids in priming under pressure.
        2) Capacity: As determined by Water Treatment Vendor.
        3) Complete with discharge check valves, foot valves, polyethylene suction and discharge tubing.
    c. Quantity: three (3).
7. Bleed-off piping assembly:
    a. Inlet shut-off valve.
    b. Wye strainer.
    c. Strainer blowdown valve.
    d. Throttling valve.
    e. Brass solenoid valve compatible with main control panel.
    f. Assembly shall be sized by Water Treatment Vendor.
8. Secondary containment spill pallets for chemical drums:
    a. Material: Polyethylene.
    b. Capacity: 66 GAL each.
    c. Dimensions each: 53 IN length x 29 IN wide X 7 IN high.
    d. Provide each pallet with grating and drain plug.
    e. Provide one portable loading ramp.
    f. Quantity: Two (2).
9. Provide liquid level switch assemblies with a PVC bung hole adapter to mount directly into 55 GAL chemical drum bung hole.
    a. Interface with main control panel.
    b. Quantity: Three (3).
10. Corrosion monitor rack:
    a. Materials: Corrosion resistant.
    b. Construction: ASME specifications.

c. Number of coupons: four (4).
d. Coupon holders: quick disconnect type.

11. Provide test kits for monitoring inhibitor levels, total dissolved solids, chlorides, alkalinity and closed system inhibitors.
12. Provide one (1) year's supply of chemical treatment including quantity of chemicals necessary to chemically treat system to control scale, corrosion and biological fouling.
    a. Provide water treatment products that perform the following:
        1) Inhibitor to protect against corrosion and scale formation.
        2) Two liquid biocides for prevention of slime, bacteria and algae.
        3) Chromate based chemical are unacceptable.
        4) Water treatment chemicals to remain stable throughout operating temperature range.
        5) Are compatible with pump seals and other elements in the systems.
        6) Provide precleaning chemicals to remove system dirt, debris, and cutting oils from system for all condenser piping. Precleaning materials to be non-acid in composition and not harmful to system metallurgy.
        7) All chemicals to be acceptable for discharge to sanitary sewer.

B. Side Stream Filtration
1. General:
    a. Contractor shall furnish and install a high efficiency media filtration system for side stream filtration for condenser water. The filter shall be rated to filter 392 gpm (maximum flow). Flow rate through the media filter shall not exceed 20 gpm/ft^2 of filter surface area.
    b. Filter shall be capable of removing 90% of all particles by volume and total mass, ten-micron and larger. Filtration system shall be designed for continuous operation and shall automatically backwash upon reaching a 16 psig pressure drop across the filter or once every 24 hours.
2. Vessel:
    a. The filter vessel shall be rated for 150 psig (maximum) continuous operating pressure. The vessel shall be constructed in accordance with ASME Section VIII, Div. 1 standards. Vessel shall include a top access port. Vessel over-drain and under-drain shall be constructed of schedule 80 PVC pipe. The vessel shall have a bottom drain. The drain shall include a full flow spiral wound media retaining device located in the lowest part of the vessel. Vessel shall include manual and high capacity heavy duty cast iron automatic air vents. The vessel shall be sandblasted to SSPC-SP10 “near white” metal externally followed by a primer coat covered by a urethane coating. Vessel internal surfaces shall be sandblasted to SSPC-SP5 “white metal” finish followed by Bar-rust 233 to a minimum thickness of 6 mils.
3. Valves:
    a. Valves shall be wafer butterfly style with epoxy coated cast iron body and shall meet ANSI 150 pressure ratings for hydrostatic shell test requirements and shall also meet the requirements of ASTM A126 Class B. Valve seat shall be EDPM, valve disc shall be nylon 11 coated ductile iron and valve stem shall be 416 series stainless steel. Actuator mounting flange and stem connection shall meet the requirements of ISO 5211 and ISO 5752. To eliminate “out of sequence” operation, the backwash valves shall be mechanically linked via heavy duty linkage rods.
4. Actuators:
    a. Actuators shall be electric and shall incorporate an electric brake to prevent back-drive. Actuators shall be rated for at least a 25% duty cycle and shall incorporate field adjustable limit switches. All actuator electrical components shall be housed in a thermoplastic enclosure with O-ring seal.

5. Control Panel:
    a. The control panel shall be NEMA 4X and shall be UL listed. Power disconnect switch and filter mode indicator lights shall be surface mounted on the control panel. Control functions shall include automatic backwash upon differential pressure, 24-hour clock and pushbutton for manual initiation of the backwash cycle. Discrete analog components shall include but not be limited to status indicator lights (green ~ filter, and red ~ backwash), relay for remote indication of filter status, main disconnect switch, fuses and differential pressure switch.
6. Pressure Gauges:
    a. The filter shall have inlet and outlet pressure gauges. The gauges shall be minimum 2.5 IN diameter and shall be glycerin filled.
7. Filter Media:
    a. Media shall be permanent type nominal 0.85 mm diameter silica sand and 0.55 mm garnet and rechargeable by a backwash at a minimum flow rate of 15 gpm/ft^2 of filter surface area. Under-drain support shall be 4.75 mm gravel. Media shall be AWWA or NSF approved
8. Backwash Holding Tank:
    a. The backwash holding tank shall have a capacity of 1500 gallons. Provide with a fill connection, 2 IN drain connection, vent and accommodation for the installation of level controls and trouble alarm to the BAS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all systems and components in accordance with manufacturer's instructions and recommendations.

B. Provide all piping and wiring for a complete functional system.
   1. All wiring shall be in metallic conduit complying with Electrical Specification Divisions.

C. Locate chemical feed pumps, chemical drums, and other components as indicated.

D. Install impulse water meter at the following locations:
   1. Cooling tower make up piping.

E. Provide a by-pass line around water meters and bleed off piping assembly. Provide ball valves to allow for bypassing, isolation, and servicing of components.

F. Bleed off water piping with bleed off piping assembly shall be piped from pressure side of circulating water piping to a convenient drain. Bleed off connection to main circulating water piping shall be upstream of chemical injection nozzles.

G. Provide 1 IN Schedule 80 PVC piping for the flow assembly piping to the main control panel and accessories.
   1. The inlet piping shall connect to the discharge side of the circulating water pump.
   2. The outlet piping shall connect to the water piping serving the cooling tower downstream of the heat source.
   3. Provide inlet PVC wye strainer and PVC ball valves to isolate and service main control panel and accessories.

H. Install PVC injection nozzles with corporation stops in the water piping serving the cooling tower downstream of the heat source.

I. Provide Schedule 80 PVC piping for corrosion monitor rack per manufacturer's installation instructions. Provide PVC ball valves to isolate and service rack.

J. Provide installation supervision, start-up and operating instruction by manufacturer's technical representative.

K. Provide minimum of 4 HRS instruction of Owner's personnel.

END OF SECTION

SECTION 23 31 13
AIR DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Air Distribution System, as indicated, in accordance with provisions of Contract Documents.

B. Definitions:
   1. Low and high pressure ductwork:
      a. See Article 2.2 of this section.
   2. Gage:
      a. Steel sheet and wire: U S Standard Gage.
      b. Aluminum sheet: Browne & Sharpe Gage.
      c. Steel wire: Washburn and Moen Gage.
   3. Concealed insulated surfaces:
      a. Piping, ductwork and equipment in walls, partitions, floors, pipe chases, pipe shafts, duct shafts and above suspended ceilings.
   4. Exposed insulated surfaces:
      a. Piping, ductwork and equipment located in mechanical rooms, tunnels and rooms without suspended ceilings.

C. Duct sizes indicated are based upon internal dimensions.

D. Location of diffusers, registers and grilles are indicated on Architectural Reflected Ceiling Plans.

E. Control Dampers Installed in Air Handling Units:
   1. Furnished in Section 25 10 00.
   2. Deliver to air handling unit manufacturer and factory mount in unit.

F. Dampers:
   1. Factory built and assembled.

G. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE):
   1. ASHRAE Handbook - HVAC Systems and Equipment: Current chapter on duct construction.
   2. ASHRAE Standard 70-72, Method of Testing for Rating the air flow performance of outlets and inlets.

B. Air Diffusion Council (ADC):
   1. ADC Standard 1062: GRD-84, Test Code for Grilles, Registers and Diffusers.
   2. ADC Test Code FD 72-R1, Flexible Air Duct Test Code.

C. Air Movement and Control Association International (AMCA):
   1. AMCA Standard 210, Test Code for Air Moving Devices.

D. National Fire Protection Association (NFPA):
   1. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems, current edition.
   2. NFPA 96 Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment, current edition.
   3. NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials

E. Sheet Metal & Air Conditioning Contractors National Association (SMACNA):
   1. SMACNA HVAC Duct Construction Standard - Metal and Flexible, Current Edition.
   2. SMACNA Duct Cleanliness for New Construction, Current Edition.

F. ASTM International (ASTM):
   1. ASTM A109 Standard Specification for Steel, Strip Carbon (0.25 Maximum Percent), Cold-Rolled.
   2. ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanealed) by the Hot-Dip Process.
   3. ASTM B23 Standard Specification for White Metal Bearing Alloys (Known Commercially as Babbit Metal).
   4. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials.
   5. ASTM E96 Standard Test Methods for Water Vapor Transmission of Materials.

G. Underwriters Laboratories (UL):
   1. UL 181A Closure Systems for Use with Rigid Air Ducts.
   2. UL 181B Closure Systems for Use with Flexible Air Ducts and Air Connectors.
   3. UL 723 Standard for Test for Surface Burning Characteristics of Building Materials

H. International Mechanical Code 2015 Edition.

I. International Energy Conservation Code 2015 Edition.

J. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Ductwork layout at 1/4 IN to 1 FT scale.
      a. Layout drawings to include sign-off from balancing contractor indicating the contractor has reviewed the documents to ensure volume damper installation is in compliance with the requirements of this section.
      b. Shop drawings may not be copied, traced, or any other reproduced version of the construction documents.
      c. Shop drawings should show progress from coordination with other trades, ductwork elevations, fittings, joints, sheet metal gauges, and any other pertinent information related to the layout, installation, or construction of the ductwork.

B. Product Data:
   1. Ductwork and fittings.
   2. Dampers.
   3. Diffusers, registers and grilles.
   4. Sound Attenuators.
   5. CBR Air Filtration Systems: HEPA filters with side access bag in, bag out housing.
   6. Pressure relief doors.

C. Contract Closeout Information:
   1. Operation and Maintenance Data:
      a. Including but not limited to fire and smoke dampers, control dampers and combination louvers.
      b. See Section 01 78 23.
   2. Test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. High Pressure Flat Oval and Round Spiral Ductwork:
  1. Base:
     a. United McGill Airflow Corporation.
  2. Optional:
     a. Semco Incorporated.
     b. Sheet Metal Connectors, Inc.
     c. Eastern Sheet Metal, Inc.
     d. Spiral Pipe of Texas.

B. Factory Fabricated Duct Connection Systems:
  1. Base:
     a. Ductmate Industries.
  2. Optional:
     a. Nexus.
     b. Ward Industries, Inc.

C. Sealants, Mastics and Adhesives:
  1. Base:
     a. Hardcast.
  2. Optional:
     a. United McGill Airflow Corporation.
     b. Foster (Division of HB Fuller).

D. Turning Vanes:
  1. Base:
     a. Aerodyne Controls.
  2. Optional:
     a. Airsan.
     b. Tuttle & Bailey.
     c. Titus.
     d. VentProducts.

E. Flexible Fan Connections:
  1. Base:
     a. Ventfabrics.
  2. Optional:
     a. Duro-Dyne.
     b. Elgin.

F. Preinsulated Flexible Duct:
  1. Base:
     a. Atco.
  2. Optional:
     a. Flexible Technologies, Thermaflex.
     b. Hart and Cooley.
     c. Flexmaster.

G. Access Doors, Low Pressure:
  1. Base:
     a. Ruskin Manufacturing.
  2. Optional:
     a. Air Balance.
     b. Nailor-Hart Industries, Inc.
     c. Ventfabrics.

d. CESCO products.
e. Safe-Air of Illinois.

H. Access Doors, Low and High Pressure:
1. Base:
a. Ductmate.
2. Optional:
a. Ward Industries.
b. United McGill Airflow Corporation.

I. Dampers, Manual and Backdraft:
1. Base:
a. Ruskin Manufacturing.
2. Optional:
a. Arrow Louvers and Dampers, Inc.
b. American Warming & Ventilating.
c. Air Balance.
d. Cesco Products.
e. Greenheck.

J. Dampers, Bubble Tight:
1. Base:
a. Ruskin.
2. Optional:
a. AAF International.
b. Camfil Farr.
c. Greenheck.

K. Fire and Smoke Dampers:
1. Base:
a. Ruskin Manufacturing.
2. Optional:
a. Air Balance.
b. Greenheck.
c. Nailor-Hart Industries, Inc.
d. Prefco Products.
e. Safe-Air of Illinois.
f. CESCO products.
g. Pottorff.

L. Diffusers, Registers and Grilles - Not including laminar flow in ceiling systems and radial throw diffusers:
1. Base:
a. Titus.
2. Optional:
a. Anemostat Air Products.
b. Carnes.
c. Tuttle & Bailey.
d. Krueger.
e. Price.

M. Diffusers, Radial Throw:
1. Base:
a. Anemostat Air Products.
2. Optional:
a. Price.

N. Sound Attenuators:
   1. Base:
      a. Semco Incorporated.
   2. Optional:
      a. Ruskin Sound Control.
      b. Semco Incorporated.
      c. McGill AirSilence, LLC.
      d. Vibro-Acoustics.
      e. Commercial Acoustics.

O. CBR Air Filtration System - HEPA Filters with Bag In, Bag Out Service Housing:
   1. Base:
      a. American Air Filter.
   2. Optional:
      a. Flanders.
      b. Farr.
      c. P & G Manufacturing Inc.

P. Pressure Relief Doors:
   1. Base:
      a. Kees.
   2. Optional:
      a. United Enertech.

Q. Engine Exhaust Extraction System:
   1. Base:
      a. Monoxivent.
   2. Optional:
      a. Nederman.

2.2 MATERIALS

A. Sheet Metal:
   1. Galvanized steel (G90): ASTM A653/A653M.
   2. Black steel: ASTM A109.

B. Duct Sealer:
   1. NFPA rating of "Non-Combustible".
   2. Flame spread rating: 25 or lower, in dry condition.
   3. Smoke developed rating: 50 or lower, in dry condition.
   4. Resistant to water and water vapors.
   5. Pressure rupture rating: 16 IN WG, minimum.
   6. Durkee-Atwood Permatite Class I Duct Sealer; Hardcast Iron Grip 601 and Duct Seal 321; or United McGill Sheet Metal Uni-Mastic 181 Duct Sealer and United Duct Sealer.
   7. Duct sealer shall have a VOC content no greater than 250 g/L.

C. Solder:
   1. Grade-50B per ASTM B23.

D. Duct Sealing Tape:
   1. NFPA rating of "Non-Combustible".
   2. Flame spread rating: 25 or lower, in dry condition.
   3. Smoke developed rating: 50 or lower, in dry condition.
   4. Adhesive: Specifically compounded for maximum adhesion to galvanized and stainless steel.
   5. Listings/Labels: UL 181A or UL 181B.

E. RTV Foam:
   1. UL listed room temperature vulcanized silicone rubber foam.

F. Ductwork:
   1. Maintain full areas and suitable shapes at every point.
   2. Shapes may be changed to fit unusual space conditions.
      a. Cross sectional area to be maintained.
      b. Modifications increasing system pressure drop require Architect approval.
      c. Modifications increasing aspect ratio beyond 5:1require Architect approval.
   3. Provide necessary transitions and offsets to complete systems.
   4. Construct systems of G90 galvanized steel, except as follows:
      a. Entire exhaust system for EF-3 (linear accelerator area) shall be constructed of type 316 stainless steel. All joints shall be sealed or soldered watertight. Provide drains at all low points.
   5. Ductwork, Low Pressure, Sheet Metal:
      a. Construct in accordance with SMACNA HVAC Duct Construction Standard per appropriate SMACNA table.
         1) Ductwork for systems operating between 2 IN WG and 3 IN WG static pressure, positive or negative:
            a) Rectangular duct.
            b) Round spiral seam duct.
         2) Ductwork systems operating under 2 IN WG positive or negative:
            a) Rectangular duct.
            b) Round duct: spiral or longitudinal seam.
      b. Low pressure ductwork includes but is not limited to:
         1) Supply ductwork on outlet side of single duct air terminal units.
         2) Return, relief air, and outside air ductwork.
         3) Exhaust air ductwork from air inlets to air terminal units (e.g. lab snorkel exhaust system).
         4) Exhaust air for other exhaust systems operating less than 3 IN WG static pressure, positive or negative.
         5) Supply ductwork for constant volume systems without air terminal units.
      c. Transverse joints, rectangular:
         1) Ducts with longest side 36 IN and longer:
            a) Use factory fabricated flanged duct connection systems (e.g. Ductmate 35/25 slide on systems).
            b) Non-proprietary SMACNA defined T-22 or T-24 flanged connections
            c) Seal transverse flanged duct connections with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
         2) Ducts with longest side shorter than 35 IN:
            a) Flanged duct connection systems as defined above are optional.
            b) Refer to SMACNA HVAC Duct Construction Standard for proper duct construction.
      d. Longitudinal seam: Use Pittsburgh lock seam only.
      e. Seal low pressure ducts to Seal Class A requirements.
      f. Runouts to diffusers, register and grilles:
         1) Flexible duct.
         2) Provide rigid ductwork where ducts pass through smoke or fire rated walls, floors or ceilings.
         3) Maximum flexible duct length: 3 FT.
         4) Minimum turning radius:
            a) As recommended by manufacturer.
            b) Do not kink, bend or restrict free area of duct.
   6. Ductwork, Exposed to Weather:
      a. Construct using flanged duct connection systems.
      b. Seal flanged ends with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
      c. Provide continuous cleat seals on top joints of ducts.

d. Supports, pedestals and curbs:
    1) See Section 07 72 13.

7. Ductwork, High Pressure:
    a. Construct in accordance with SMACNA HVAC Duct Construction Standard per following:
        1) Rectangular duct: Table 1-8, 6 IN WG static pressure, positive or negative.
        2) Round duct: Table 3A & Fig. 3-1, 10 IN WG static pressure.
    b. Transverse joints, rectangular:
        1) Use factory fabricated flanged duct connection systems (e.g. Ductmate 35/25 slide on systems).
        2) Non-proprietary SMACNA defined T-22 or T-24 flanged connections
        3) Seal transverse flanged duct connections with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
    c. Longitudinal seam: Pittsburgh lock seam.
    d. High pressure ductwork includes:
        1) Supply ductwork from air handling unit discharge to connection with single duct air terminal units.
        2) Exhaust ductwork between suction side of exhaust fan and air terminal units (e.g. isolation exhaust system).
        3) Exhaust or return ductwork for other exhaust systems operating over 3 IN WG static pressure.
    e. Runouts to air terminal units: Rigid or flexible ductwork.
        1) Maximum flexible duct length: 3 FT.
        2) Minimum turning radius:
            a) As recommended by manufacturer. Do not kink, bend or restrict free area of duct as to generate additional pressure drop or noise.
        3) Provide rigid ductwork on units located in rated corridors or corridors requiring smoke tight construction, where ducts pass through smoke or fire rated walls, floors or ceilings, and connections to air terminal units for exhaust or return systems.
    f. Seal high pressure duct to seal Class A requirements.

G. Duct Hangers and Supports:
1. High and low pressure sheet metal ductwork:
    a. SMACNA HVAC Duct Construction Standard.

H. Duct Fittings and Joints:
1. Low Pressure Systems:
    a. Radius elbows without vanes:
        1) Radius ratio (R/W) of 1.5 and greater.
    b. Connections to diffusers, grilles and registers: Fitted securely to necks or collars provided behind diffuser, grille, or register face area.
    c. Branch connections:
        1) Round: Factory built short cone or bellmouth type. Air scoops are not acceptable.
        2) Rectangular: 45 degree entry type or radius elbow.
    d. Provide necessary transition pieces and duct collars to make connections to ductwork from neck sizes scheduled or indicated on drawings.
2. High Pressure Systems:
    a. Elbows 3-8 IN diameter: Die stamped, for minimum air friction loss, with continuous corrosion resistance welds.
    b. Elbows over 8 IN diameter: Welded segment type, not less than 5 pieces for 90 degree elbows, and not less than 3 pieces for 45 degree elbows, using corrosion resistant welds.
    c. Tees: "Low loss, short cone type", unless specifically detailed otherwise for space limitations.
    d. "Y's" 45 degree type. 60 degree type may be used if space conditions dictate.

e. Install "Y's" as indicated.
f. Where tees are indicated, "Y's" may be substituted if space is available.
g. "Y's": Straight sided type (no cone).
h. Takeoffs from air handling unit plenums: Standard Bellmouth fittings.
   1) Construct in accordance with SMACNA HVAC Duct Construction Standards.
i. "Y" takeoffs from horizontal ceiling mounted ducts to serve boxes: May be straight sided, shop fabricated type by accurately cutting and welding "Y's" into spiral ducts without use of fittings.

I. Turning Vanes, Square Elbows:
   1. Velocities up to 2500 FPM: Single vane, runner Type 2, with 3/4 IN trailing edge, 2 IN vane radius and 1.5 IN vane spacing, minimum 24 GA.
      a. For widths over 36 IN install vanes in 2 or more sections or use tie rods to limit unbraced vane length.
   2. Where inlet and outlet dimensions of elbows are not equal, set 2 or more sections at 45 DEG angle to give optimum turning.
   3. Radius elbows without vanes: Radius ratio (R/W) of 1.5 and greater.
   4. Radius elbows with vanes: Radius ratio (R/W) less than 1.5; use where space limitations occur.
      a. R/W = 0.75 to 1.0: Provide 3 vanes in elbow.
      b. R/W = 1.0 to 1.25: Provide 2 vanes in elbow.
      c. R/W = 1.25 to 1.5: Provide 1 vane in elbow.
      d. Provide vane spacing per SMACNA HVAC Duct Construction Standards.
   5. Where square elbows are indicated or required, provide with turning vanes.

J. Partitions and Blank-Off Plates:
   1. Where used as part of an air handling unit, construct of 14 GA sheet metal with 1-1/2 IN standing seams.
   2. Partitions 8 FT long or less: Provide additional bracing of 1-1/2 x 1/4 IN angles spaced 2 FT on center.
   3. Partitions over 8 FT long: Provide additional bracing of 2 x 1/4 IN angles spaced 2 FT on center.

K. Flexible Fan Connections:
   1. Material: Neoprene double coated closely woven glass fabric flexible connections.
   2. Fasten fabric to sheet metal duct work and to fan collar extension with 3/16 IN rivets spaced not more than 5 IN OC.
   3. Locate in inlet and outlet of fans, as close to fan as possible.
   4. Provide at ducts crossing building expansion joints and as indicated on drawings.
   5. Connections shall not be under tension.
   6. Provide minimum separation distance of 1 IN across the connection.

L. Flexible Ducts, Preinsulated:
   1. Low pressure construction:
      a. Liner: Steel wire helix encapsulated with chlorinated polyethylene (CPE) film.
      b. Insulation:
         1) 1 IN x 3/4LB/CF fiberglass insulation, minimum resistance of R-4.2.
      c. Jacket:
         1) Bi-directional metalized polyester.
         2) Permeability: Not to exceed 0.05 perms when tested in accordance with ASTM E96 Procedure A.
   2. High pressure construction:
      a. Liner: Heavy gauge corrugated aluminum with watertight continuous lock seams.
      b. Insulation: 1 IN x 3/4LB/CF fiberglass insulation, minimum resistance of R-4.2.
      c. Jacket:
         1) Bi-directional metalized polyester.

2) Permeability: Not to exceed 0.05 perms when tested in accordance with ASTM E96 Procedure A.
3) Flex duct must also meet any other local or state requirements for flexible duct construction and performance.
3. Rated working pressure:
a. Low pressure duct: Positive 4 IN WG minimum; negative 1 IN WG minimum, for return or exhaust air connections.
b. High pressure duct: Positive 8 IN WG minimum; negative 8 IN WG minimum for return or exhaust air connections
4. Fire resistant, self extinguishing, UL-181, Class 1, with flame spread of 25 or less and smoke development not to exceed 50.
5. Thermal conductance(C): 0.23 BTU/ h-FT^2-F.
6. Low pressure connections:
a. Secure duct to collar or sleeve with screws, or metal or nylon clamps or bands.
b. Seal connection with 2 wraps of duct tape.
7. High pressure connections:
a. Secure duct to collar or sleeve with duct sealer and 1/2 IN aluminum or galvanized steel bands or clamps.
b. Secure insulation jacket with 2 wraps of duct tape.
8. Turn radius: Not less than R/D equal to 1.0.
9. Provide flexible duct supports in accordance with SMACNA HVAC Duct Construction Standards.
10. As applicable, all products or assemblies to meet local or state code requirements.

M. Access Doors:
1. Provide at fire dampers, smoke dampers, fire and smoke dampers, duct mounted automatic dampers, immediately upstream of square elbows with turning vanes, and where indicated on Drawings.
2. Position access doors to permit easy visual inspection and allow maintenance and resetting of device served.
3. Increase duct dimensions at devices when necessary to accommodate required access.
4. Install access doors above accessible lay-in ceilings.
5. Where access doors are installed above gypsum wall board ceilings or within shafts, provide access panels per Section 20 05 00.
6. Access doors at low pressure ductwork:
a. Minimum Sizes:
1) Access doors in ducts less than 24 IN wide: 12 IN X 12 IN.
2) Access doors in ducts larger than 24 IN wide: 18 IN x 18 IN.
b. To install doors in round ducts, provide duct boot.
1) Ruskin ADC22.
7. Low and high pressure ductwork:
a. Access doors:
1) Removable, double wall construction.
2) 1 IN thick fiberglass insulation.
3) Closed cell neoprene gasket and attachment bolts.
4) Air tight seal to static pressures of 20 IN WG.
b. Sizes:
1) For ducts 18 IN and under, the minimum door size shall be 10 IN X 6 IN.
2) For ducts 19 IN to 24 IN, the minimum door size shall be 16 IN X 12 IN.
3) For ducts over 24 IN the minimum door size shall be 24 IN X 18 IN.
c. Provide duct boot to install doors in round ducts or rounded side of flat oval duct.

N. Fume Hood Exhaust Ductwork:
1. Classified as high velocity and high pressure.
2. Ducts and plenums fabricated from standard gauges.
3. Construction material for ductwork, fittings and accessories:

a. Type 316 stainless steel for Radiochemistry Lab.
b. G90 galvanized steel for hoods in KMR Potting, Shared Wet Lab, and SES GSEL Gown Room.
4. Bolts, screws and rivets:
a. Zinc plated stainless steel, machine hex head type with machine hex nuts.
b. Exposed in air stream: 316 stainless steel.
5. Sleeves:
a. 24 GA galvanized spiral duct or 18 GA black steel.

O. Dampers:
1. Sizes and types: As indicated.
2. Locate as indicated.
3. Factory built and assembled dampers.
4. Dampers Manual, Rectangular and Square:
a. Opposed blade type, fitted with shank bolts, marked for direction (open/closed).
b. Provide locking hand quadrant, with 2 IN standoff bracket.
c. Construction:
1) Greater than 36 x 12 IN:
a) Frame: 16 GA galvanized steel formed into structural shape.
b) Blades: 16 GA galvanized steel, equipped with brass pin running on stainless steel pivot for vertical axis.
c) Axles: Continuous, steel 1/2 IN hex.
d) Basis of design: Ruskin MD35.
2) 36 IN x 12 IN and less:
a) Frame: 22 GA galvanized steel, flat or angle.
b) Blades: 22 GA galvanized steel, equipped with brass pin running on stainless steel pivot for vertical axis.
c) Axle: Continuous, steel 3/8 IN hex.
d) System pressure and velocity rating: 2.5 IN WG and 1500 FPM.
e) Basis of design: Ruskin MD25 or MD15.
5. Dampers Manual, Round:
a. Butterfly type with circular blade mounted to shaft.
b. Frame: Minimum 20GA galvanized steel 7 IN segment duct.
c. Blade: Minimum 20 GA galvanized steel.
d. Shaft: Continuous, Steel 3/8 IN hex.
e. System pressure and velocity rating: 2.5 IN water gauge and 1500 FPM.
f. Hand quadrant: Locking type with 2 IN standoff bracket.
g. Bearings: Self-lubricating nylon or stainless steel sleeve.
h. Basis of design: Ruskin MDRS25.
6. Dampers, Backdraft, Low Pressure:
a. Counterbalanced, gravity operated.
b. Fabricate of aluminum.
c. Blades: Provided with common linkage rod and felt seals.
7. Dampers, Bubble-tight:
a. Frame:
1) 316 stainless steel channel.
b. Blade:
1) Butterfly type of 316 stainless steel, stiffened as required.
2) Mounted to axle within formal flanged frame.
c. Seal:
1) Silicone blade seal, mechanically attached to blade with full circumference retainer ring.
2) Adhesive seals are not acceptable.
d. Bearings:
1) Stainless steel sleeve bearing in 2-bolt cast housing, with integral shift seals, bolted to frame.

e. Shaft:
   1) Damper shift continuous 316 stainless steel extending through the entire damper diameter.
f. Actuator:
   1) Worm gear operator with hand wheel.
g. Temperature rating:
   1) 250 DEGF maximum.
h. Pressure and velocity rating:
   1) 10 IN WG pressure differential at 4000 FPM.

P. Fire Dampers:
1. UL labeled, 1-1/2 HR rated unless otherwise indicated.
2. Fire dampers shall have 165 DEGF fusible link.
3. Fire dampers shall be dynamic type.
4. Provide as indicated and as required by NFPA and local regulations.
5. Provide with mounting angles and sleeves.
6. For curtain-type fire dampers, blades must be out of air stream (Type B fire damper), except as follows:
   a. Fire dampers with blades in the airstream (Type A fire damper): where dampers are installed at a wall mounted grille and ductwork is not installed on both sides of the wall penetration.
   b. For ducts where the smallest dimension is 8 IN or less: Type C fire dampers shall be 1 IN larger in each dimension and both the frame and the blades must be out of the air stream. This is not required at locations where fire dampers are installed at wall mounted grilles.
7. On round ductwork, provide dampers in enclosure with round connections on each side.
   a. Fire Dampers in Low Pressure Ducts:
      1) Provide curtain type damper, Ruskin Model DIBD2.
         a) Rated up to 2000 FPM at 4 IN WG for vertical mounted applications.
         b) Rated up to 2000 FPM at 4 IN WG for horizontal mounted applications.
   b. Fire Dampers in High Pressure Ducts:
      1) For vertical mounted applications: curtain type damper, Ruskin Model DIBDX2.
         a) Rated up to 4000 FPM at 8 IN WG.
      2) For horizontal mounted applications: curtain type damper, Ruskin Model DIBD2.
         a) Rated up to 2000 FPM at 4 IN WG.
   c. Fire Dampers for Stainless Steel Ductwork Systems:
      1) Provide as specified above except with type 304 stainless steel construction.
      2) Provide as specified above except with type 316 stainless steel construction.

Q. Smoke Dampers:
1. UL classified as a leakage rated damper for use in smoke control systems under UL555S, latest edition, and bear a UL label attesting to same.
2. Suitable for velocity and pressure of system.
3. Jamb seals: Stainless steel flexible metal compression type.
4. Provide in ductwork adjacent to smoke partition (not in wall) with actuator in accessible location and visible for inspection.
5. Provide dampers and actuators as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators as a rated assembly.
6. Frame: 16 GA galvanized steel, minimum.
   a. Loss through wide open damper based on AMCA Test Figure 5.3:
   b. 12 IN x 12 IN duct size: Not more than 1.25 IN WG at 3000 FPM face velocity.
   c. 24 IN x 24 IN duct size: Not more than 0.45 IN WG at 3000 FPM face velocity.
   d. 36 IN x 36 IN duct size: Not more than 0.3 IN WG at 3000 FPM face velocity.
7. Provide factory supplied caulked sleeve.

8. Smoke Dampers, Low Pressure:
   a. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
   b. UL555S Leakage Rating: Class I (4 CUFTM/ SF at 1 IN WG).
      1) Ruskin Model SD37.
   c. Blades: Single or double thickness type.
      1) Single thickness type: 16 GA steel, minimum.
      2) Double thickness type: 18 GA steel.
   d. Blade width: Not more than 6 IN.
   e. Single blade dampers may be used for up to 8 IN wide blade, or up to 12 IN round.
9. Smoke Dampers, Square or Rectangular, High Pressure:
   a. Parallel or opposed blade type with linkage for automatic operation.
   b. UL555S Leakage Rating: Class I (8 CUFTM/ SF at 4 IN WG).
      1) Ruskin Model SD60 or SD50.
   c. On round ductwork:
      1) Provide dampers in an enclosure with round connections on each side.
10. Smoke Dampers, Round, High Pressure:
    a. Single blade type with encompassed blade edge seal.
    b. UL555S Leakage Rating: Class I (8 CUFTM/ SF at 4 IN WG).
       1) Ruskin Model SDRS25.
11. Damper actuator:
    a. Electric type, factory installed.
       1) Two-position type.
       2) 120 VAC.
       3) Spring return fail closed.
       4) UL listed at 250 DEGF.

R. Combination Fire-Smoke Dampers:
1. Fire-Smoke Dampers, Combination:
   a. UL classified as a Leakage Rated damper under UL555S, latest edition, bearing a UL label attesting to same.
   b. UL555 fire rating: 1.5 Hour.
   c. Suitable for velocity and pressure of system.
   d. Compressible metal jamb seals.
   e. Operator installed per UL requirements, in accessible location and visible for inspection.
   f. Provide dampers and actuators as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and actuators as a rated assembly.
   g. Frame: 16 GA galvanized steel, minimum.
   h. Loss through wide open damper:
   i. Loss through wide open damper based on AMCA Test Figure 5.3:
      1) 12 IN x 12 IN duct size: Not more than 1.25 IN WG at 3000 FPM face velocity.
      2) 24 IN x 24 IN duct size: Not more than 0.45 IN WG at 3000 FPM face velocity.
      3) 36 IN x 36 IN duct size: Not more than 0.3 IN WG at 3000 FPM face velocity.
   j. Provide factory supplied caulked sleeve.
2. Fire-Smoke Dampers, Combination, Low Pressure:
   a. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
   b. May be used in lieu of separate fire and smoke dampers.
   c. UL555S Leakage Rating: Class II (10 CUFTM/ SF at 1 IN WG).
      1) Ruskin FSD36.
   d. Fusible link: 165 DEGF melting point.
3. Fire-Smoke Damper, Combination, High Pressure:
   a. Parallel blade type.
   b. May be used in lieu of separate fire and smoke dampers.

c. UL555S Leakage Rating: Class I (8 CUFTM/ SF at 4 IN WG).
   1) Ruskin Model FSD60 .
d. Fusible link: 165 DEGF melting point.

4. Actuators, Fire-Smoke Damper:
   a. Electric type, factory installed.
   b. Two-position.
   c. 120 VAC.
   d. Spring return fail closed.

S. Diffusers, Registers and Grilles:
   1. Diffusers, Ceiling:
      a. Square type.
      b. Size, type and manufacturer: As scheduled.
      c. Finish of steel units: Factory applied, baked or electrocoated enamel; color as selected by Architect or as indicated.
      d. Finish of aluminum units: Satin anodized.
      e. Provide sponge rubber gasket for ceiling diffusers.
      f. Provide necessary screws, duct collars, transitions and air pattern deflectors.
   2. Diffusers, HEPA Filtered Radial Throw Type:
      a. Size, type and manufacturer: As scheduled.
      b. Provide steel housing with hinged face to allow filters to be replaced from within the room without requiring access to the ceiling.
      c. Diffusers: capable of 180 degree radial throw pattern.
      d. HEPA filters: guaranteed to be 99.97 PCT efficient on 0.3 micron size thermally generated particles. Filter frames: gel seal for leak tight installation.
      e. Provide gasket material around frame body on frame face of air seal.
      f. Finish: Baked, white epoxy finish.
   3. Diffusers, Radial Throw Type:
      a. Size, type and manufacturer: As scheduled.
      b. Provide with steel housing with hinged face to allow filters to be replaced from within the room without requiring access to the ceiling.
      c. Diffusers: Capable of 180 degree radial throw pattern.
      d. Provide gasket material around frame body on frame face of air seal.
      e. Baked, white epoxy finish.
   4. Air Grilles and Registers:
      a. Size, type and manufacturer as scheduled.
      b. Finish of steel units:
         1) Factory applied, baked or electrocoated enamel.
         2) Color as selected by Architect or as indicated.
      c. Finish of aluminum units: Satin anodized.
      d. Provide sponge rubber gasket for ceiling and wall units.
      e. Provide necessary screws, duct collars and transitions.
   5. Diffusers and Grilles, Linear:
      a. Size, type and manufacturer as scheduled on Drawings.
      b. Adjustable pattern controller (on supply units only) capable of 180 degree air pattern adjustment and volume control. All adjustments accessible from the face of the diffuser.
      c. Extruded aluminum or steel ceiling linear diffuser.

T. Sound Attenuators:
   1. Prefabricated, straight through design.
   2. Airflow pressure drop and noise reduction (NR) values as indicated on drawings.
   3. Size and shape as indicated on Drawings.
   4. Outer casing: 22 GA, minimum, galvanized steel.
   5. Interior partitions or splitters: 24 GA, minimum, perforated galvanized steel.
   6. Aluminum construction: At least 50 PCT thicker than steel specified.

7. Straight through air passages.
8. Airtight construction.
   a. Leakproof when subjected to differential air pressure of 8 IN WG between outside and inside.
   b. Weld lock joints or seams or fill with mastic.
9. Sound attenuators, noise reduction (NR) rating:
   a. Tests made in such manner as to eliminate end reflections, beaming or directivity, flanking, standing waves, and room absorptions.
   b. Test method may be either "in-duct with anechoic termination" or "reverberant rooms with tunnel between".
   c. Size of units tested: Not smaller than 24 IN x 24 IN rectangular or 24 IN round outside, with full size connections.
   d. Submit corroborative report of tests made in nationally recognized, qualified, independent testing laboratory approved by AMCA for airflow determinations.
10. Sound attenuators, airflow pressure drop rating:
    a. Do not exceed pressure drop at specified airflow.
    b. Base rating on results of tests made in manner to provide reliable data.
    c. Basic setup: Standard code method as adopted by AMCA for testing fans.
11. Sound attenuators, acoustical fill:
    a. Inert, vermin and moisture proof, inorganic glass or mineral fiber.
    b. Pack behind partitions or splitters under not less than 5 PCT compression to provide "spring" and avoid settling.
    c. Fill containment:
       1) Encapsulated and sealed with a polymer film.
       2) Separate fill material from perforated baffle by a non-combustible, erosion resistant, acoustical stand-off.
       3) Refer to schedule for applicability.

U. Chemical, Biological, and Radiological (CBR) Air Filtration System - HEPA Filters with Bag In, Bag Out Side Service Housing:
1. HEPA filters:
   a. 99.97 PCT efficient on 0.3 micron size thermally generated particles.
   b. Ultra fine, water resistant fiberglass with safe-edge aluminum separators and galvanized steel enclosing frame.
   c. Supply with neoprene gaskets for leak tight installation in side service housing.
   d. Sizes and pressure drop as scheduled
2. Side service housing:
   a. Bag in, bag out type suitable for scheduled prefilters and HEPA filters.
   b. Type 304 stainless steel construction.
   c. Test housing at +/- 10 IN WG pressure.
   d. Provide removable access doors for each filter bank on one side of housing.
   e. Provide externally operated clamp type locking mechanism to completely seal filters.
   f. Provide straps, gaskets, and other necessary hardware to allow for bagging of filters.
   g. Each filter bank shall be provided with bags for two filter changes.

V. Pressure Relief Doors:
1. Frame: 12 GA galvanized steel, Z-shaped.
2. Door: 12 GA galvanized steel.
3. Seal: Polyurethane foam around door perimeter.
4. Pressure setting: As indicated.
5. Springs: Negator type for door closure upon loss of over pressurization.
6. Size: 18 IN x 18 IN.
7. Insulation: For supply duct locations, provide 1 IN thick foil faced insulation on the inside surface to prevent condensation.
8. Locations: As indicated.
9. Model: Kees BI or Kees BO as applicable.

W. Engine Exhaust Extraction System:
    1. The vehicle exhaust extraction system shall consist of an Automatic Spring Hose Reel, designed for manual extension and spring return of high temperature flexible exhaust hose.
    2. The Hose Reel shall consist of the following features: The hose reel side plate mounting frame shall be constructed of 11 gauge cold rolled steel. The side plates shall be drawn securely together and retained by heavy gauge “J” channel steel support braces. These support braces keep the side plates square and solid.
    3. The hose reel drum shall be constructed of 16 gauge cold rolled steel. The drum shall be formed and rolled to an 18 IN diameter and strengthened by four inner support bars. These bars are secured to the drum end flanges and pull the drum tightly against the end flanges.
    4. The drum end flanges shall be constructed of 16 gauge cold rolled steel. The end flange outer edge shall be rolled to provide strength and rigidity. Each end flange shall have a center pressed 18 IN diameter groove. This groove allows the reel drum and end flange to mate so the drum’s inner support bars draw the end flanges securely to the drum. This unique design feature offers added strength, quality and reliability.
    5. Powder Coating: All steel parts are painted with a powder coating for longevity and to resist corrosion.
    6. The hose reel shall have a hose to drum connection fitting allowing for use of 6 IN hose. The connection fitting supports an inner 6 IN diameter tube that completes the connection from the connection of 6 IN diameter discharge duct. The hose reel drum shall also be supplied with a hose tracking bar to guide the hose during the recoiling function. The hose capacity on the drum shall be 36 FT.
    7. The hose reel function shall consist of a spring cassette housing containing a high carbon drive spring. The activation of the manual extension and spring return is by a Lock and Latch feature.
    8. The necessary length of hose desired can be locked in place and the hose is automatically retracted after use. The hose reel functions of uncoiling and recoiling of the hose shall be by direct pulling on the extraction hose. The reel shall have an adjustable hose stop to set the hose at the desired recoiling height. This stop shall be mounted to the extraction hose.
    9. End of hose shall be provided with adaptor for connection to vehicle exhaust pipe.

X. Canopy Hood: Provide stainless steel canopy with hangers and miscellaneous hardware at location and size as indicated on the Mechanical drawings.
    1. Canopy hood shall be constructed to avoid interference with any access required above furnace door. Coordinate with furnace manufacturer.
    2. Materials:
        a. Type 304 stainless steel.
            1) Finish, exposed to view components: No. 4.
        b. Canopy Hood, Baffle, and Fascia Panel Thickness: 18 GA, minimum.
        c. Hood Support Brackets; 16 GA, 1-1/4 IN wide.
        d. Baffle Support:
            1) Stainless steel slotted channel framing.
            2) Brackets: 16 GA, 1-1/4 IN wide.
        e. Threaded Rod: 3/8 IN minimum.
        f. Hardware and Fasteners: Stainless steel nuts and washers
    3. Construction:
        a. Provide reinforcing necessary to prevent oil canning or deflection of panel between supports.
        b. Continuously weld corners and joints, grind smooth, free of defects. Welded joints with visible burn marks will not be accepted.
        c. Provide welded 18 GA exhaust collar with no open seams.
    4. Accessories: Provide stainless steel hangers and miscellaneous support hardware as required for a complete installation.
    5. Provide exhaust duct transition pieces for mechanical connection above the ceiling.
    6. Refer to Mechanical Drawings for exhaust rate and duct connection size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine structure, substrates, and conditions under which work is to be installed.

B. Correct deficiencies.

C. Installation constitutes acceptance of responsibility for performance.

D. Install air flow measuring stations specified in Division 25 in accordance with manufacturer's installation instructions and as specified.

3.2 INSTALLATION OF DUCTWORK

A. Ductwork Cleanliness:
   1. Reference Standard:
      a. SMACNA – Duct Cleanliness for New Construction.
   2. Basic Level:
      a. Under this level of ductwork cleanliness it is acknowledged that ductwork leaving the premises of the manufacturer will include some or all of the following:
         1) Internal and/or external self-adhesive labels or marking for parts identification.
         2) Exposed mastic sealant.
         3) Sealant shall have a VOC content no greater than 420 g/L.
         4) Light zinc oxide coating on the metal surface.
         5) A light coating of oil on machine formed ductwork.
         6) Minor protrusions into the airway of rivets, screws, bolts and other jointing devices.
         7) Internal insulation and associated fasteners.
         8) Discoloration marks from plasma cutting process.
      b. The internal surfaces of ductwork shall be wiped to remove excess dust immediately prior to installation.
   3. Intermediate Level:
      a. Under this level of ductwork cleanliness it is acknowledged that ductwork leaving the premises of the manufacturer will include some or all of the following:
         1) Internal and/or external self-adhesive labels or marking for part(s) identification.
         2) Exposed mastic sealant.
         3) Light zinc oxide coating on the metal surface.
         4) A light coating of oil on machine formed ductwork.
         5) Minor protrusions into the airway of rivets, screws, bolts and other jointing devices.
         6) Internal insulation and associated fasteners.
         7) Discoloration marks from plasma cutting process.
      b. Site storage: The area provided for storage shall be clean, dry and exposure to dust minimized.
      c. The working area should be clean and dry and protected from the elements.
      d. The internal surfaces of ductwork shall be wiped to remove excess dust immediately prior to installation.
      e. Open ends on completed ductwork and overnight work-in-progress shall be sealed.
   4. Advanced Level:
      a. In addition to the provisions of the Intermediate level the following requirements apply:
         1) All self-adhesive labels for part identification are to be applied to external surfaces only.
         2) To maintain cleanliness during transportation, all ductwork shall be sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping.
      b. Site Storage:
         1) A clean and dry environment where the ductwork is protected from dust must be provided for the storage of ductwork prior to installation.

2) All sealed ends shall be visually examined and if damaged resealed with an appropriate material.

c. The working area shall be clean, dry and the ductwork protected from dust. Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.

5. Duct Cleanliness levels by space type:
   a. Basic Level:
      1) Ductwork systems serving mechanical or electrical equipment rooms.
   b. Advanced Level:
      1) All Laboratory areas.
      2) Computer, telephone equipment rooms, Data Centers and similar areas housing high tech equipment or fabrication processes.
   c. Intermediate Level:
      1) All building areas not covered under Advanced or Basic Level duct cleanliness (i.e. general office and administration areas, meeting rooms, etc.)

B. Install generally as indicated.

C. Conceal ductwork in finished spaces unless indicated otherwise.

D. Do not install ductwork in or allow to enter or pass through electrical rooms, elevator machine rooms, or spaces housing switchboards, panelboards or distribution boards, except ductwork that serves electrical rooms, elevator machine rooms, or spaces.

E. Exercise special care to provide tight fitting well fabricated, well braced ductwork systems.

F. Field assemble rectangular or round ductwork as follows:
   1. Use duct joint sealer applied slip joints.
   2. Use Ductmate Spiralmate systems.
   3. Isolate dissimilar metals with elastomeric sealant tape or fiber gaskets, and gaskets and washers for bolts.
   4. Install TDC flanged duct connection systems in accordance with SMACNA construction standards.

G. In high pressure ductwork, do not use 2 piece mitered 90 degree elbows with or without vanes unless approved by Engineer.

H. Fabricate duct connections for hoods, openings, fans, and other devices.

I. Where ducts pass thru fire rated and smoke rated construction, maintain rating indicated.
   1. Where fire dampers are not used, seal around duct with firestopping.
   2. See Section 07 84 00 for materials.

J. Do not kink, bend or otherwise restrict the free area of flexible ductwork.

K. Ductwork Hangers:
   1. Install per SMACNA Duct Construction Standards but in no case shall ductwork hangers or ductwork be directly supported to or supported off of other ductwork.

3.3 INSTALLATION OF MANUAL DAMPERS

A. Provide volume dampers, to facilitate air balancing, in the following locations whether shown on the plans or not:
   1. Run-outs to individual room terminal devices (i.e. supply grilles and diffusers, return and exhaust grilles and registers). Locate damper as close to the run-out take off as possible. Damper shall not be required for single air device connected to air terminal unit.
   2. Lateral duct take-offs from a return or exhaust main riser for systems serving multiple floors.

B. Provide additional branch main volume dampers required by the balancing contractor, refer to Section 20 08 00.

3.4 INSTALLATION OF FIRE AND SMOKE DAMPERS

A. Install in accordance with manufacturer's instructions and UL requirements.
   1. See Section 07 84 00.

B. Floor mounted dampers may be installed in a concrete floor curb.

3.5 CBR AIR FILTRATION SYSTEM

A. Install filter housing and associated filters in accordance with manufacturer's instructions.

3.6 ENGINE EXHAUST EXTRACTION SYSTEM

A. Install extraction system components in accordance with manufacturer's instructions.

3.7 PERFORMANCE TESTS

A. Test high pressure air ductwork with air pressure not less than 6 IN WG pressure before external insulation is applied.
   1. As required, test portions of system to permit finish work.
   2. Leakage not to exceed maximum values identified by SMACNA HVAC Air Duct Leakage Test Manual.
   3. Testing procedures shall be as described by SMACNA HVAC Air Duct Leakage Test Manual.
   4. Test all high pressure ductwork systems.

B. Test 25 PCT of low pressure ductwork to 1.5 times listed fan operating pressure with 2 IN WG minimum but not greater than duct construction pressure limits. Test ductwork before insulation is applied.

C. Use a pressure blower with volume control and orifice flow meter to provide supply air for test.

D. Submit reports to Architect.

3.8 CLEANING

A. At substantial completion, clean work installed under this section.

3.9 EQUIPMENT DEMONSTRATION

A. At substantial completion, inspect and test, and operate satisfactorily, in presence of Engineer and representative of Owner, operation of each piece of equipment and its accessories.

B. If inspection or test indicates defects, replace defective work or material.

C. Repeat inspections and tests until defects are eliminated.

END OF SECTION

SECTION 23 35 00
EXHAUST AND VENTILATING FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Systems Included:
   1. In-line square centrifugal fans.
   2. Tubular centrifugal fans.
   3. Mixed-flow exhaust fans.
   4. Air curtains.

B. Abbreviations:
   1. AMCA: Air Movement and Control Association.
   2. ADC: Air Diffusion Council.
   3. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Standards:
   1. ADC Standard 1062R2, Air Diffusing Equipment Test Code.
   2. AMCA Standard 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
   3. AMCA Standard 204, Balance Quality and Vibration Levels for Fans.
   4. ASHRAE Standard 70, Method of Testing for Rating the Performance of Air Outlets and Inlets.
   5. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
   6. ASTM B117-03: Standard Practice for Operating Salt Spray (Fog) Apparatus.
   7. ABMA: American Bearing Manufacturers Association.

1.3 SUBMITTALS

A. Product Data:
   1. Performance data.
   2. Physical dimensions.
   3. Fan curves.
   4. Sound data.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. General Fans:
   1. Base:
      a. Members of AMCA.

B. In-line Square Centrifugal Fans:
   1. Base:
      a. Twin City Fan & Blower.

2. Optional:
   a. Carnes.
   b. Cook, Loren.
   c. PennBarry.
   d. Acme Engineering and Manufacturing.
   e. Greenheck.

C. Tubular Centrifugal Fans:
1. Base:
   a. Twin City Fan & Blower.
2. Optional:
   a. Carnes.
   b. Cook, Loren.
   c. New York Blower.
   d. PennBarry.
   e. Acme Engineering and Manufacturing.
   f. Greenheck.
3. Mixed-flow exhaust fans:
   a. Base:
      1) Twin City Fan & Blower.
   b. Optional:
      1) Greenheck.
      2) Strobic Air.

D. Air Curtains.
1. Base:
   a. Mars Air Systems.
2. Optional:
   a. Cook, Loren.
   b. Greenheck.
   c. Leading edge.

2.2 MATERIALS

A. Fans - General:
1. Performance ratings: Based on laboratory tests conducted in accordance with latest edition of ASHRAE/AMCA Standard Test Codes.
2. UL 705 listed.
3. Capacity and ratings: As indicated.
4. Arrangement and drive: As indicated.
5. Provide removable belt guard, as required.
6. Fan drive sheaves for belt driven fans over 5 HP:
   a. Cast iron, split tapered bushings dynamically balanced at factory.
   b. Provide initial fixed pitch sheave based upon design conditions.
   c. Provide final fixed pitch drive sheaves for proper RPM determined during balancing process.
7. Belt driven fans 5 HP and less: Provide with adjustable sheaves.
8. Fan wheels shall be statically and dynamically balanced per AMCA Standard 204.
9. Finish:
   a. Steel fan components: Finished with paint system exceeding 1000 HR salt spray under ASTM B117 test method, minimum 2 MIL thick.
   b. Aluminum, galvanized, and stainless steel fan components: Unfinished.

B. Motors and Control:
1. See Section 20 05 00.
2. Provide TEFC motor for outdoor installations exposed to weather.
3. For direct drive fans, provide TEFC motors when motor is located in the airstream.

C. Belt Drives:
1. Single or multiple belts as required to develop full horsepower of driving motor with service factor of not less than 1.50.
2. Where more than one belt is used for drive, provide "matched" sets.
   a. Use new belts on final fixed pitch drive sheaves.
3. Motors on fan drive: Provide with adjustable rail motor mounts of type using screws for tightening of belts.
4. Bolt motor mounts to fan bases or frames.
5. For fans suspended from ceilings, belt tightening device may be pivoted type.

D. Belt Guards:
1. See Section 20 05 00.

E. Control Dampers:
1. Control dampers shall be as specified in Section 23 31 13.
2. Actuator for control dampers shall be as specified in Section 25 10 00.

2.3 IN-LINE SQUARE CENTRIFUGAL FANS

A. General:
1. Direct or belt drive, as indicated.

B. Housing:
1. Constructed entirely of minimum 18 gauge galvanized steel.
2. Inlet bell.
3. Prepunched inlet and outlet flanges.
4. Bolted, gasketed access door located on three sides.

C. Fan Wheel:
1. Centrifugal type, aluminum construction.
2. Backward inclined shaped blades.
3. Statically and dynamically balanced.

D. Bearings:
1. Bearings shall be fixed to the fan shaft using concentric mounting locking collars. Set screws will not be allowed.
2. Self aligning, extra heavy duty type, ball or roller bearings with regreasable lubrication.
3. Select for minimum average bearing life L-50 rating of 200 000 HRS operation at maximum cataloged operating speed.

2.4 TUBULAR CENTRIFUGAL FANS

A. General:
1. Direct or belt drive, as indicated.
2. AMCA Construction Class I, II, III as required for the fan to operate at 115 PCT of design RPM. Construction class shall be increased when necessary to comply with this requirement. Maximum allowable RPM for fan construction shall be indicated on submittals.
3. Configure for duct mounted in-line installation or upblast roof mounted exterior installation, as indicated.

B. Housing:
1. Constructed entirely of minimum 14 gauge steel, continuously welded.
2. Inlet bell and diffuser section.
3. Prepunched inlet and outlet flanges.
4. Continuously welded air foil blades in diffuser section.
5. Bolted access door for inspection on accessible side.
6. Welded lifting lugs.

C. Fan Wheel:
   1. Centrifugal type, steel construction.
   2. Air foil shaped blades.
   3. Statically and dynamically balanced.

D. Fan Shaft:
   1. Hot rolled and accurately turned, ground, and polished.
   2. Sized for critical speed of at least 125 PCT of maximum RPM.

E. Bearings:
   1. Bearings shall be fixed to the fan shaft using concentric mounting locking collars. Set screws will not be allowed.
   2. Self aligning, extra heavy duty type, ball or roller bearings with regreasable lubrication.
   3. Select for minimum average bearing life L-50 rating of 500 000 HRS operation at maximum cataloged operating speed.
   4. Extend fittings for lubricating bearing to exterior of housing.

2.5 MIXED-FLOW EXHAUST FANS

A. General:
   1. Provide a direct drive mixed-flow induced dilution fan for the described purpose and duty shown on the plans and as described by this specification. To assure system performance, the fan, plenum section, and roof curb shall be provided by the unit manufacturer and manufactured under their supervision. See fan schedule for performance requirements.
   2. The fans shall have been tested under AMCA 210-85, “Laboratory Methods of Testing Fans for Rating” and shall have been witnessed by an independent agency. Documented aspiration tests shall have been preformed in conjunction with the fan performance testing. Provide documentation of testing along with equipment submittals.
   3. The fans shall be sound tested in accordance with AMCA 300 and shall be UL and CUL listed per UL 705 safety standard. Fans shall meet NFPA-45 criteria.
   4. Fan manufacturer shall furnish a certificate of guarantee stating that the fan, mixing plenum, outlet nozzle, stack extension, and all related accessories specified herein have been pre-tested at the factory and that the curves supplied in submittal documentation have been de-rated for any and all system effects created by the accessories.
   5. Start-up shall be provided by a factory certified start-up technician in accordance with the factory start-up procedures. Provide start-up certification along with the “Operation and Maintenance” documentation. Provide O&M documentation to Owner at start-up completion. Technician shall be available to assist the Building Automation Contractor at start-up of the BAS controls.

B. Mixed-flow induced dilution fan(s):
   1. The fan impeller shall be mounted directly to the motor shaft to provide a direct drive arrangement 4 type fan. All motors shall be isolated from the primary exhaust air stream and shall be visible and accessible from the fan exterior for inspection and service.
   2. The mixed-flow impeller shall consist of combination axial/backward curved blades and shall be of welded steel construction. The impeller shall have non-stall and non-overloading performance characteristic with stable operation at any point on its fan curves. Stationary discharge guide vane sections shall be provided to increase fan efficiencies.
   3. The fan shall be dynamically balanced and shall not exceed 0.5 mil peak to peak at the blade pass area when operation at the fan design frequency. Vibration isolation shall be limited to rubber-in-shear pad type isolators and shall be provided by the manufacturer with the fan/plenum.
   4. Fan assemblies shall be capable of supporting stack extension sections and discharge nozzle. Any additional supports required shall be provided at no cost to Owner.
   5. The fan shall discharge through twin FRP chemical and UV resistant nozzles with passive third central tacks that are capable of generation aspiration.

6. A steel entrainment windband shall provide secondary induction of outside air. The induction shall take place downstream of the fan impeller and shall not influence BHP or static pressure requirements. The windband shall discharge up to 270% of the design flow rates. The manufacturer shall publish discharge volumes for all fans at specified primary exhaust flow.
7. A non-ferrous inlet bell shall be provided in order to reduce sparking in the event of a motor bearing failure.
8. The fan shall be modular construction. PTFE gaskets shall be provided at all companion flanged joints. All fastening hardware shall be 316 stainless steel.
9. A bolted access door shall be provided for impeller inspection on each fan.
10. The fans and accessories shall have an internal drain system to prevent water from entering the building through the duct system.
11. Provide a TEFC Mill & Chemical duty electric motor with a 1.15 service factor and an L-50 bearing life of 200,000 hours. The motor shall have sealed bearings up through a 256T NEMA frame. The motors shall be C-Face and foot mounted. All motors shall comply with efficiencies listed in U.S. Energy Policy Act of 1992. Motors must be rated for use with variable speed drives.
12. A NEMA 3R non-fused disconnect switch shall be provided, mounted and wired to each motor.
13. Coatings - All steel and aluminum surfaces shall be prepared for coating by blasting or chemical etching. Coating will be Epoxy (8-10 mils) for protection against weather, chemical vapors and splashes.

C. Accessories:
1. An inlet mixing plenum shall be provided by the fan manufacturer. Each plenum shall be sized to support the weight and performance requirements of the fan.
2. All plenums shall be capable of supporting the fan(s) without guy wires or supports. The plenums shall include hinged access doors and safety screens over primary air inlets. The primary air inlets shall be located as noted on the construction drawings. Coatings shall be the same as specified for the fans. Plenums shall be suitable for mounting on steel frame as shown. Plenum bottom shall be blanked off.
3. A stainless safety screen shall be supplied over the back primary air inlet.
4. Bypass dampers shall be provided with all mixing plenums for outside air with primary exhaust. Dampers shall be opposed blade low leakage air foil control dampers with extended shaft for connection to an operator. The dampers shall be all aluminum construction. Heavy duty plastic UV resistant rain hoods shall be provided with each damper. Each damper shall be controlled by an electric 24V operator. The operator shall be provided by the ATC contractor and field mounted.
5. Outer shell of sound attenuator shall be constructed of fiber reinforced plastic with minimum 3/16 IN wall thickness. The attenuator shall be packed with sound attenuating fiberglass. The acoustical media to be isolated from air stream by a tedlar lining. The air passageway of attenuator to be lined with perforated metal. The sound attenuator shall not increase the height of the fan unit as specified. Acoustical screening shall not be used and will not be approved.
6. Attenuator must provide appropriate dynamic insertion losses as tested with fan unit so that maximum sound level shall not exceed 100 dB in any octave band.
7. Access to the motor junction box of the fan unit shall not be blocked by the sound attenuator.
8. The fan performance curves must include any performance losses due to the addition of sound attenuator per factory tested data.
9. A low leakage isolation damper(s) shall be provided for each fan and be constructed of aluminum air foil extrusions and coated with epoxy. Operators shall be 2 position, spring return and shall be 120V electric. The electric operator shall be factory wired via a transformer to the fan disconnect switch to open when the fan is energized and close via a spring return when de-energized. When the fan ships separate from the plenum, all wiring and conduit shall be factory supplied for easy connection in the field.

10. Vortex breakers shall be provided on all side inlet fan plenums.
11. A 14 gauge galvanized steel roof curb shall be provided to support the fans/plenums.

2.6 AIR CURTAIN

A. Air Curtain:
  1. Cabinet: Minimum 18 gauge aluminum with intake grille.
  2. Motors: High efficiency type with unit mounted, factory wired 2 speed switch and thermal overload protection.
  3. Electrical: Prewired junction box for single point electrical connection.
  4. Outlet: Full width discharge with adjustable directional vanes to direct airflow from front to back at a full 40 degree sweep.
  5. Blowers: Twin forward curved type with permanently lubricated bearings and resilient mounts.
  6. Mounting Height: Same as roll-up door. See Architectural Drawings.
  7. Air curtain fans shall capable of providing air at 1600 FPM measured at 3 FT above the floor.
  8. Door micro switch (combination plunger/roller type) for automatic on-off control.
  9. Motor control panel, UL listed, NEMA 1 cabinet with HOA switch on cover.
  10. Extended wall mounting brackets for drum type roll-up doors.
  11. Heating coil, 5/8 IN copper tubes with aluminum fins, copper manifolds, 16 GA casing with finish to match air curtain cabinet.
  12. Control panel for connection of wiring between micro switch and fans and power source.
  13. Thermostat: Wall-mounted, 110-volt operation with heater on/off selection.
  14. Size and performance: As indicated.

2.7 PREFABRICATED INSULATED ROOF CURBS

A. Construction:
  1. Curb height: 8 IN, above finished roof.
  2. Curb height: 6 24 IN, above finished roof.
  3. Style: Straight sides (without cants) to accommodate tapered roof insulation. Roof curbs shall be approved by roofing manufacturer and compatible with roofing system.
  4. Shell, liner, and base: G90 galvanized steel with fully mitered and welded corners, integral base plates.
  5. Insulation: Factory applied, 1-1/2 IN thick, 3 PCF density fiberglass insulation.
  6. Nailers: Factory installed pressure treated wood.
  7. Provide level installation, regardless of roof slope.

2.8 VIBRATION ISOLATION

A. Vibration isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's recommendations and as specified.

B. Caulk roof curbs for watertight installation.

C. Coordinate placement of equipment on roof with other trades.

3.2 VIBRATION ISOLATION

A. Vibration isolation: Section 20 05 50.

3.3 FAN DYNAMIC BALANCING

A. Experienced, trained mechanics from factory shall dynamically balance centrifugal fans 7-1.2 HP and above. Balancing shall include the following:
   1. Inspection of fans to determine if damage has occurred during storage or installation and coordinate repair of damages.
   2. Inspection of fan drives including bearing and motor mounts.
   3. Inspection of tensioning of drive belts on adjustable and fixed pitch sheaves.
   4. X-Y dynamic vibration plot on each fan resulting in a properly balanced installation within factory specifications, performed after system has been balanced and final fixed pitch drive sheaves installed.

END OF SECTION

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SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, tools, equipment, and services for Air Terminal Units, as indicated, in accordance with provisions of Contract Documents.

B. Systems Included:
   1. Air terminal units.

C. Operators and controllers:
   1. Operators and controllers for air terminal units: Provided in Section 25 10 00.

D. Definitions:
   1. Low pressure ductwork: Refer to section 23 31 13.
   2. High pressure ductwork: Refer to section 23 31 13.

E. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Design and installation standards:
   1. ASHRAE Guide and Data Book – Systems and Equipment, current chapter on duct construction.
   2. Air Diffusion Council, ADC Standard 1062R2, Air Diffusing Equipment Test Code.
   3. Air Moving and Conditioning Association, AMCA Standard 210, Test Code for Air Moving Devices.
   4. ASHRAE Standard 70-72, Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
   5. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems, current edition.
   6. SMACNA HVAC Duct Construction Standard - Metal and Flexible current edition.
   7. UL Publication No.181, Erosion Test Methods.
   8. ARI 885-98: Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

1.3 SUBMITTALS

A. Product Data:
   1. Air Terminal units.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Air terminal units:
   1. Base:
      a. Titus
   2. Optional:
      a. Anemostat Air Products.
      b. Tuttle and Bailey.
      c. Krueger.

d. Price.
e. Metalaire.
f. Trane.

2.2 MATERIALS

A. Air Terminal Units
1. Air terminal units - general: Factory assembled.
a. Configured for pressure independent control.
b. Capacity: As indicated.
c. Noise level: Based on ARI 885-98. Refer to plans for scheduled values.
d. Operators: Furnished in Section 25 30 00.
1) Factory installed on units.
e. Acoustical fiberglass liner:
1) Comply with NFPA-90A for fire resistivity and UL Standard 181 for erosion.
2) Insulation shall consist of 1 IN thick non-porous foil faced rigid fiberglass insulation secured by full length galvanized steel z-strips which enclose and seal all edges, eliminating tape and adhesives.
f. Provide multi-point velocity pressure sensors with external pressure taps.
g. Provide static pressure tube(s).
h. Valve adjustment: Field adjustable.
i. Set air terminal units to air flow rates indicated.
j. Casing leakage: 5 PCT, maximum, of nominal rated capacity at 3.0 IN WG internal pressure.
2. Heating coils for air terminal units: ARI certified, continuous plate or spiral fin type, leak tested at 300 PSI.
a. Capacity: As indicated, based on scheduled entering water temperature.
b. Headers: Copper or brass.
c. Fins: Aluminum, maximum 8 fins per IN.
d. Tubes: Copper, arrange for counter-flow of heating water.
e. Water velocity: 8 FPS maximum with head loss not greater than indicated.
f. Provide 20 GA galvanized steel casing with slip and drive construction for attachment to metal ductwork.
g. Provide vent and drain connection at high and low point, respectively, of each coil.
h. Coils guaranteed to drain.
3. Inlet air valves for air terminal units: Corrosion resistant, self-seating type.
a. Frame, links and levers may be of zinc coated steel or aluminum.
b. Vanes, pivots, hinged or knuckle joints: Aluminum or other non-ferrous metal.
c. Leakage: Not greater than 3 PCT of maximum rated capacity when closed against inlet static pressure of 4.0 IN WG.
d. Equip with suitable linkage and motor mounting platform to accommodate control operators.
e. Use resilient sealing members to prevent leakage.
f. Provide direct reading air flow rate scale and external adjustment.
4. Air terminal units, single duct, with coils: Constant or variable volume, high velocity unit with reheat coil, as indicated.
a. Construction: 22 GA galvanized steel or 0.040 IN aluminum, minimum.
b. Sound Attenuators: Refer to specification section 23 31 13 for requirements.
c. Sound Attenuators: Provide where indicated on schedules.
5. Air terminal units, single duct, without coils:
a. Construction: 22 GA galvanized steel or 0.040 IN aluminum, minimum.
b. Sound Attenuators: Refer to specification section 23 31 13 for requirements.
c. Sound Attenuators: Provide where indicated on schedules.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units as indicated and in accordance with manufacturer's recommendations and instructions and as specified.

END OF SECTION

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SECTION 23 51 00

STACK AND BREECHING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Stack and Breeching, as indicated, in accordance with provisions of Contract Documents.

B. Systems included:
   1. High efficiency gas burning equipment, vent system.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Standards:
   1. Structural steel: ASTM-A325.
   2. Anchor bolts: ASTM-A307.
   3. NFPA-54: National Fuel Gas Code.
   4. UL 103: 1000 DEGF chimney test.

B. The entire stack system(s) from each boiler or appliance to the termination; including accessories, except as noted shall be from one manufacturer.

C. Verify the inner diameter as shown on the plans by utilizing the manufacturer’s computations.
   1. The computation shall follow ASHRAE calculation methods and incorporate manufacturer specific flow characteristics of the inner pipe.
   2. The contractor shall furnish the exact boiler model and operating characteristics to the factory representative.
      a. Operating Characteristics shall include the following
         1) Flue gas flow rate.
         2) BTU input.
         3) Outlet Temperature
         4) Local Altitude
         5) Stack layout
         6) Available pressure at boiler outlet.
         7) Other parameters that could affect system operation at maximum and minimum levels of burner turndown range.

1.3 SUBMITTALS

A. Shop Drawings:
   1. High efficiency gas burning equipment, vent system
      a. Jacket material, fittings, joints, connection and mounting.
      b. Detailed fabrication drawings provided by manufacturer.
         1) System shall be designed to scale.
         2) System shall be designed to compensate for all flue gas induced thermal expansions.
      c. UL rating of system.
      d. Warranty.

B. Product Data:

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. High efficiency gas burning equipment, vent system
   1. Base:
      a. Selkirk Metalbestos
   2. Optional:
      a. United McGill

B. Breeching thermometer:
   1. Base:
      a. American.

2.2 MATERIALS

A. High Efficiency Gas Burning Equipment, Vent System
   1. High efficiency gas burning equipment, vent system: Factory built modular exhaust system.
      a. UL listed to serve appliances which produce flue gases at temperatures not exceeding 550 DEGF under continuous operation.
      b. Designed and installed to be gas tight.
      c. Single wall pipe.
         1) Material
            a) Fabricated from AL 29-4C stainless steel.
      d. Double wall pipe
         1) Inner liner:
            a) Fabricated from AL 29-4C stainless steel.
         2) Outer Jacket
            a) 430 stainless steel with a space of approximately 1IN between flue gas conduit and the jacket.
   2. Single wall joints:
      a. Fastened with ring and tab tapered closure system.
      b. Sealed with a factory applied seal.
      c. Gas tight at 2.5 times the listed pressure rating of 8 IN WC.
   3. Double wall joints
      a. Fastened with a closure system that consists of tabs and a locking band.
      b. The locking band is tightened from a single location, pulling the two pieces together creating a pressure type assembly.
      c. When installed on a positive pressure or condensing applications, the joints must be factory or field sealed per terms of listing.
      d. Gas tight at 2.5 times the listed pressure rating of 15 IN WC.
   4. Horizontal Stack termination: Stack vent cap on exterior of building.
   5. Accessories:
      a. Provide following components for a complete system:
         1) Expansion joint(s).
         2) Guy section(s).
         3) Manifold tee.
         4) Elbows, 30, 45 and 90 degree.
         5) 45 deg lateral tee(s).
         6) 90 deg wye(s).
         7) Thermal expansion.
         8) Wall guide assembly.
         9) Condensate drain section
         10) Increasers.
         11) Storm Collar
         12) Wall penetration assembly

b. Terminations
   1) Horizontal
      a) Mitered termination
      b) Elbow termination
      c) Screen termination
6. Basis of Design: Saf-T Vent EZ Seal
7. Basis of Design: Saf-T Vent GC
8. Basis of Design: Saf-T Vent CI Plus

2.3 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 GENERAL

A. All products shall be installed with required minimum clearances to combustibles as identified with the terms of its listing.

B. Store materials inside and protected from the weather.

C. Protect incomplete stack installations by attaching temporary closures over open ends of sections.

D. Clean all stacks and breechings of dust and debris prior to final connection to appliances or equipment.

3.2 INSTALLATION OF HIGH EFFICIENCY GAS BURNING EQUIPMENT, VENT SYSTEM

A. Install vent system in accordance with manufacturer’s installation instructions and those of the appliance manufacturer.

B. Horizontal vent connectors shall be sloped at 1/4 IN per foot continuously toward an appliance drain, drain fitting, or drain tee.

C. Provide a condensate drain section every 30 FT of horizontal vent and/or at the bottom of a vertical stack.
   1. Install trap loop in the drain hose. Prime the trap prior to final assembly.

D. When passing 5 FT or more of a single wall vent system through an unheated area, the vent shall be double wall to prevent condensation and freezing as per manufacturers recommendation.

3.3 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.4 WARRANTY

A. Installation of High efficiency gas burning equipment, vent system:
   1. The system shall be installed as designed by the manufacturer and in accordance with the terms of the manufacturer’s 15 year warranty.

END OF SECTION

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SECTION 23 52 16

BOILER - PACKAGED CONDENSING BOILER

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Boiler – Packaged Condensing Boiler, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Factory test: In accord with ASME code.
   1. Boiler construction test for 80 PSIG water working pressure.
   2. Fire test with specified fuel to check operation and function of controls.

B. Standard for manufacture: ASME Code for Boilers and Pressure Vessels and State and local boiler codes.

C. Referenced standards:
   1. ASME CSD-1: Control and Safety Devices for Automatically Fired Boilers.
   2. ASME Section IV: Heating Boilers.
   3. ASME B31.3: Process Piping 516-70.
   4. ANSI Z21.13/CSA 4.9: Gas Fired Low Pressure Boilers.
   5. NFPA 85: Boiler and Combustion Systems Hazards Code.
   6. CSA: CSA International

D. Emissions permitting:
   1. Provide assistance to Contractor and Owner with regard to state, local or federally required air quality, source emissions or pollution control permitting.

1.3 SUBMITTALS

A. Product data:
   1. Boiler.
      a. Factory test reports.
      b. Assembly Drawings.
      c. Performance Data.
      d. Wiring Diagrams.
      e. Gas Train Diagrams.
      f. ASME certification documents.

B. Contract closeout information:
   1. Field test reports.
   2. Operation and Maintenance Data.
   3. Owner instruction report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Packaged Condensing Boiler:
   1. Base:
      a. Patterson-Kelley.
   2. Optional:
      a. Aerco.
      b. Cleaver-Brooks.

B. Multiple Boiler Control Panel:
   1. Base:
      a. Patterson-Kelley
   2. Optional:
      a. Cleaver-Brooks
      b. Thermodynamic Process Control, TPC

2.2 MATERIALS

A. Boiler: Factory packaged low pressure hot water boiler complete with controls and accessories ready to operate on natural gas as primary fuel.
   1. Stamped in accordance with Section IV of the ASME code and National Board Registered for a maximum allowable working pressure of 80 PSIG.
   2. Capacities: As scheduled.
   3. Heat Exchanger Construction:
      a. Cast aluminum or stainless steel. **Coated heat exchangers are not acceptable.**
   4. Heat Exchanger Header Construction:
      a. Fabricated Steel.
      b. Removable for inspection.
      c. Provide with EPDM seals for 400 DEGF service.
   5. Boiler Casing:
      a. Boiler shall be enclosed with a single wall outer casing fabricated from steel with a powder coat finish.
      b. Composite structure of the boiler combustion chamber, insulating air gap and outer casing shall be of such thickness and materials designed such that the outer casing temperature does not exceed 50 DEGF above ambient temperature when the boiler is operated at full load.
   6. Size: To fit space allowed in accordance with Local and State Authorities Having Jurisdiction.
   7. Boiler shall be designed for condensing operation.
   8. Provide necessary piping connections.
   9. Efficiency: The boiler shall be capable of operating at a CSA certified thermal efficiency of up to 92 PCT.

B. Boiler trim:
   1. The boiler will be completely factory packaged and plumbed, requiring only job site hookup to utilities, venting, relief valve outlet, fuel gas inlet, feed water inlet, and boiler water outlet.
   2. Provide boiler with safety relief valve in compliance with ASME Code, operating temperature control to control the sequential operation of the burner, water pressure-temperature gauge, inlet water temperature sensor, outlet water temperature sensor, and exhaust temperature sensor.
   3. Boiler shall monitor flow by flow switch, temperature differential, or pressure differential.
   4. Lock out control, requiring manual reset, after any of the following:
      a. Pilot or main flame interruption.
      b. Low water cutout.
      c. High limit operation.
   5. The boiler shall be jacketed with coated steel panels, and mounted on heavy-duty channel skids.

C. Burner: Natural Gas.
   1. Include an integral, power type, straight natural gas, fully automatic burner.
   2. The burner assembly shall consist of gas burner, combustion air blower, valve train, and ignition system.
   3. Burner Construction
      a. Steel with stainless steel inner and stainless steel mesh outer screen.

4. Burner shall be fully modulating at any firing rate between 20 PCT and 100 PCT with constant O2 levels equal to or less than 5 PCT.
5. Combustion air blower:
   a. Variable speed.
   b. Shall be provided with low airflow differential pressure switch and high exhaust back pressure switch.
   c. Provide blower with sufficient capacity at the rated firing rate to provide air for stoichiometric combustion and excess air.
6. Provide gas regulator to reduce gas supply pressure from 2 PSIG to manufacturer's inlet design pressure. Verify gas supply pressure to burner controls.
7. Provide burner flame observation port.
8. The boiler shall be a category IV appliance according to NFPA-54 and be UL-listed for use with a positive pressure stainless steel vent.
9. The boiler shall be capable of direct venting both inlet air and exhaust gases.
10. Boiler shall be able to automatically adjust to maintain air and gas ratios due to changing inlet air conditions to maintain ratios set up by start-up technician.
11. Burner certification, one of the following:
    a. The burner shall meet U.L. Standard 795 gas train requirements.
    b. The burner shall be CSA certified.

D. Boiler Controls:
1. Boiler shall be provided with a micro-processor control panel.
2. Provide with burner on-off switch and electronic combination temperature control.
3. The micro-processor shall use a proportional algorithm to determine the firing rate. The control must have the following capabilities.
   a. Ability to sequence other boilers in a lead-lag operation that uses same control device/platform.
   b. Maintain single set point.
   c. Reset the set point based upon outdoor air temperature.
   d. Boiler shutdown based on outdoor air temperature.
   e. Internal dual set point program with an external switchover via the Building Automation System (BAS) and shall be coordinated with Division 25 Sections.
   f. Alarm relay for any manual reset alarm function.
   g. Programmable low fire delay to prevent short cycling based on a time and temperature factor for release to modulation.
   h. LED Display showing current supply and return temperatures, burner sequence, service codes, fan speed, current set points as well as differential set points. It must also display any fault codes whether automatically reset or manually reset.
   i. Local Manual Operation.
   j. The boiler control shall be capable of accepting a 0 -10vdc remote external analog signal to control the firing rate from an external source.
   k. Computer (PC) interface for programming and monitoring all functions.
   l. Provide 5 amp control circuit breaker and 24 VAC transformer for control system.
4. Electrical connection: Single point 120V/1phase/60Hz power supply to each boiler protected by a 15 amp circuit breaker.
5. Provide an electric spark ignition system. Main flame shall be monitored and controlled by flame rod (rectification) system.
6. Each boiler shall be provided with necessary controls, necessary programming sequences, and safety interlocks. Each boiler control system shall be properly interlocked with safeties.
7. Provide thermal overload protection.
8. Provide under voltage protection.
9. Locate control devices and relays in splash-proof steel cabinet mounted on boiler.
10. Flame safeguard, UV scanner for monitoring main flame and pilot.
    a. If other technology is used, obtain approval from architect.
11. Other safety limits:
    a. Combustion air interlock.

b. Enforced low fire start.
12. Automatic recycling after power failure or normal operation of operating control.
13. Provide pre-purge and post-purge cycles with full protection against flame failure during both ignition and normal burning periods.
14. Interlock burner-blower controls to prevent burner operation without mechanical draft.
15. Conform to local gas company codes and regulations.
16. Gas solenoid valves, diaphragm valves, hydraulic valves and regulators: UL or Factory Mutual approved and labeled.

E. Gas piping:
1. Provide necessary gas piping properly valved between main and connection to burner and pilot.
2. Size in accord with National, State and Local ordinances and Codes, and NFPA recommendations.
3. Gas cocks: Lubricated plug cocks with operating handles.

2.3 MULTIPLE BOILER CONTROL PANEL

A. Provide Main Boiler Sequencing Control Panel that shall communicate to the boilers to sequence them on and off as required to maintain building heating water setpoint temperatures.
1. Equal to TPC Flow Intelligence Boiler Control System. Coordinate with Section 25 10 00 for wiring and programming.

B. Main Boiler Sequencing Control panel shall be provided with the following:
1. Color touch screen with human-machine-interface (HMI) and shall communicate to control devices and transmitters.
2. Provide one (1) Main Boiler Control Panel.
3. Provide two (2) Temperature sensors with transmitters that shall be located in the main supply and main return heating hot water piping.
4. Provide one (1) water flow sensor with transmitter that shall be located in the main hot water heating loop.
5. Provide one (1) outdoor air sensor.
6. Provide six (6) field control devices two (2) for each boiler. One shall communicate with the local boiler control panel and one shall communicate with the motorized combustion air damper.

C. Provide additional field control devices, sensors, transmitters, etc. as required for a complete installation according to the manufacturer's installation instructions.

2.4 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install boiler in accord with NFPA, ASME, local codes and manufacturer's instructions.

B. Verify boiler manufacturer's PH level requirements and verify that chemical treatment procedures account for correct PH level maintenance.

C. Wire low water cutoff to burner control circuit with manual reset device (if applicable).

D. Teflon tape shall not be used for natural gas piping.

3.2 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.3 DUTIES OF SERVICE REPRESENTATIVE

A. Boiler and burner manufacturer's factory trained service representative to perform start-up services.

B. Instruct personnel designated by Owner in operation and maintenance of equipment.

C. Service representative shall supervise following:
   1. Setting of safety valves.
   2. Adjustment of firing equipment.
   3. Boiler performance demonstration.

3.4 CLEANING (WASH-OUT)

A. Before boilers and heating system are placed in service either for temporary or permanent use, clean and flush.
   1. When used temporarily, flush boiler and piping each time additional new piping is added to the system. Boil air from water each time.
   2. Circulate for a short time then drain and refill.

3.5 START-UP

A. Start-up shall consist of:
   1. Set and calibrate safety valves.
   2. Adjust firing equipment.
   3. Check safety devices and confirm that safeties operate correctly.
   4. Verify that burner operates over full range burner firing capacity.
   5. Verify that boiler sequencing control panel is sequencing boilers correctly.

3.6 OPERATING DEMONSTRATION

A. Demonstrate to Owner operation of system over entire range.

END OF SECTION

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SECTION 23 57 00
HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Heat Exchangers, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Design standards: ASME, ARI400.

1.3 SUBMITTALS

A. Product Data:

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.
   3. Test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Heat exchangers, Plate:
   1. Base:
      a. Tranter.
   2. Optional:
      a. Alfa Laval.
      b. Armstrong.
      c. Bell & Gossett.

2.2 MATERIALS

A. Heat exchangers, Plate:
   1. Instantaneous flat plate and frame type:
      a. Corrugated heat transfer plates.
      b. Support frame.
      c. Nozzles.
      d. Tightening mechanism.
      e. Sheet metal shroud.
   2. Capacity: As scheduled.
   3. Fouling factor: 0.002. Manufacturer shall increase the initial plate quantity to account for fouling factor impact.
   4. Plates: 316L Stainless steel, herringbone type.
   5. Heat transfer coefficient: Greater than 1000 BTU/HR/SF/degF.
   6. Plate gaskets: EPDM, single piece molded construction, bonded to plates.
   7. Nozzles: 150 LB ASA rated flange type.
   8. ASME code construction.
   9. Finish: Baked epoxy with manufacturer's standard color.
   10. The carrying bar of each heat exchanger shall be long enough to permit the installation of 25% additional plates beyond the scheduled capacity including fouling factor impacts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install components in system piping as indicated.

END OF SECTION

SECTION 23 64 10
SCROLL CHILLER

PART 1 - GENERAL

1.1 SCOPE

A. The requirements of the General Conditions, Supplementary Conditions, Division 1, and Drawings apply to all Work herein.

B. Provide Microprocessor controlled, multiple-scroll compressor, water-cooled, liquid chillers of the scheduled capacities as shown and indicated on the Drawings, including but not limited to:
   1. Chiller package.
   2. Electrical power and control connections.
   3. Chilled water connections.
   4. Charge of refrigerant and oil.
   5. Factory start-up.

1.2 QUALITY ASSURANCE

A. Products shall be Designed, Tested, Rated and Certified in accordance with, and installed in compliance with applicable sections of the following Standards and Codes:
   1. ANSI/ASHRAE Standard 15 – Safety Code for Mechanical Refrigeration
   2. ASHRAE 90.1– Energy Efficiency compliance.
   3. ANSI/NFPA Standard 70 – National Electrical Code (N.E.C.)
   4. ASME Boiler & Pressure Vessel Code, Section VIII, Division 1
   5. ASHRAE 34 – Number Designation and Safety Classification of Refrigerants
   6. ARI Standard 550/590 – Positive Displacement Compressors and Water Cooled Rotary Screw Water-Chilling Packages
   7. Conform to UL code 1995 for construction of chillers and provide ETL/cETL Listing label
   8. Manufactured in facility registered to ISO 9001
   9. OSHA - Occupational Safety and Health Act

B. Factory Test: Chiller shall be pressure-tested, evacuated and fully charged with refrigerant and oil, and shall be factory operational run tested with water flowing through the vessels.

C. Chiller manufacturer shall have a factory trained and supported service organization that is within a 50 mile radius of the site.

D. Warranty: Manufacturer shall Warrant all equipment and material of its manufacture against defects in workmanship and material for a period of one year from date of initial start-up or eighteen (18) months from date of shipment, whichever occurs first.

1.3 DELIVERY AND HANDLING

A. Unit shall be delivered to job site fully assembled, and charged with refrigerant and oil by the Manufacturer.

B. Unit shall be stored and handled per Manufacturer's instructions.

C. Unit and its accessories shall be protected from the weather and dirt exposure during shipment.

D. During shipment, a covering shall be provided over vulnerable components. Nozzles and open ends shall be fitted with plastic enclosures.

PART 2 - PRODUCTS

2.1 CHILLER MATERIALS AND COMPONENTS

A. General: Install and commission, as shown on the schedules and plans, factory assembled, charged, and tested water-cooled scroll compressor chiller as specified herein. Chiller shall be designed, selected, and constructed using a refrigerant with Flammability rating of "1", as defined by ANSI/ASHRAE STANDARD - 34 Number Designation and Safety Classification of Refrigerants. Chiller shall include, but is not limited to: a complete system with not less than two refrigerant circuits, scroll compressors, direct expansion type evaporator, water-cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety and operating controls including capacity controller, control center, motor starting components, and special features as specified herein or required for safe, automatic operation.

2.2 COMPRESSORS

A. Compressors shall be hermetic, scroll-type, including:
1. Compliant design for axial and radial sealing.
2. Refrigerant flow through the compressor with 100% suction cooled motor.
3. Large suction side free volume and oil sump to provide liquid handling capability.
4. Compressor crankcase heaters to provide extra liquid migration protection.
5. Annular discharge check valve and reverse vent assembly to provide low pressure drop, silent-shut-down and reverse rotation protection.
6. Initial Oil charge.
7. Oil Level sightglass.
8. Vibration isolator mounts for compressors.
9. Brazed-type connections for fully hermetic refrigerant circuits.
10. Microprocessor controlled, Factory installed Across-the-Line type compressor motor starters.

2.3 REFRIGERANT CIRCUIT COMPONENTS

A. Each refrigerant circuit shall include: liquid line shutoff valve with charging port, low side pressure relief device, filter-drier, solenoid valve, discharge service valve, system high pressure relief device, sight glass with moisture indicator, expansion valves, and flexible, closed-cell foam insulated suction line.

2.4 HEAT EXCHANGERS

A. Evaporator:
1. Evaporator shall be a direct expansion shell and tube construction, dual circuit heat exchanger capable of refrigerant working pressure of 400 PSIG and liquid side pressure of 150 PSIG.
2. Evaporator shall be covered with 3/4 IN, flexible, closed-cell insulation, thermal conductivity of 0.26k ([BTU/HR-Ft2-°F]/in.) maximum. Water nozzles shall be insulated by Contractor after pipe installation.
3. Heat exchangers shall be ASME pressure vessel code certified.
4. Installing contractor must include accommodations in the chilled water piping to allow proper drainage and venting of the heat exchanger.
5. The water connections shall be fully accessible and grooved to accept ANSI/AWWA C-606 couplings if used (by others).

B. Condenser:
1. Condenser shall be a cleanable thru-tube construction with removable heads and integral subcooling. Heat exchanger shall be capable of a refrigerant side working pressure of 560 PSIG and liquid side pressure of 150 PSIG.
2. The condenser shall be equipped with relief valves and be capable of holding the full refrigerant charge for pumpdown.

3. The water connections shall be fully accessible and grooved to accept ANSI/AWWA C-606 couplings if used (by others).

2.5 CONTROLS

A. General: Automatic start, stop, operating, and protection sequences across the range of scheduled conditions and transients.

B. Microprocessor Enclosure: NEMA 1 (IP32) powder painted steel cabinet with hinged, latched, and gasket sealed door.

C. Microprocessor Control Center:
1. Automatic control of compressor start/stop, anti coincidence and anti-recycle timers, automatic pump down on shutdown, evaporator pump, and unit alarm contacts. Automatic reset to normal chiller operation after power failure.
2. Remote water temperature reset via a Pulse Width Modulated (PWM) input signal or up to two steps of demand (load) limiting.
3. Software stored in non-volatile memory, with programmed setpoints retained in lithium battery backed regulated time clock (RTC) memory for minimum 5 years.
4. Forty character liquid crystal display, numeric data in English units. Sealed keypad with sections for Setpoints, Display/Print, Entry, Unit Options & clock, and On/Off Switch. Display descriptions and membrane keypad graphics shown in English language.
5. Programmable Setpoints (within Manufacturer limits): display language; chilled liquid temperature setpoint and range, remote reset temperature range, set daily schedule/holiday for start/ stop, manual override for servicing, number of compressors, low liquid temperature cutout, low suction pressure cutout, high discharge pressure cutout, anti-recycle timer (compressor start cycle time), and anti-coincident timer (delay compressor starts).
6. Display Data: Return and leaving evaporator liquid temperatures, low leaving liquid temperature cutout setting, English or metric data, suction pressure cutout setting, each system suction pressure, discharge pressure, liquid temperature reset via a 0-20 VDC input, 2-10 VDC input or a 0-20mA input contact closure, anti-recycle timer status for each compressor, anti-coincident system start timer condition, compressor run status, no cooling load condition, day, date and time, daily start/ stop times, holiday status, automatic or manual system lead/lag control, lead system definition, compressor starts/operating hours (each), status of hot gas valves (if supplied), run permissive status, number of compressors running, liquid solenoid valve status, load & unload timer status, water pump status.
7. System Safeties: Shall cause individual compressor systems to perform auto shut down; manual reset required after the third trip in 90 minutes. Includes: high discharge pressure, low suction pressure, high pressure switch, and motor protector. Compressor motor protector shall protect against damage due to high input current or thermal overload of windings.
8. Unit Safeties: Shall be automatic reset and cause compressors to shut down if low ambient, low leaving chilled liquid temperature, under voltage, and flow switch operation. Contractor shall provide flow switch installation and wiring per chiller manufacturer requirements.
9. Alarm Contacts: Low ambient, low leaving chilled liquid temperature, low voltage, low battery, and (per compressor circuit): high discharge pressure, and low suction pressure.
10. BAS/EMS Temperature Reset: Chiller to accept 4 to 20mA, 0 to 10 VDC, or discrete contact closure input to reset the leaving chilled liquid temperature.

D. Pressure Transducers and Readout Capability:
1. Discharge Pressure Transducers: Permits unit to sense and display discharge pressure.
2. Suction Pressure Transducers: Permits unit to sense and display suction pressure.

E. Manufacturer shall provide any controls not listed above, necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system.

2.6 POWER CONNECTION AND DISTRIBUTION

A. Power Panels:
   1. NEMA 1 (IP32), powder painted steel cabinets with hinged, latched, and gasket sealed outer doors. Provide main power connection(s), control power connections, compressor start contactors, current overloads, and factory wiring.
   2. Power supply shall enter unit at a single location, be 3 phase of scheduled voltage, and connect to individual terminal blocks per compressor. Separate disconnecting means and/ or external branch circuit protection (by Contractor) required per applicable local or national codes.

B. Exposed compressor and control power wiring shall be routed through liquid tight conduit.

C. Power Supply Connection shall be:
   1. Single Point Power Supply: Single point Terminal Block for field connection and interconnecting wiring to the compressors. Separate external protection must be supplied, by others, in the incoming power wiring, which must comply with the National Electric Code and/or local codes.

2.7 ACCESSORIES AND OPTIONS

A. Power Supply Connections (Factory Mounted):
   1. Single Point Disconnect Switch: Single point Non-Fused Disconnect and lockable external handle (in compliance with Article 440-14 of N.E.C.) can be supplied to isolate the unit power voltage for servicing. Separate external fusing must be supplied, by others, in the incoming power wiring, which must comply with the National Electric Code and/or local codes.

B. Control Power Transformer (Factory Mounted): Converts unit power voltage to 120-1-60 (500 VA capacity). Factory mounting includes primary and secondary wiring between the transformer and the control panel.

C. Flow Switch (Field-mounted): Vapor proof SPDT, NEMA 3R switch (150 PSIG), -20 DEGF to 250 DEGF. Available with evaporator.

D. Differential Pressure Switch (Field mounted): Alternative to the paddle-type flow switch. 3-45 PSIG range with 1/4 IN NPTE pressure connections. Available with evaporator.

E. Double Thick Evaporator Insulation (Factory Mounted): Evaporator covered with double thick (1-1/2 IN) flexible, closed-cell Insulation in lieu of standard (3/4 IN) insulation. Water nozzles shall be insulated by Contractor after pipe installation.

F. ANSI/AWWA C-606 Flange Kit (Field Mounted): ANSI/AWWA C-606 flange adapters included with the water connections on the evaporator and condenser providing raised face flanges for field piping connection.

G. Service Isolation valves (Factory Mounted): Service suction (ball type) isolation valves are added to unit per circuit in addition to the standard discharge service valve. (Factory-mounted.)

H. Hot Gas By-Pass (Factory Mounted): Permits continuous, stable operation at capacities below the minimum step of unloading to as low as 5% capacity (depending on both the unit & operating conditions) by introducing an artificial load on the evaporator. Hot gas by-pass is installed on only one refrigerant circuit (System #2).

I. Microprocessor Membrane Keypad Graphics on in lieu of Standard English.

J. Sound Reduction (Factory-mounted):
   1. Each compressors is individually enclosed in an acoustic sound blankets.

K. Vibration Isolation (Field-mounted):
   1. Elastomeric Pad Isolators.

2. 1 IN Deflection Spring Isolators: Level adjustable, spring and cage type isolators for mounting under the unit base.
3. 2 IN Deflection Seismic Isolators: Level adjustable, restrained isolators, mounts in rugged welded steel housing with vertical and horizontal limit stops. Housings shall be designed to withstand a minimum 1.0g accelerated force in all directions to 2 IN.

L. Final Paint Overspray: Overspray painting of assembled unit with Caribbean blue enamel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Rig and Install in full accordance with Manufacturers requirements, Project drawings, and Contract documents.

B. Location: Locate chiller as indicated on drawings, including cleaning and service maintenance clearance per Manufacturer instructions. Adjust and level chiller on support structure. If equipment provided exceeds height of scheduled chiller, installing contractor is responsible for additional costs associated with extending the height of parapet or screening walls/enclosures

C. Components: Installing Contractor shall provide and install all auxiliary devices and accessories for fully operational chiller.

D. Electrical: Coordinate electrical requirements and connections for all power feeds with Electrical Contractor.

E. Controls: Coordinate all control requirements and connections with Controls Contractor.

F. Finish: Installing Contractor shall paint damaged and abraded factory finish with touch-up paint matching factory finish.

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SECTION 23 64 16
CENTRIFUGAL CHILLER

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Centrifugal Chiller, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 DESCRIPTION

A. Work furnished but not installed:
   1. Paddle type flow switches or differential type pressure switches:
      a. See Section 25 30 00.
      b. Manufacturers providing factory mounted and wired switches are to note this on their quotations and to stipulate the type of flow protection being provided (i.e. paddle type flow switch, differential pressure type pressure switch, solid state flow switch, etc.).

1.3 QUALITY ASSURANCE

A. Design and performance of chiller shall be certified in accordance with ARI 550/590.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Wiring diagrams.
   2. Control diagrams.

B. Product Data:
   1. Chiller.
      a. Provide computer selection data with ARI 550/590 certified performance.
      b. Letter from manufacturer detailing current position with regard to proposed refrigerant and its ozone depletion characteristics, future availability, and future equipment conversion that may be required.
      c. Statement from manufacturer detailing minimum condenser water temperature for safe operation, with continuous operation at load point from 10-100 PCT.

C. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.
   3. Test reports.
   4. Warranty.

1.5 WARRANTY

A. Provide full parts and labor manufacturer warranty to include all parts, labor, travel time, and incurred expenses. Warranty to cover from date of start up to date of substantial completion, plus an additional 24 month full parts and labor manufacturer warranty from date of substantial completion.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Chiller(s):
   1. Base:
      a. York Chiller Solutions.

2. Optional:
   a. Trane.

2.2 DESIGN CRITERIA

A. Evaporator fouling factor: 0.00010.

B. Condenser fouling factor: 0.00025.

C. Chiller shall be capable of capacity reduction to 10 PCT of scheduled value without surging.
   1. Reduction shall be based on condenser water temperature drop per ARI 550/590.

D. Manufacturers utilizing water cooled components shall state quantity and source of external cooling water requirements, (ie: condenser water, chilled water).
   1. Cooling water used shall be over and above flow rates specified.

2.3 MATERIALS

A. Chiller(s): Open or hermetic, electric motor driven centrifugal chiller, with compressor, evaporator, condenser lubrication system, capacity control system, motor starter, purge or pumpdown unit, control panel, and other items as indicated.
   1. Capacity: As scheduled.
   2. Shop prime coat equipment.
   3. Complete initial charges of refrigerant and oil.
   4. Relief valve on condenser and evaporator.
   5. Rupture disc.
   6. Controls as indicated.
   7. Capable of safe operation with 55 DEGF condenser water temperature at load point from 10-100 PCT.
      a. Manufacturers unable to comply shall submit specific data indicating their condenser water requirements.

B. Chiller compressor: Industrial grade single or multi-stage centrifugal.
   1. Multi-stage unit(s): Provide with interstage flash economizer.
   2. Provide pre-rotation vanes to modulate capacity from 100 to 10 PCT of that specified.
   3. Bearings: Self-aligning type per manufacturers recommendations.
   4. Force-feed lubrication system:
      a. Oil pump.
      b. Oil cooler.
      c. Pressure regulator.
      d. Oil filter.
      e. Oil heater.
      f. Operating and safety controls.
      g. Provide positive supply of oil to bearings during coastdown, including power failure shutdown.

C. Compressor motor:
   1. Open or hermetic.
   2. Voltage, maximum KW/ton, maximum NPLV values: Not to exceed values indicated in design criteria.
   3. Hermetic motors:
      a. Provide over-temperature winding sensor to prevent burnout.

D. Evaporator(s) and condenser(s):
   1. Shells:
      a. Provide with removable water boxes fabricated of steel or cast iron.
      b. Rolled carbon steel plate with fusion welded seams.
      c. Carbon steel tube sheet welded to each end drilled and reamed to accommodate tubes.
      d. Provide nozzle connections with "Victaulic" grooved ends suitable for "Victaulic" couplings, or field welded flange at Contractor's option.

e. Cap nozzles for shipment.
f. Provide plugged 1/2 IN drain and vent connections in each water box.
g. Provide evaporator with standard water box.
h. Provide condenser with standard water box.

2. Evaporator:
   a. Horizontal, flooded, shell and tube type.
   b. Distribution system: Consisting of a distributor trough to give uniform distribution throughout shell length and a perforated distributor plate to equally distribute refrigerant.
   c. Provide 1/2 IN thick intermediate steel tube supports spaced no more than 4 FT on centers.
   d. Provide mesh eliminators located above tubes to prevent liquid refrigerant carryover.
   e. Liquid level sight glass.
3. Condenser:
   a. Horizontal, shell and tube type.
   b. Discharge gas baffle to prevent direct high velocity impingement on tubes.
   c. Provide intermediate 1/4 IN thick, steel tube supports 4 FT on centers.
4. Tubes:
   a. Individually replaceable.
   b. 3/4 IN OD integrally finned copper heat exchanger tubes.
   c. Roller-expanded into tube sheets providing a leak-proof seal.

E. Purge or pumpout/transfer unit:
1. Purge unit: Fully automatic in operation, providing positive means for collection, return of refrigerant and removal of non-condensibles.
   a. Provide necessary operating controls, piping, and service valves to isolate purge unit from chilling unit.
   b. Factory mounted, piped, and wired.
   c. Provide display message indicating excessive purging.
   d. Provide purge unit(s) on chiller(s) operating at sub-atmospheric pressures.

2.4 CHILLER CONTROL CENTER

A. Chiller control center - general:
1. Factory mounted and wired microcomputer panel.
   a. Program and display operating parameters.
   b. Protect chiller with integral safety logic from damaging malfunctions.
   c. Interface with remote printer or building automation system and/or chiller plant automation system as specified.

B. Operating controls:
1. Four position key switch for operator to select mode of operation (local, remote, program, or service).
2. Operating setpoints:
   a. Leaving chilled water temperature DEGF.
   b. Infinite current limit (0-100 PCT).
   c. Infinite demand limit.
   d. Daily start/stop scheduling of chiller pump(s) and cooling tower fan(s).
   e. Separate holiday schedule.
3. Operating displayed data (temperatures DEGF pressure PSI):
   a. Entering chilled water temperature.
   b. Leaving chilled water temperature.
   c. Entering condenser water temperature.
   d. Leaving condenser water temperature.
   e. Evaporator refrigerant pressure.
   f. Condenser refrigerant pressure.
   g. Oil pressure.

h. Percent of motor current.
i. Evaporator saturation temperature.
j. Condenser saturation temperature.
k. Compressor discharge pressure.
l. Oil temperature.
m. Purge pressure.
n. Current limit (when in effect).
o. Low pressure limit (when in effect).
p. High pressure limit (when in effect).

C. Safety controls: Display complete safety annunciation for each shutdown occurrence including day, time, and reason for shutdown (temperature DEGF pressure PSI).
1. High condenser pressure.
2. Low evaporator pressure.
3. High oil temperature.
4. Low oil pressure.
5. High oil pressure.
6. High compressor discharge temperature.
7. Low evaporator temperature.
8. Motor controller fault.
9. Sensor malfunction.
10. Low water temperature.
11. Evaporator flow interruption.
12. Condenser flow interruption.
13. Power fault.
14. Internal time clock.
15. Anti-recycle.

D. Interface controls:
1. Printer interface: Provide factory mounted or remote mounted printer and interface control to allow operating and safety data to be printed when:
a. Operator initiates print.
b. Operator programs automatic print at programmable interval time period.
c. Shutdown occurs, either a cycling or safety shutdown.
2. Remote current limit reset.
3. Remote temperature control reset.
4. Remote start/stop.
5. Building automation system (BAS):
a. Provide hardware (interface panel, sensors, etc.) necessary to interface directly with building automation system including wiring between interface panel, chiller control panel and associated sensors.
b. Operating parameters:
1) Entering and leaving chilled water temperatures DEGF.
2) Entering and leaving condenser water temperatures DEGF.
3) Evaporator and condenser refrigerant pressures PSI.
4) Oil pressure PSI.
5) Purge pressure PSI.
6) Percent of motor current.
c. Safety and cycling shutdowns/warnings:
1) Low water temperature DEGF.
2) Power fault.
3) High compressor discharge temperature DEGF.
4) High oil temperature DEGF.
5) High oil pressure PSI.
6) Low oil pressure PSI.
7) Low evaporator pressure PSI.

8) High condenser pressure PSI.
9) Motor starter failure.
10) Water flow interrupt of evaporator and condenser.
11) Remote stop from BAS.
12) High condenser pressure limit (when in effect).
13) Low evaporator pressure limit (when in effect).

2.5 STARTER(S)

A. Solid state starter(s):
1. Reduced voltage, liquid cooled solid state type.
2. Factory mounted and wired on chiller.
3. Starter to provide complete access to parts without disturbing refrigerant circuit.
4. Factory installed power wiring from starter to compressor motor and control wiring from starter to chiller control panel.
5. Factory tested with design starting current and overload settings adjusted.
6. Provide smooth acceleration of motor without current transitions or transients.
7. Provide following factory mounted and wired protective devices to starter:
    a. Three leg sensing electronic overloads with indicating lights and reset button to shut unit down if current exceeds 105 PCT of FLA to protect motor windings.
    b. Phase rotation protection circuit and indicating light to deny startup when detecting incorrect power wiring phase sequence to starter.
    c. Phase failure protection and indicating light to shut unit down if power loss occurs in any of incoming lines during startup.
    d. High temperature safety protection with indicating light and reset button to shut unit down if SCR temperature exceeds limits.
    e. Hinged access door with lock and key to prevent access to unauthorized personnel.
    f. Auxiliary 1.5 KVA transformer.
    g. Digital elapsed time meter.
    h. Power fault protection to detect power interruption within 0.75 line cycle and interrupt power to compressor motor within 4 line cycles.
    i. Three phase digital ammeter and digital voltmeter.
    j. Non-fused disconnect.

2.6 REFRIGERANTS

A. Chiller manufacturer shall meet design criteria with HCFC-123 or HFC-134a.

2.7 ACCESSORIES

A. Differential pressure switch PSI:
1. Adjustable cut-in and cut-out points.
2. 120V rating.
3. 4 IN face.
4. Orange Research; Series 1203 with dial indicator.

2.8 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's instructions.

3.2 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.3 STARTUP AND OPERATING TRAINING

A. Provide services of a factory employed service technician for a minimum of 40 HRS to charge chiller(s) with refrigerant and oil, leak test, start-up machine and provide concurrent operator instructions.

END OF SECTION

SECTION 23 65 13

COOLING TOWER - PACKAGED

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Cooling Tower - Packaged, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Thermal Performance Standard:
   1. Cooling Tower Institute (CTI), Certification Standard STD-201 For Water Cooling Towers.

B. Listed Manufacturers and Manufacturers Desiring Approval:
   1. Meet dimensions of base manufacturer without affecting the pad or enclosure layout shown on the contract documents or ability to service equipment.
   2. Manufacturers who do not meet this requirement may be rejected at discretion of Engineer.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Layout of cooling tower with connection sizes and locations.
   2. Layout of sump tank sweeper eductors and associated piping. Pipe sizes shall be as recommended by manufacturer. Include calculations confirming eductor flow and system performance coordinated with pumping supply system.
   3. All listed manufacturers shall meet the dimensions of base manufacturer without affecting the mechanical room or enclosure layout shown on the contract documents, the ability to service equipment, or tower performance. Manufacturers who do not meet this requirement may be rejected at the discretion of the Engineer.

B. Product Data:
   1. Cooling tower.
      a. Performance curves or actual performance test results on tower of same design criteria.
      b. Sound performance data: Manufacturer's sound power levels by frequency (60 to 8000 Hz) on every side and top; and overall dBA rating.

C. Project Information:
   1. Test reports.

D. Contract Closeout Information:
   1. Operation and Maintenance Data, Owner instruction report and Warranty.
      a. See Section 01 78 23.

1.4 WARRANTY

A. Signed Manufacturer Warranty:
   1. Guarantee drift eliminators, fill and supports for 18 months after substantial completion.
   2. Provide 60 month comprehensive motor and drive warranty to include fan, fan shaft, belts, sheaves, fan bearings, gear box, flexible coupling, driveshaft and motor. Guarantee to begin after substantial completion.

B. Provide full parts and labor manufacturer warranty to include parts, labor, travel time, and incurred expenses.

C. Warranty to cover from date of start up to date of substantial completion, plus an additional 60 month parts and labor manufacturer warranty from date of substantial completion..

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cooling Towers, Induced Draft:
   1. Base:
      a. Baltimore Air Coil.
   2. Optional:
      a. Evapco.
      b. Marley Cooling Tower.

B. Basin Cleaner System:
   1. Base:
      a. Process Efficiency Products Inc. (PEP).
   2. Optional:
      a. Griswold Controls.
      b. Lakos.

2.2 MATERIALS

A. Cooling Tower:
   1. Packaged, induced draft, axial fan, vertical discharge, crossflow type.
   2. Performance: As scheduled on drawings
   3. Structure: Suitable for applications requiring equipment anchorage to resist wind loads up to 30 LBS per square foot. Fan deck and basin covers designed for 50 LBS per square foot live load or 200 LB concentrated load.

B. Construction:
   1. Heavy gauge 304 stainless steel angles, channels, panels, cold water basin, hot water basin, and fan deck.
   2. Access doors: Stainless steel, hinged or sliding type. Provide for access to eliminators, fan plenum section or any other section requiring routine maintenance.
   3. Bolts, nuts and washers: Stainless steel.
   4. Alternate side panel construction: Fiberglass reinforced polyester (FRP) with UV protection.

C. Cold Water Collection Basin:
   1. Joints sealed and caulked at factory to ensure watertight performance.
   2. Self-cleaning and complete with depressed center section, clean out and drain fitting, bottom outlet suction connection with screen and anti-cavitation device. Bottom outlet shall have grooved mechanical or flanged connection.
   3. Construction: Heavy gauge type 304 stainless steel.
   4. Makeup valve: Float operated; one per tower cell.
   5. Design to support tower when resting on only 2 grillage beams or 4 piers per cell.

D. Multiple Cell Towers:
   1. Provide bottom equalizer connection for connection to equalizer piping.

E. Hot Water Distribution:
   1. Open basin gravity type with nozzles or schedule 40 PVC spray header with plastic diffusing type metering orifices.
   2. Furnish distribution basin with flanged connections suitable for direct piping connection or flow control valves as indicated.
   3. Provide basin covers.
   4. Basin construction: Heavy gauge type 304 stainless steel.
   5. For crossflow towers (gravity type basin), provide heavy duty flow control valves at inlet to each basin or self-balancing chamber as indicated.
   6. Each tower cell shall be capable of reduced flow at 25% of design flow while maintaining wet fill without any dry fill surfaces.

F. Fill, Louvers and Drift Eliminators:
   1. Formed polyvinyl chloride material.
   2. Fill suspended from structural tubing supported from upper tower structure.
   3. Drift eliminators maximum drift rate: 0.005 PCT or less of the circulating water rate.
   4. Crossflow towers: Provide factory installed hot dipped galvanized steel wire screens over air inlets.

G. Fans:
   1. Axial type with adjustable pitch, heavy duty, cast aluminum blades.
   2. Provide one for each cell.
   3. Each blade adjustable and individually attached to stainless steel or aluminum hub.
   4. Fan:
      a. Motor:
         1) Protected type with 1.15 service factor constructed for cooling tower service.
         2) Single speed, totally enclosed, complying with 20 05 00.
         3) Mount motors out of fan cylinder.
      b. Drive:
         1) Right angle, industrial duty, oil lubricated, geared speed reducer type.
      c. Provide variable frequency drive for control of fan motor. Refer to specification section 25 23 00 for requirements.
      d. Fan cylinder: Designed to minimize fan tip loss.
      e. Fan cowl and guard: Conical shape welded stainless steel with hot dipped galvanized steel guard, conforming to OSHA standards. Provide over each fan cylinder.

H. For crossflow towers, provide perimeter OSHA approved handrail of 1-1/2 IN diameter galvanized steel pipe on top of tower and an OSHA approved ladder to provide access from base of tower to fan deck.

I. Internal access: provide internal galvanized steel bar grating walkway for access to drift eliminators and fan plenum section. Top of grating shall be above the cold water basin overflow level.

J. Cold Water Basin Heaters:
   1. Provide two (2) 12 kW electric heaters installed at opposite sides of basin and ready for field wiring.
   2. Provide thermostat control with sensing bulb located in water basin.
   3. Provide low water cutoff control to prevent heater operation unless element is fully submerged.
   4. 460 volt electrical connection to heater by Electrical Specification Divisions.
   5. Contactor:
      a. Provide 3-pole electrically held contactor with contacts rated for voltage and current of the cooling tower pan heaters.
      b. Contactor coil voltage shall be rated to match the rating of the pan heaters control thermostat.
      c. Contactor enclosure:
         1) Rating: NEMA 3R.
         2) Mounting: Between the pan heaters and the branch feeder disconnect switch.
         3) Control transformer: mounted within contactor enclosure and fuse both primary and secondary voltages. The primary voltage of the transformer shall match the supply voltage of the pan heater circuit and the secondary voltage of the transformer shall match the voltage rating of the pan heater thermostat.
      d. Provide a control wiring diagram for the pan heater thermostat control with the cooling tower submittal.

K. Vibration Limit Switch (one per tower cell):
   1. Type: Single pole, double-throw, vibration limit switch.
   2. Housing: NEMA 4.
   3. Provide with manual reset.

4. Provide with sensitivity adjustment.
5. Vibration Limit Switch shall be mercury free.
6. Installed at grade on the mechanical equipment support for wiring into the Owner's control panel.
7. In the event of excessive vibration, the limit switch will interrupt power to the motor.

2.3 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

2.4 BASIN CLEANER SYSTEM

A. Basin cleaner system shall serve the cold water basin of the cooling towers.

B. Separator package:
1. Factory assembled, prewired, prepiped system with the following:
2. Solids separator: Carbon steel.
3. Circulating pump:
    a. In-line or close coupled end suction, single stage.
    b. Cast iron housing.
    c. Stainless steel or bronze impeller.
    d. Stainless steel shaft.
    e. Tungsten carbide or ceramic mechanical seal.
4. Basket strainer.
5. Solids collection vessel with 20-25 micron filter bag.
6. Service indicator with dry contacts for remote indication. Includes differential pressure sensor and gauge with valving.
7. Prewired control panel:
    a. Motor starter with three phase protection.
    b. Nema 4X enclosure.
    c. HOA selector switch.
    d. UL listed.
8. Maximum working pressure: 50 PSI .
9. Piping: Schedule 40 steel with reinforced rubber hose to collection vessel.
10. Provide isolation valves on inlet, outlet, and purge line.
11. Capacity: As scheduled.
12. Finish: Enamel.

C. Tank Sweeper Eductors:
1. Provide tank sweeper eductors in basin. Number of eductors and eductor installation pattern shall be as recommended by the factory.
2. Piping within sump: schedule 80 PVC.
3. Pipe supports: Stainless steel.
4. Eductor submergence: in accordance with manufacturer's recommendations for the eductor size used.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install components in accordance with manufacturer's instructions and as indicated.

B. Install piping for tank sweeper eductors in accordance with approved manufacturer's shop drawings.

C. Attach piping eductor system piping supports to basin or sump by method approved by basin or sump manufacturer.

3.2 FIELD QUALITY CONTROL

A. Perform operational tests to determine performance.
   1. Test in conjunction with chillers and pumps tests.

B. Make alterations necessary to conform to design criteria.

C. Retest as necessary.

3.3 VIBRATION ISOLATION

A. Vibration Isolation:
   1. See Section 20 05 50.

END OF SECTION

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SECTION 23 73 23
FACTORY BUILT CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Factory Built Custom Air Handling Units, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Construction Standards and Criteria:
   1. Unit Construction Pressure Class: 10 IN static pressure, positive and negative.

B. Minimum Quality Control Requirements and Performance:
   1. Factory balancing:
      a. Fan wheels and shaft assemblies shall be factory balanced both statically and dynamically to meet AMCA 204 standards for residual unbalance.
   2. Fan performance curves:
      a. Tests shall be conducted in a certified AMCA laboratory in accordance with current AMCA Standards.
   3. Leakage: No more than 1/2 PCT of scheduled air handling unit cfm at 10 IN static pressure.
   4. Panel deflection: No more than 1/240 of an inch.
   5. Coils:
      a. Coils shall be factory tested to 325 PSI compressed air under clear water.
   6. Air handling units shall be designed and manufactured in strict accordance with UL-1995, Standard for Heating and Cooling Equipment. All units shall be listed and shall bear the UL 1995 label.
   7. All internal components shall be removable/replaceable through the Service Vestibule.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Dimensional shop drawings.
      a. Show casing construction (base, floor, housing); access door hardware; operating weight (point and distributed loads).
   2. Filter frames.
   3. Fan/motor vibration isolation details.
   4. Field connection details.
   5. Required clearances.
   6. Predicted sound data at eight octive bands for each opening in the unit.

B. Product Data:
   1. Casing thermal performance.
   2. Fan data:
      a. Sound power levels based on fan arrangement in unit.
      b. Certified fan curves at following conditions:
         1) Scheduled operating conditions including initial and final as noted.
         2) 50 PCT airflow operating condition (used to evaluate potential surge conditions).
      c. Computer selections based on schedule performance criteria.
      d. Motor electrical characteristics.
   3. Filters.
   4. Coil data:
      a. Computer selections of based on scheduled performance criteria.
   5. Dampers.

6. Humidifier.
7. Sound attenuators.
   a. Certified test data on dynamic insertion loss, self-noise power levels, and aerodynamic performance for reverse and forward flow test conditions.
8. Vibration isolation components.

C. Contract Closeout Information:
   1. Operation and Maintenance Data including:
      a. Bearing lubrication instructions.
      b. Filter replacement instructions.
      c. Motor and drive replacement instructions.
      d. Wiring diagrams.
   2. Owner instruction report.
   3. Factory certified pressure test report on cabinet casing.
      a. With access doors in place, test to 10.0 IN TSP:
         1) Report to factory certify air handling unit cfm leakage rate.
         2) Report to factory certify air handling unit panel deflection.
   4. Warranty.

1.4 WARRANTY

A. Provide full parts and labor manufacturer warranty to include all parts, labor, travel time, and incurred expenses. Warranty to cover from date of start up to date of substantial completion, plus an additional 24 month full parts and labor manufacturer warranty from date of substantial completion.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Factory Built Custom Air Handling Units:
   1. Base:
      a. York Custom.
   2. Optional:
      a. Huntair.
      b. Ingenia.
      c. Ventrol.
      d. Governair.
      e. Trane.

B. Filters:
   1. Base:
      a. Camfil.
   2. Optional:
      a. Eco-Air Products.
      b. American Air Filter.
      c. Flanders.

2.2 MATERIALS

A. Thermal Break Construction:
   1. Unit shall be guaranteed not to form surface condensation under the following conditions:
      a. Interior dry bulb temperature: 50 DEGF.
      b. Exterior dry bulb/dew point temperature: 94/75 deg F.

B. Unit Base:
   1. Air handling unit base:
      a. Material: Heavy duty structural steel channel; formed metal base structure is not permitted.

b. Channels: Solid welded at connection points to assure rigidity.
 1) Perimeter channel: Sized to allow for rigging and handling.
c. Base cross supports: Located and sized to support internal components.
 1) Internal supports: Properly spaced to avoid oil canning of unit floor above.
 2) Cope structural members that intersect with open side of channels or add filler piece to assure structural integrity.
d. Equipment eight feet wide and wider: Provide with a means of supporting center of unit on a truck.
e. Lifting lugs: Add to perimeter channel along longest length of unit or unit module.
 1) Position and/or extend each lug to avoid any obstruction which extends beyond unit casing, including piping vestibules, surface mounted electrical or control panels, piping connections, and other appurtenances affixed to the unit exterior housing.
 2) Incorporate into each lug a means of attaching a cable or chain.
f. Split in maximum size pieces to allow for economical shipment to jobsite.
 1) Coordinate with installation conditions on site.

2. Base drain pans:
 a. Provide as integral part of unit base in following sections:
  1) Cooling coil section.
  2) Heating coil section.
  3) Humidifier section.
  4) Outside air inlet and mixed air sections.
 b. Where drain pans exist in adjacent sections, weld adjacent drain pans together water tight.
 c. Double wall construction of type 304 stainless steel.
  1) Drain pan underliner: Type 304 stainless steel filled with insulation to provide a minimum R-7 insulation assembly.
   a) Underliner not required for foam insulation.
  2) Provide 2-1/2 IN wide, 12 gauge type 304 stainless steel inverted channels on a maximum of 24 IN centers to reinforce pan to support coils.
 d. Size:
  1) Minimum width: .
   a) Pitch in direction of air flow to assure water migration.
   b) Drain pan shall extend a minimum of 12 IN downstream of the cooling coil.
   c) Drain pan shall extend a minimum of 24 IN beyond the leaving side of the humidification elements.
   d) Drain pans in mixed air sections: Extend the width of the section.
   e) Drain pans in outside air inlet sections:
    (1) Top or side inlet: extend from the edge of the next upstream component to the edge of the next downstream component.
 e. Clearances:
  1) Provide adequate clearance, but not less than 2 IN, between bottom of the inverted coil mounting channels and top of the drain pan to allow for visual inspection and cleaning of the drain pan without coil removal.
   a) Coil height, including the coil casing material, shall not extend into the drain pan height.
   b) Coil supports shall be arranged to allow the coil to be removed to one side of the air handling unit by removal of pipe connections and one cabinet wall panel and sliding the coil horizontally (above the drain pan height) on the coil supports.
 f. Drain pan slope:
  1) Double or triple slope drain pan, minimum of one percent, and pitched toward drain connection side.
 g. Provide drain connections on one side of unit where floor drain(s) are located.
  1) Construct drain lines of same material as pan.

2) Extend drain lines through perimeter base channel and continuously weld seams/penetrations to insure an air-tight seal.
3) Provide removable cap on each drain connection.

C. Unit Floor:
1. Air handling unit floor:
a. Aluminum treadplate, minimum 3/16 IN thick.
b. Continuous full seam weld.
c. Drive screw attachment is not acceptable.
d. Floor construction: Double wall and constructed to meet L/240 deflection based upon 300 LB concentrated load at mid-span.
e. For adequate support, provide a base structural member centered under edges of each sheet of flooring material.
1) At shipping splits, seal floor seams with a continuous bead sealant.
2) Base supports above floor are not acceptable due to hazards to service personnel.
f. Overlap floor on perimeter base channel to allow a means of attaching cabinet panels from exterior without penetrating structural steel.
g. Lay floor flat and flush with top surface of base channel.
h. Provide 2 IN angle dam around floor opening for piping and conduit and seal to floor panel.

D. Unit Housing:
1. Air handling unit housing:
a. Wall construction:
1) Double wall, panelized construction such that all internal components can be easily accessed for service or removal without removal or disassembly of any exterior wall sections or panels or roof sections or panels.
2) Material: G90 galvanized steel.
a) Minimum 20 gauge for foam insulation construction.
b) Minimum 16 gauge for fiberglass insulation construction.
3) Deflection: L/240 at static pressure equivalent to Unit Construction Pressure Class.
b. Outdoor air handling units:
1) The air handling unit shall be specifically designed for outdoor application.
2) Roof curb: Prefabricated, 12 GA galvanized steel mounting curb designed and manufactured by unit manufacturer for exterior units only.
a) Verify field conditions prior to unit shipment.
b) Complete perimeter support of unit plus intermediate supports required by sizes of units.
c) Height as scheduled.
d) Nominal 2 x 4 IN wood nailer strip as required.
e) Provide gasketing for field mounting between unit base and curb.
3) Roof panels: Sloped or bowed roof with a minimum of 1/4 IN/FT slope to ensure rain runoff.
a) Provide a rain lip or gutter around perimeter of roof to prevent water from running down side of unit. Provide rain lip above doors and intake louvers.
2. Supply and return openings:
a. For supply air, provide openings with rectangular, round, or oval wide radiused, bellmouth fittings and duct collars to accept supply and return air connections as indicated.
b. Provide removable G90 galvanized steel grating over floor openings inside of air handling unit.
1) Weight support: capable of supporting 300 LBS.
2) To avoid tripping hazard, grating shall be flush with the finished floor of the unit.

3. Unit split modules:
    a. Provide necessary hardware to reassemble equipment such as bolts, nuts, washers, sealant, and slip cleats.
    b. Mark each corresponding module of cabinet with matching letters to assist in reassembly.
4. View windows: provided in access doors.
    a. View window frame: Fabricated from 16 gauge galvanized steel.
    b. Provide 3/4 IN thick thermopane wire glass window.
    c. Seal window frame to cabinet with open cell gasket on sides to ensure an air tight seal.
    d. Window open viewing size: 12 IN x 12 IN.

E. Unit Insulation:
1. Air handling unit insulation - general:
    a. Meet NFPA-90A smoke and flame spread requirements.
    b. Provide insulation materials with facings that will not promote microbial growth.
    c. R-value of wall, roof and floor assemblies: minimum of R-12.
    d. Type: Foam or fiberglass.

F. Unit Liners:
1. Liners - general:
    a. As a protective cover for insulation, provide liners on the interior of the air handling unit integral parts of the exterior panel system.
    b. Consolidate internal reinforcing as well as interior lining surface into one piece.
        1) Allow attachment of interior liner to cabinet without exposing any drive screws or bolts which can be hazardous to service personnel.
        2) Provide a smooth, uninterrupted surface.
        3) Exposed reinforcing is unacceptable due to impedance of air performance.
2. Solid liner:
    a. Liner material: Minimum 20 gauge G-90 galvanized steel, except where specifically indicated otherwise.
    b. Liner material in wetted sections: Minimum 20 gauge type 304 stainless steel.
        1) Provide in following sections:
            a) Cooling coil section.
            b) Heating coil section.
            c) Humidifier section.
    c. Do not allow exposure of any insulation to air stream.
    d. Fabricated from a solid sheet without any perforations.
    e. Cover openings and corners to completely contain insulation.
3. Perforated liner:
    a. Liner material: G-90 galvanized steel.
    b. Provide in following sections:
        1) Fan sections.
        2) Economizer section.
    c. Protect insulation while allowing acoustical absorption.
    d. Perforations: 1/4 IN diameter.
        1) Minimum allowable free area: 40 PCT.

G. Unit Finishes:
1. Exterior finish: Wall and roof panels.
    a. One coat of polyurethane primer and one coat of polyester-hybrid semi-gloss top coat.
        1) Prime and top-coat panels on both sides.
        2) Color: Manufacturer’s standard.
        3) Custom Color (Exterior units only): As selected by Architect.
        4) Paint system shall pass a minimum of 1000 HR salt spray test per ASTM-B117.
2. Base finish:
    a. Alkyd enamel.

1) Provide industrial grade alkyd enamel red oxide primer by air brush to 2 mils thickness.
2) Provide alkyd enamel top coat with air brush to 2-3 mills thickness.

b. Color: Manufacturer's standard.

3. Fan assembly finish:
   a. One coat of polyurethane primer and one coat of polyester-hybrid semi-gloss top coat.
      1) Prime and top-coat panels on both sides.
      2) Color: Manufacturer's standard.
      3) Paint system shall pass a minimum of 1000 HR salt spray test per ASTM-B117.
   b. Aluminum fans shall not require paint finish.
4. Interior finish:
   a. Paint non-galvanized or welded surfaces with red oxide primer and machinery gray enamel.

H. Fan Assembly
1. Performance ratings: rated in accordance with laboratory tests conducted in accordance with AMCA Standard 210.
2. Ratings: As indicated.
3. Arrangement: As indicated
4. Fan Array:
   a. Multiple direct driven, arrangement 4 plenum fans constructed per AMCA requirements for duty specified, (Class I, II, or III).
   b. Multiple fans, spaced in the air way tunnel to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein.
   c. All fans shall be selected to deliver design air flow at the specified operating TSP (Total Static Pressure) at the specified motor speed as scheduled.
   d. The fan array shall be selected to operate at a system TSP that does not exceed 90 PCT of the specified fan's peak static pressure producing capability at the specified fan speed.
   e. Performance:
      1) The fan array shall produce a uniform air flow profile and velocity not to exceed the specified cooling coil and filter bank face velocity when measured at a point 12 IN from the intake side of the fan array septum wall, and a distance of 42 IN from the discharge side of the fan array septum wall.
      2) Fan shall be structurally designed to withstand the maximum motor RPM at 60 hertz.
      3) Each fan shall be individually wired to a control panel containing a single VFD (with standby) for the total connected HP for all fan motors contained in the fan array.
   f. Fan/motor cartridge:
      1) Each fan/motor cartridge shall consist of:
         a) Steel intake wall: 11 gauge A60 galvanized steel.
         b) Inlet funnel: 14 gauge spun steel.
         c) Motor support plate and structure: 11 gauge A60 galvanized steel.
         d) All components to be powder coated epoxy for enhanced corrosion resistance.
         e) Motors: See section 20 05 00.
            (1) Shall be selected by the manufacturer and suitable for array application.
            (2) Efficiency: NEMA premium efficiency in compliance with MG-1.
            (3) Type: Totally enclosed fan cooled (TEFC).
         f) Each fan/motor cartridge shall be removable.
   g. Balancing:
      1) Each fan array and assembly shall be dynamically balanced to meet the following requirements of AMCA standard 204:
         a) Category: BV-4.
         b) Grade: G 1.0.
         c) Residual unbalance: equal to or less than .0028 oz-in/lb of rotor mass.

h. Drives and wiring:
   1) Each fan motor shall be individually wired to a control panel containing a single VFD (Refer to 25 23 00 for VFD requirements.), sized for total connected horsepower for the fan array.
   2) Wiring sizing shall be determined in accordance with NEC standards.
i. Safety screens at fan discharge: Provide on all fans.
j. Sound Pressure Levels:
   1) Unit inlet and outlet discharge sound pressure levels and radiated sound pressure levels shall not exceed the values scheduled for the or alternate single direct drive plenum fan.

5. Air flow measuring stations: Comply with Division 25.
   a. Factory install air flow measuring stations in the inlets of the supply and return fans. For units with multiple supply and return fans, mount stations such that the fan blank off panels can be mounted so they do not disturb air flow station.
   b. Inlet venturi cone/ring may be used with airflow station transmitter as specified in Division 25.
      1) Device shall meet or exceed airflow station requirements identified in Division 25.
   c. Transmitters specified in Division 25 may be field or factory installed.

I. Economizer
1. Economizer section includes:
   a. Dampers and linkage for return air, outside air, and exhaust/relief air.
   b. Drain pan.
2. Dampers, control:
   a. Provide control dampers for return, outside and exhaust/relief air.
      1) Control dampers: As specified in Section 23 31 13, factory mounted.
      2) Damper actuators: As specified in Division 25, field or factory mounted.
      3) Size dampers with 1500 to 1800 FPM air velocity.
      4) Outside and return air dampers: Parallel blades arranged to provide convergent airflow to minimize stratification.
3. Drain pan: double sloped to assure positive condensate drainage with connections on one side opposite to Service Vestibule. The pan shall be of double wall construction with a stainless steel liner and have a minimum of 2 IN of insulation (uncompressed). The pan shall have a minimum depth (free-board) of 2 IN.

J. Filter Banks
1. Filter banks (filter frames with filters) - General:
   a. Factory fabricate as part of air handling unit.
   b. Mount filter bank in air handling unit.
      1) Continuously bond periphery of filter frame to inside of air handling unit to eliminate air bypass.
2. Filter frames - General:
   a. Provide frames compatible with filters scheduled.
   b. 16 gage galvanized steel.
   c. Equip frame with protective diagonal support members on both air entering and air exiting sides of filters.
   d. Equip frame with gaskets and heavy-duty, positive-sealing fasteners capable of being attached or removed without use of tools.
   e. Filters shall be accessible from inside the unit.
3. Filters:
   a. Capacities and types: As scheduled.
   b. Locations: As scheduled.
   c. UL Class 2 listed.
   d. Provide quantities and standard sizes to match requirements of air handling unit.
   e. Provide two sets of pre-filters and final filters.

4. Pre-filters: Extended surface bag type.
   a. Provide two sets of prefilters.
   b. Average media efficiency: As scheduled.
      1) Efficiency is based on ASHRAE Test Standard 52.1.
   c. Filters arranged for face loading into positive sealing "type 8 IN filter frames.
   d. Micro-fine fiberglass media encased in thin non-woven polyester backer mat.
   e. Open area on filter face for air passage: Not to less than 90 PCT.
   f. Flexible internal support stitching to maintain individual pleats in a controlled form under rated air flow conditions.
   g. Provide edges finished with a four-thread overlock stitch to prevent air bypass.
   h. Headers gasketed with polyfoam on vertical sides to prevent leakage when installed in framing modules.
5. Final filters:
   a. Filters: Rigid cartridge type.
      1) High performance, deep pleated, totally rigid and totally disposable type with high density microfine glass fiber media, media support grid, contour stabilizers and enclosing frame.
      2) Average media efficiency: As scheduled.
         a) Efficiency is based on ASHRAE Test Standard 52.1.
      3) Filters arranged for face loading into positive sealing "type 8 IN filter frames.
      4) Constructed by pleating a continuous sheet of moisture-resistant water-laid micro-fine glass media into closely spaced pleats with hemmed-edge corrugated aluminum separators.
      5) Sealed into a 24 gauge galvanized steel frame with fire-retardant potted urethane elastomer sealant.
      6) Frame:
         a) Enclosing frame: Assembled in a rigid manner and incorporate a single or double header as required for job conditions.
         b) Headers: Gasketed with polyfoam on vertical sides to prevent leakage when installed in framing modules.
6. HEPA filters:
   a. Efficiency: As scheduled.
      1) Efficiency is based on DOP (0.3 micrometer) and laser spectrometer testing.
   b. Media: Waterproof, fire retardant fiberglass.
   c. Sides: Exterior grade particle board.
   d. Separators: Aluminum.
   e. Bond: Polyurethane foam.
   f. Gaskets: Rubber on both sides.
7. For each individual filter bank, provide Dwyer Series 2000 magnahelic filter gauges.
8. Provide walk-in filter access sections upstream of filter rack with adequate space available for filter service.

K. Coils
1. Coils - general:
   a. Certified in accord with ARI 410.
   b. Coil capacity, size and type: As scheduled.
   c. Arrange coils for easy removal.
   d. Coil support rack:
      1) Mount coils on support rack.
      2) For stacked coils, lower coil sections shall be capable of being removed without disturbing upper coil sections.
      3) Rack construction:
         a) Heating coils: 16 gauge G90 galvanized steel
         b) Cooling coils: 16 gauge 304 stainless steel.
   e. Blank off coil ends to ensure air passes through the coils.
      1) Heating coils: 12 gauge G90 galvanized steel

2) Cooling coils: 12 gauge 304 stainless steel.

f. Working Pressure Rating:
   1) Water coils: 250 PSIG.
g. Temperature Rating: 300 DEGF.
h. Coil Connections:
   1) Threaded connections located on same end, except where otherwise noted or shown.
   2) Coil headers, distributors and connections completely enclosed in unit casing.
   3) Water coil vent and drain connections:
      a) Provide for each section.
      b) Extend all vents and drain lines to the exterior of the unit housing on side away from Service Vestibule.
      c) Interior manifolding of individual coil drain and vent lines, prior to extending to the unit exterior is not acceptable.

2. Water Heating Coils:
   a. 5/8 IN OD copper tubes, 0.025 IN wall; 0.035 IN wall on return bends.
   b. Minimum 0.0075 IN thick aluminum fins, spiral or plate fin design.
      1) The maximum fin spacing shall be 10 FPI.
   c. 16 gauge G90 galvanized steel casing.
   d. Non-ferrous, copper headers.
3. Chilled Water Cooling Coils:
   a. 5/8 IN OD copper tubes, 0.025 IN wall; 0.035 IN wall on return bends.
   b. Minimum 0.0075 IN thick aluminum fins, plate fin design.
      1) The maximum fin spacing shall be 10 FPI.
   c. 16 gauge type 304 stainless steel casing.
   d. Non-ferrous, copper headers.
4. Intermediate condensate drain pans:
   a. On stacked cooling coils, provide intermediate pan to prevent condensate from upper coil(s) from passing over lower coil(s).
   b. Intermediate drain pans shall be insulated with 1 IN elastomeric insulation on the underside to prevent condensation formation and moisture carry-over due to adiabatic condensation formation on the intermediate drain pans.
   c. Fabricated from same material and in same style as base drain pan.
   d. Provide 1 IN diameter, 304 SS or copper down spouts from upper pan(s) to lower pan(s).

L. Humidifiers
1. High pressure water humidifier: Nozzle manifolds shall be mounted and installed by humidifier manufacturer.
   a. Comply with Section 23 84 14.
   b. Air handling unit manufacturer shall coordinate humidifier installation with humidifier manufacturer.

M. Sound Attenuators
1. Sound attenuator (silencer) segments shall be provided as shown on drawings. Silencers shall be rectangular sized to fill the AHU tunnel.
2. Silencers shall be made of similar material as the AHU cabinet.
3. Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5 PCT compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof.
4. Combustion ratings for the silencer acoustic fill shall be not greater than the following when tested to ASTM E84, NFPA Standard 255, or UL No. 723:
   a. Flamespread Classification: 20
   b. Smoke Development Rating: 20

5. Provide minimum insertion loss performance in dB per the following:

Octave Band Center Frequency (Hz)							
63	125	250	500	1000	2000	4000	8000
4	9	18	18	14	12	9	9

N. Access Doors
1. Access doors: Hinged, double wall, insulated, thermal break type.
    a. Provide access doors where shown on air handling unit details.
    b. Door construction:
        1) Door size, minimum: 24 IN wide x 72 IN high.
        2) Size door(s) to accommodate removal of following equipment through the door(s):
            a) Motors.
            b) Humidifier manifold.
        3) Exterior door skin: Same material and finish as unit housing.
        4) Door interior liner: Same material and finish as interior liner of section in which door is installed.
        5) Access door perimeter: One piece, welded.
        6) Insulation: Same as unit wall insulation.
    c. Door frame: One piece, welded.
    d. Gasketing:
        1) Provide full circumference gasketing with a closed cell, replaceable neoprene gasket.
        2) Provide gasketing system that allows for easy removal for replacement.
        3) Provide system that will maintain a tight seal without assistance of operating pressure.
    e. Hinges and latches:
        1) Provide corrosion resistant, fully adjustable hinges and latches to allow for maintenance of a tight seal between door and unit as gasketing material compresses over time.
        2) Provide stainless steel, removable hinge pins to allow door to be easily removed during servicing.
        3) Leaf and Piano type hinges are not acceptable.
        4) Provide for padlocking of latches to Service Vestibule.
        5) Latch and paw assemblies: One piece, bolted together.
    f. Hinge access doors so they open against unit operating pressure unless otherwise indicated.

O. Electrical
1. Each unit shall be provided with single point of power connection.
2. Wiring to comply with NEC requirements and conform with applicable U/L standards and Electrical Specification Divisions.
3. Each unit shall be wired and tested at the factory before shipment.
4. Provide separate factory wired branch circuits for each supply and return air fan motors. Terminate with junction boxes in Service Vestibule.
5. Variable frequency drives for exterior air handling units:
    a. Variable frequency drives (VFD): As specified in Section 25 23 00.
    b. Factory mount VFD(s) in Service Vestibule as indicated.
    c. VFD(s) to be mounted and pre-wired to motors.
    d. VFD(s) to be interfaced with and controlled by Owners existing Building Automation System (BAS).
6. Lights:
    a. Provide one factory installed light for each air handling section which has an access door.
    b. Fixture: LED marine type.

c. Each fixture shall be controllable from externally mounted light timer (1-hour) with pilot light.
d. Provide weatherproof 3-way switch with pilot light at each exterior door into the Service Vestibule. Switches shall control multiple LED light fixtures in the Service Vestibule.
e. Provide a separate 120 volt factory wired circuit for unit lights. Terminate circuit at junction box in Service Vestibule.
f. At shipping sections, provide additional junction boxes on each module to allow the installer to make final connections in the field.
    1) Clearly label wiring to ease final interconnections.

7. Outlets:
    a. Provide three factory installed double grounded GFCI receptacles along the length of each Service Vestibule.
    b. Provide a separate 120 volt factory wired circuit for unit receptacles. Terminate circuit at junction box in Service Vestibule.
    c. At shipping sections, provide additional junction boxes on each module to allow the installer to make final connections in the field.
        1) Clearly label wiring to ease final interconnections.

2.3 VIBRATION ISOLATION

A. Vibration isolation: See Section 20 05 50.

2.4 UNIT TESTING

A. Air leakage: Factory pressure test unit to positive and negative 10 IN WG and eliminate all noisy leaks. Leakage shall not exceed 1/2 PCT of unit design airflow volume. Submit test report.

B. Panel deflection test:
1. Panel deflection checks shall be done in conjunction with and at pressures stated in pressure leak test.
2. Once unit is leak tested and determined to be acceptable, a panel deflection test may be conducted. Deflection will be measured at four (4) points around the cabinet. Each point will be located at the largest unsupported span for the side. A dial micrometer will be placed against panel seam at the mid-point of the panel height. The cabinet will be pressurized to the specified static load and the deflection will be measured.
3. Pass/Fail criteria will be based on 1/240 of the panel span as a maximum allowable deflection at specified static load.
4. Submit test report.

C. The above test described in Paragraph "A" and "B", shall be performed at the manufacturer's facility prior to shipment.

D. The Owner/Architect shall be given the option to witness the tests at their own expense.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Field assemble air handling unit modules in accordance with manufacturer's installation drawings and instructions.
1. Assemble unit complete with vibration isolation components.
2. Sealing and fastening hardware shall be supplied by air handling unit manufacturer.
3. Provide lamps for lights.
4. Coordinate humidifier installation with humidifier manufacturer.

B. Touch-up abraded or damaged finish.

C. Provide a trap on drains at jobsite on exterior of unit.
   1. Traps shall be adequate to maintain a water seal while equipment is in operation

D. Coordinate with Division 25 for location of water valves, temperature sensors, and damper operators.

E. Provide fan dynamic balancing services as specified in Section 23 35 00.

3.2 START-UP

A. Provide services of factory trained service technician to inspect units after erection, perform minimum 16 HR startup service and perform concurrent Owner instruction.
   1. File written report and include in maintenance manual.
   2. Coordinate startup with Test and Balance provider and Temperature Controls provider.

B. Equipment Startup:
   1. Unit start-up to take place at completion of work.
   2. Prior to the engineer's scheduled startup, complete the following:
      a. Ensure automatic temperature controls work is complete.
      b. Turn on power, and "bump" unit motors to verify correct fan rotation.
      c. Remove shipping materials.
      d. Ensure that spring isolated components are off shipping supports.
      e. Level spring isolated components.
      f. Install filtration media in equipment.
         1) Replace filters used in construction.
      g. Complete piping and duct connections.
         1) Complete leak checks on water piping prior to startup.
      h. On multiple piece units, complete interconnections (electrical, piping and ductwork) and roof joints.
      i. Make startup requests to manufacturer two weeks prior to scheduled date.
   3. Temperature control and air balance providers shall be on site at time of equipment startup.

END OF SECTION

SECTION 23 81 23
COMPUTER ROOM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Computer Room Air Conditioning Units, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 SUBMITTALS

A. Product Data:
   1. Manufacturer's information including single-line diagrams, dimensional and capacity data, electrical data and piping and electrical connection drawings.

B. Contract Closeout Information:
   1. Operation and Maintenance Data and Owner instruction report.
      a. See Section 01 78 23.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Computer Room Air Conditioning Units:
   1. Base:
      a. Liebert.
   2. Optional:
      a. Data Aire.
      b. EDPAC.
      c. Airflow.

2.2 MATERIALS

A. Floor Mounted Units:
   1. Computer room air conditioning units: Self-contained factory assembled units, floor mounted.
      a. Airflow configurations: Upflow top air supply, front air return.
      b. Design system for pull through air arrangement to insure even air distribution to entire face area of coil.
      c. Design to allow control system and electrical circuitry to be serviced and/or checked while system is in operation without disturbing air flow and performance of system.
      d. Design based upon Liebert CW and PCW units.
   2. Cabinet and frame construction: Frame constructed of heliarc welded tubular steel for maximum strength.
      a. Interior sheet metal welded to frame assembly.
      b. Exterior panels insulated with minimum 1 IN 1-1/2 PCF density fiber insulation.
      c. Provide panels with captive quarter fasteners quickly removable for easy access to equipment.
      d. Arrange panels to provide access to electrical control panel and compressor section without interrupting air flow.
      e. Factory finish.
      f. Colors: Main unit and accent panel by Architect.

3. Chilled water coil: A-frame design with minimum of 25 SQFT face area, 6 rows deep for Liebert CW and minimum of 9.8 SQFT face area, 4 rows deep for Liebert PCW.
   a. Construct of copper tubes and aluminum fins.
   b. Design water circuit to distribute water into entire coil face area.
   c. Mount entire coil assembly in a stainless steel condensate drain pan.
   d. Controlled by a 2-way modulating control valve.
4. Electronically Commutated (EC) Fans:
   a. The fans shall be plug/plenum type, single-inlet and shall be dynamically balanced. The drive package shall be direct drive, electronically commutated and variable speed.
   b. EC fans shall be available on upflow models and fans shall operate outside the unit in a factory-provided plenum.
   c. Motor power: As scheduled.
   d. Locate fans to draw air over A-frame coil to ensure even air distribution and maximum coil performance.
5. Filter chambers: Integral, designed within frame and cabinet.
   a. Filters shall be deep-pleated 2 or 4 IN filters with an ASHRAE 52.2 - 2007 MERV8 efficiency filter.
   b. Filters serviceable from either end of unit without use of ladders or special rigging.

B. Ceiling-mounted Unit:
1. Computer room air conditioning unit: Self-contained factory assembled unit, ceiling-mounted.
   a. Airflow configurations: Front air supply, rear air return.
   b. Design system for pull through air arrangement to insure even air distribution to entire face area of coil.
   c. Capacity: As scheduled.
   d. Design based upon Liebert MM unit.
2. Cabinet and frame construction: Frame constructed of heavy gauge galvanized steel.
   a. Exterior panels insulated with minimum 1 IN 1-1/2 PCF density fiber insulation.
   b. Arrange side access panel to provide access to electrical control panel and compressor section without interrupting air flow.
   c. Factory finish.
3. Chilled water coil: Minimum of 3.0 SQFT face area, 3 rows deep.
   a. Construct of copper tubes and aluminum fins.
   b. Design water circuit to distribute water into entire coil face area.
   c. Mount entire coil assembly in a stainless steel condensate drain pan.
   d. Controlled by a 2-way modulating control valve.
4. Fans:
   a. The fan shall be direct-drive, double-inlet blower and shall be dynamically balanced. Blower includes self-aligning ball bearings and lifetime lubrication.
   b. Fan motor shall be permanent-split capacitor, high efficiency type.
   c. Motor power: As scheduled.
5. Filter box for attachment to return-air opening:
   a. Filter shall be 16 IN x 20 IN x 1 IN MERV8 efficiency filter.

C. In-row Units:
1. Computer room air conditioning units: Self-contained factory assembled units, floor mounted.
   a. Airflow configurations: Front air supply, rear air return.
   b. Capacity: As scheduled.
   c. Design based upon Liebert CRV units.
2. Cabinet construction:
   a. Exterior panels shall be 20 gauge steel and powder coated with paint to protect against corrosion.
   b. Double wall side panels insulated with minimum 1/2 IN 2 PCF density fiber insulation.
   c. Factory finish.

3. Chilled water coil: Minimum of 7.8 SQFT face area, 3 rows deep.
   a. Construct of copper tubes and hydrophilic-coated aluminum fins.
   b. Design water circuit to distribute water into entire coil face area.
   c. Mount entire coil assembly in a stainless steel condensate drain pan.
   d. Controlled by a 2-way modulating control valve.
4. Electronically Commutated (EC) Fans
   a. The fans shall be plug type, single-inlet and shall be dynamically balanced. The drive package shall be direct drive, electronically commutated and variable speed.
   b. Motor power: As scheduled.
   c. Locate fans to draw or blow air over tilted slab cooling coil to ensure even air distribution and maximum coil performance.
5. Filter channel: Integral, designed within cabinet and serviceable from the rear.
   a. Filters shall be deep-pleated 4 IN filters with an ASHRAE 52.2 - 2007 MERV8 efficiency filter.

2.3 CONTROLS

A. Control system: Electronic, microprocessor based.
   1. Provide LED numerical display of:
      a. Room temperature and humidity.
      b. Temperature set point.
      c. Temperature sensitivity.
   2. Unit-mounted display panel:
      a. Provide following colored LED normal operating mode:
         1) Cooling.
   3. Monitor unit operation and activate an audible and visual alarm for the following factory preset alarm conditions:
      a. High temperature.
      b. Low temperature.
      c. High humidity.
      d. Low humidity.
      e. EC fan fault.
      f. Change filters.
      g. Loss of air flow.
      h. Loss of power.
      i. Smoke sensor shut down.
      j. Field accessible local alarm.
      k. Manual override activated.
   4. Provide battery back-up to maintain programmed setpoints during power outage.

B. Disconnect switch:
   1. Locking type.
   2. Non-automatic molded case circuit breaker mounted in high voltage section of electrical panel.
   3. Switch to be accessible from outside of unit with access panel closed.

C. Smoke Sensor: Mount in electrical panel with sensing element in return air, to immediately shut down air conditioning system when smoke sensor is activated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions and as specified.

3.2 PERFORMANCE TEST

A. Provide services of a factory trained representative to start and run unit under load for minimum of 8 HRS to ensure complete system is operating and performing as specified.

3.3 OWNER INSTRUCTIONS

A. Provide service of manufacturer's representative for minimum of 4 HRS, when requested by Owner, to instruct Owner's operating personnel.

END OF SECTION

SECTION 23 82 39

HYDRONIC HEATING AND COOLING TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Hydronic Heating Terminal Units, as indicated, in accordance with provisions of Contract Documents.

B. Description of system:
   1. Unit heaters.
   2. Fan coil units.
   3. Active chilled beams.

C. Work installed but not furnished:
   1. Control valves: Furnished under Section 25 30 00.

D. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Standards:
   1. Methods of Testing for Rating Fan-Coiled Air Conditioners: ASHRAE-79.
   2. Room Fan-Coil Air Conditioners: ARI-440.
   3. Safety Standards for Fan Coil Units and Room Fan Heater Units: ANSI/UL-883.
   4. Advanced Installation Guide for Hydronic Heating Systems: IBR-250, 2nd Edition.
   5. American Society of Testing and Materials (ASTM):
      a. E 136 Test Method for Behavior of Materials in a Vertical Tube Furnace at 1382 DEGF.
      b. C 553 Standard Specification for Mineral Fiber Blanket and Felt Insulations.
      c. C665 Specification for Mineral Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.

1.3 SUBMITTALS

A. Product Data:
   1. Unit heaters.
   2. Fan coil units.
   3. Active chilled beams.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Unit heaters:
   1. Base:
      a. Trane
   2. Optional:
      a. American Air Filter
      b. Airtherm
      c. Carrier
      d. Daikin
      e. Dunham-Bush

f. Modine
g. Vulcan

B. Fan coil units:
1. Base:
a. International Environmental
2. Optional:
a. Airtherm
b. Carrier
c. Daikin
d. Dunham-Bush
e. Trane
f. Envirotec

C. Active chilled beams:
1. Base:
a. York
2. Optional:
a. Titus
b. Price
c. Semco

2.2 MATERIALS

A. Unit Heaters
1. Horizontal unit heaters: Propeller type, with finned heating coil thru which air is blown, horizontal discharge.
a. Capacity: As indicated.
b. Casing: Sheet steel, with removable 18 GA back, with factory finish.
c. Fan: Aluminum, mounted directly on shaft of motor, with guard.
1) Provide fan guard.
d. Motor: Totally enclosed:
1) Provide thermal overload protection for motors up to 1/2 HP.
2) Provide vibration isolated motor mounts.
e. Heating coil: Copper tubing, non-ferrous fins; mechanically bond fins to tubes.
f. Coil leak tested to 300 PSIG.
g. Horizontal adjustable louvers with vertical adjustable louver fins.

B. Fan Coil Units
1. Fan coil units, vertical: Top discharge units with finned heating and cooling coils, motor driven centrifugal fans and 18 GA galvanized steel chassis with flanged edges.
a. Capacity: As scheduled.
b. Type: Floor cabinet model.
c. Fans: Centrifugal type, forward curved, double width, double inlet, selected for quiet operation. Fan housing of formed galvanized steel.
d. Motor: Direct drive type with internal thermal overload protection. See Section 20 05 00.
e. Heating and cooling coils: Copper tube mechanically bonded to configurated non-ferrous fins with continuous fin collars and sleeved end supports.
1) Maximum working pressure 300 PSIG.
2) Capacity certified in accordance with ARI Standard 441-70.
3) Leak tested to maximum working pressure.
f. Filters: Permanent, cleanable aluminum mesh.
g. Drain pans: Galvanized steel with solderless drain connections and molded polystyrene foam insulating liner.
1) Auxiliary drain pan: Located under control valve.
2) Provide condensate pump to handle condensate from drain pans where indicated.
h. Provide motor starters.

i. UL listed.
j. Control Package: Temperature controller shall be furnished by Section 25 10 00 for factory installation. No switch required for belt driven units. Provide deluxe motor controls and interlocking disconnect for single point electrical connection. Provide control transformer as required.
    1) For vertical units, factory install control package furnished by Section 25 10 00 with a sensor located in return air stream.
    2) Sequence: Modulate coil control valve in response to room temperature during continuous fan operation.
k. Valve Package: Section 25 10 00 shall furnish electronic actuated two way control valve (per flow diagram) for factory installation. Fan coil unit manufacturer shall provide other valves and accessories required by the coil piping details.
l. Unit sound data to be pre-tested and rated in accordance with ARI Standard 443-70.
m. Cabinet enclosure:
    1) 18 GA steel panels.
    2) Heavy density thermal and acoustical insulation inside face of front panel.
    3) Hinged access doors with tamper proof fasteners.
    4) Top panel shall slope down from back to front at an angle of 25 degrees.
    5) Double deflection discharge grille shall provide discharge at nominal 30 degrees from the vertical.
    6) Finish: Factory applied rustproofing and baked enamel in manufacturer's standard color as selected by Architect.

2. Fan coil units, horizontal: Blow thru type, heating and cooling coils, motor driven centrifugal fans, filters and drain pan.
    a. Capacity: As scheduled.
    b. Casing: Horizontal concealed type.
        1) Provide:
            a) Discharge duct collar.
            b) Return air opening with duct collar located in rear of unit.
    c. Fans: Double width, double inlet, forward curved, centrifugal type with heavy gauge galvanized steel housing.
    d. Motors: Direct-drive type with internal thermal overload protection. See Section 20 05 00.
    e. Heating and cooling coils: Copper tube mechanically bonded to configurated non-ferrous fins with continuous fin collars and sleeved end supports.
        1) Maximum working pressure 300 PSIG.
        2) Capacity certified in accordance with ARI Standard 441-70.
        3) Leak tested to maximum working pressure.
    f. Filters: Permanent, cleanable aluminum mesh.
    g. Drain pans: Galvanized steel with solderless drain connections and molded polystyrene foam insulating liner.
        1) Auxiliary drain pan: Located under control valve.
        2) Provide condensate pump to handle condensate from drain pans where indicated.
    h. Provide motor starters.
    i. UL listed.
    j. Control Package: Temperature controller shall be furnished by Section 25 10 00 for factory installation. No switch required for belt driven units. Provide deluxe motor controls and interlocking disconnect for single point electrical connection. Provide control transformer as required.
        1) For horizontal units, factory install control package furnished by Section 25 10 00 for installation. Furnish combination remote mounting type wall thermostat and switch to Section 25 10 00 for installation. Unit mount speed switch where present.
        2) Sequence: Modulate coil control valve in response to room temperature during continuous fan operation.

k. Valve Package: Section 25 10 00 shall furnish electronic actuated two way control valve (per flow diagram) for factory installation. Fan coil unit manufacturer shall provide other valves and accessories required by the coil piping details.
l. Unit sound data to be pre-tested and rated in accordance with ARI Standard 443-70.

3. Fan coil units, horizontal: Draw thru type with heating and cooling coils, centrifugal belt-driven fan with adjustable pulley, filters and drain pan.
a. Capacity: As scheduled.
b. Casing: 16 GA galvanized steel with side access panels for maintenance and service.
c. Coils: Copper tube, aluminum plate fins.
1) Leak tested at 300 PSIG minimum air pressure.
2) Automatic air vent.
d. Fan: Forward curved, centrifugal type.
1) Provide with heavy duty adjustable V-belt drive.
2) Permanently lubricated, long life bearings.
3) Dynamically balanced.
e. Drain pans: Integrally attached to coil casing.
1) Drain pipe connection.
2) Galvanized steel with molded polystyrene foam insulating liner.
3) Provide condensate pump to handle condensate from drain pans where indicated.
f. Filters: Permanent recleanable type.
g. Motors: See Section 20 05 00.
1) Provide with built-in thermal overload protection.
2) Provide motor starters.
h. Provide discharge duct collar integral with casing.
i. Control Package: Temperature controller shall be furnished by Section 25 10 00 for factory installation. No switch required for belt driven units. Provide deluxe motor controls and interlocking disconnect for single point electrical connection. Provide control transformer as required.
1) For horizontal units, factory install control package furnished by Section 25 10 00 for installation. Furnish combination remote mounting type wall thermostat and switch to Section 25 10 00 for installation. Unit mount speed switch where present.
2) Sequence: Modulate coil control valve in response to room temperature during continuous fan operation.
j. Valve Package: Section 25 10 00 shall furnish electronic actuated two way control valve (per flow diagram) for factory installation. Fan coil unit manufacturer shall provide other valves and accessories required by the coil piping details.

2.3 ACTIVE CHILLED BEAMS

A. Active chilled beams:
1. Furnish and install active chilled beams of sizes, capacities and nozzle types as indicated on the drawings and within the mechanical equipment schedules. The beams shall be constructed and delivered to the job site as single units.
2. The face of the beam shall consist of a room air induction section of 50 percent free area perforated steel flanked by two linear supply slots. The entire visible face section shall be finished in white powder coat paint or as specified by the Architect.
3. Beams shall be provided with side and end details which will allow its integration into the applicable (nominal 24 IN wide) acoustical ceiling grid as specified by the Architect.
4. The beams shall consist of a minimum 20 gauge galvanized steel housing encasing the integral sensible cooling coil and a plenum feeding a series of induction nozzles. A side mounted connection spigot shall afford the connection of a 5 IN diameter primary supply air duct to the beam. The inside and outside surfaces of the housing and inlet spigot shall be finished with black powder coat paint. The overall height of the beam shall not exceed 8-1/2 IN.

5. Each beam shall be provided with a pressure tap (or nozzle) that may be used to measure the pressure differential between the primary air plenum and the room. An airflow calibration chart or data which relates this pressure differential reading with the primary and beam supply airflow rates shall also be provided by the beam manufacturer.
6. Each beam shall be furnished with a volume flow limiter for mounting in its inlet connection. This device shall allow field adjustment of a maximum primary air flow rate independent of any static pressure changes in the inlet ductwork. Volume flow limiter shall add no more than 0.15 IN H_20 pressure drop to the primary air delivery system and shall not require any control or power connections.
7. Beams shall be provided with connections for 2 or 4 pipe operation as indicated on plans and schedules. The coils shall be mounted horizontally and shall be manufactured with seamless copper tubing (1/2 IN outside diameter) with minimum 0.016 IN wall thickness mechanically fixed to aluminum fins. The aluminum fins shall be limited to no more than 10 fins per IN. The beam shall have a working pressure of at least 300 PSI, be factory tested for leakage at a minimum pressure of 360 PSI. Each chilled beam shall be provided with factory integrated drain and vent fittings.
8. The chilled water coil shall be provided with 1/2 IN NPT male threaded fittings where specified. These fittings must be suitable for field connection to a similar (1/2 IN NPT) female flexible hose. If not otherwise specified, coil connections shall be bare copper for field sweating to the water supply circuit. Connections shall face upwards, be located near the left end of the beam (when viewing into the primary air connection spigot and shall be at least 1-1/2 IN long to facilitate field connection; by others).
9. Beams shall be delivered clean, flushed and capped to prevent ingress of dirt.
10. All performance shall be in compliance with that shown on the equipment schedule. Acoustical testing shall have been performed in accordance with ANSI S12.51.
11. Hydronic cooling capacities shall be established by testing according to DIN Standard 4715. Manufacturer shall submit documentation that testing has been performed to this standard. Coils shall be rated in accordance with ARI Standard 410.
12. Primary airflow rates shall not result in supply (primary plus induced) airflow rates in excess of 80 CFM per linear foot of beam.
13. Chilled water flow rates to the beams shall be limited to that which results in a 10 FT head loss. Water flow velocities through the beam shall not exceed 4 FPS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

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SECTION 23 84 14
HIGH PRESSURE HUMIDIFICATION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. All applicable requirements of other portions of the Contract Documents apply to the Work of this Section including, but not limited to, all Drawings, all Specifications, General Conditions, and General Requirements including submittals.

1.2 DESCRIPTION OF WORK

A. Types of evaporative humidification system specified in this section include the following:
   1. High pressure water atomization type.

B. Refer to Division 26 sections for the following work; not work of this section:
   1. Power supply wiring from power source to power connection on water pumps. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
   2. Interlock wiring between electrically-operated equipment and field-installed control devices.
      a. Interlock wiring specified as factory-installed is work of this section.

C. Provide the following electrical work as work of this section:
   1. Control wiring between field-installed humidity sensors or BAS output panel, staging valves and humidification system control panels.

1.3 QUALITY ASSURANCE

A. Manufacturer:
   1. For each product specified, provide components by same manufacturer throughout.
   2. Manufacturing company shall have field service support to provide continuing support of humidification system.

B. Codes and Standards:
   1. UL and NEMA Compliance: Provide electrical components required as part of humidifiers, which are listed and labeled by UL and comply with NEMA Standards.
   2. Provide electrical control panels assembled and labeled in UL qualified facility.
   3. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of humidifiers.
   4. International Mechanical Code and State Mechanical Code Rules.

1.4 SUBMITTALS

A. Product Data:
   1. Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights, installation and start-up instructions, and furnished specialties and accessories.

B. Shop Drawings:
   1. Submit manufacturer's assembly-type shop drawings indicating pipe routing, nozzle locations, solenoid valves, dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams:
   1. Submit manufacturer's electrical requirements of power supply wiring to pump units, solenoid valves, sensors and control panels. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Maintenance Data:
   1. Submit maintenance data and parts lists for the entire system including pumps, sensors, valves, control and accessory: Include "trouble-shooting" maintenance guide; product data, shop drawings, and wiring diagrams in maintenance manual, in accordance with requirements of Related Documents.

1.5 WARRANTY

A. Products shall be supported with a warranty that ensures it will be free from defects in materials and workmanship for a period of (1) year after start-up or 1.5 years from shipment. Whichever occurs first.

PART 2 - PRODUCTS

2.1 MATERIALS AND COMPONENTS

A. General:
   1. Except as otherwise indicated, provide packaged humidifiers and ancillary equipment with manufacturer's standard materials and components as indicated and published product information, designed and constructed by manufacturer, and as required for complete installation.

B. Acceptable Manufactures:
   1. Subject to compliance with requirements, provide the central evaporative humidification system manufactured by:
      a. Base
         1) GoFog.
      b. Optional:
         1) MeeFog.
         2) Nortec.

2.2 HIGH PRESSURE WATER ATOMIZATION TYPE HUMIDIFIER

A. General:
   1. Provide high pressure water atomization type humidifier including the following components:
      a. Fog nozzles.
      b. Fog pump unit(s).
      c. Water treatment equipment (using RO treated water).
      d. Fog nozzle manifolds and main feed lines.
      e. Droplet filters and frames.
      f. Electrical panels and automatic control valves.
   2. The system component sizes and capacities shall meet the specified load for humidification zones.
   3. High pressure humidification system shall not use more than 0.003 kW/# of moisture generated.

B. Fog Nozzle Section:
   1. Nozzle: 316 stainless steel construction with a 0.006 IN machined office.
   2. Median droplet size to be between 10-40 microns with 95% of the droplets at 15 microns or less at 1,000 PSIG operating pressure.

3. The nozzle manifold to be constructed of 1/2 IN OD 316 stainless steel tubing with 0.035 IN wall thickness.
4. Nozzle saddles to be TIG welded to the manifold.
5. All connections between tubing to be 316 stainless steel double-ferrule compression fittings.
6. Nozzle section in AHU must be water tight, non-corrosive and include a stainless steel pan that slopes to the drain.

C. High Pressure Water Pump Units:
   1. Complete fog pump units shall include the following:
      a. Direct drive oil lubricated ceramic plunger pumps with stainless steel heads: Water lubricated axial piston pumps are not to be used due to noise and vibration.
      b. Frame: Components to be mounted on a powder coated carbon steel frame.
      c. ABB VFD's with pressure transducer to maintain 1,000 PSI pump pressure.
      d. Dual Pump System shall be rack mounted and fully assembled at the factory. The factory mounted equipment includes (2) pumps, (2) VFDs, control panel, and safety devices. Pumps/VFD's are alternating duty/standby with automatic switchover. One dual pump skid will service all AHU's.
      e. Pressure regulating valves: Stainless steel construction with stainless steel valve and valve seat.
      f. Electric motors shall be TEFC, premium efficiency model. Refer to Specifications Section 20 05 00.
      g. Pump unit shall be capable of operating minimum zone without overheating of pump.
      h. Low inlet water pressure cut-off: To protect pump in the event of low inlet pressure, manual reset with signal to BAS.
      i. Low discharge pressure switch. To shut down the system if the pressure is not able to maintain 1,000 PSI. Manual reset with signal to BAS.
      j. Pump bypass to RO storage tank or drain for pump cooling during part load.
      k. Low pressure gauge: Liquid filled, for 0 to 100 PSIG.
      l. High pressure gauge: Liquid filled, for 0 to 2,000 PSI.
      m. Fittings and hoses: Low pressure and high-pressure fittings to be a minimum of 304 stainless steel construction. Low-pressure inlet hoses and high-pressure discharge hoses shall be provided as part of humidification system.
      n. All wetted parts including piping shall be non-corrosive (stainless steel). Provide all necessary dielectric isolation.

D. Water Treatment:
   1. Reverse Osmosis (RO) water treatment will be provided as part of humidification system. The RO treated water shall be piped to the fog pump units for this central humidification system as part of this humidification work. Building water to be tempered to 55 DEGF at the inlet of the water treatment system.
      a. The system supplier shall conduct complete water analysis on the RO treated water and make recommendation for water treatment additionally required prior to commencing work.
      b. Water treatment system shall protect against:
         1) Excessive plugging of nozzles, not more than 10% per year.
         2) Any water condition that could cause excessive wear or damage to the fog nozzles.
         3) Any dangerous bacteria growth or any condition that could result in dangerous bacteria growth, and
         4) Any possibility of "dusting" of the air with mineral salts.

E. Droplet Filters and Frames:
   1. Filters shall be UL Class I rated, polymer based with biocide agent. Filters shall be rated for use up from 200-700 FPM. Filters shall be installed in stainless steel frames and all necessary mounting hardware to be provided by the humidifier manufacturer.

F. Zone Control Valves:
1. High pressure motorized ball valves shall be provided on the water supply line to each humidification zone to stage the humidification process at the fog nozzles. The valves shall be rated for a minimum 1,000 PSI operating pressure with stainless steel wetted parts. Solenoid valves are not to be used.
2. Valve control panels to accept 4-20mA or 0-10VDC demand signal from BAS and stage the valves accordingly.
3. Valve control panel(s) to send a 24V pump enable back to the pump panel whenever a demand for humidity occurs.
4. Flush cycle to occur once every 24 hours to keep fresh water in the system.
5. Valve panels and motorized ball valves are to be mounted on a stainless steel rack and pre-wired/pre-pied from the factory.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which humidifiers are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 INSTALLATION OF HUMIDIFICATION SYSTEM

A. General:
1. Installation shall be performed or supervised by the humidification system manufacturer's factory trained representative. The system shall be installed in accordance with system manufacture's written instructions, and with recognized industry practices, to ensure that humidification system comply with requirements and serve intended purposes.

B. Access:
1. Provide access space around humidification system components for service as indicated, but in no case less than that recommended by manufacturer.

C. Support:
1. Provide supports from substrate for humidification system components in accordance with manufacturer's installation instructions.

D. Electrical Wiring:
1. Install electrical wiring devices furnished by manufacturer, but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to the electrical wiring installer.
    a. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

E. Connect the RO treated make-up water providing suitable back flow prevention devices as required by Plumbing Code having jurisdiction. Connect the necessary drain piping.

F. Grounding:
1. Provide electrical equipment ground for electrical-operated humidification system components.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation and prior to initial operation, test and demonstrate that air humidification equipment is leak-tight.

B. Repair or replace air humidification equipment as required to eliminate leaks, and retest as specified to demonstrate compliance.

3.4 START-UP, ADJUSTING AND CLEANING

A. Start-Up:
   1. Start-up humidifiers in accordance with manufacturer's instructions under supervision of manufacturer's factory representative.

B. Cleaning:
   1. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

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DIVISION 25

INTEGRATED AUTOMATION

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SECTION 25 08 00
COMMISSIONING OF INTEGRATED AUTOMATION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 01 91 13 – Commissioning General Requirements

C. Section 22 08 00 – Commissioning of Plumbing Systems

D. Section 23 08 00 – Commissioning of HVAC Systems

E. Section 26 08 00 – Commissioning of Electrical Systems

F. Section 28 08 00 – Commissioning of Electronic Safety and Security Systems

G. Commissioning Plan

1.2 DESCRIPTION OF WORK

A. The purpose of this section is to specify the Division 25 responsibilities and participation in the commissioning process. All contractors responsible for Division 25 installation or other activities shall have commissioning responsibilities described herein.

B. Work under this contract shall conform to requirements of Division 1, General Requirements, Conditions of the Contract, and Supplementary Conditions. This specification covers Commissioning of Integrated Automation Systems, which are a part of this project.

C. Commissioning shall be a team effort to ensure that all controls equipment and systems have been completely and properly installed and function together correctly to meet the design intent. Additionally, system performance parameters shall be monitored and documented for fine tuning of control sequences and operational procedures. Commissioning shall coordinate and document equipment installation, equipment start-up, control system calibration, testing and balancing, and verification and performance testing.

D. The Commissioning Team is defined in Specification 01 91 13 Section 1.3 – Definitions. The trades represented on the Commissioning Team shall include but not be limited to; sheet metal, pipe and fitting, controls, test and balance, plumbing, chemical treatment and fire protection. The lead person for each trade who will actually perform or supervise the work is to be designated as the representative to the Commissioning Team. Responsibility for various steps of the commissioning process shall be divided among the members of the Commissioning Team, as described in this section.

E. Controls Contractor(s) are responsible for integrated automation systems installation, start-up, testing, preparation of O&M manuals, and operator training as defined in various Division 25 specification sections. Controls Contractor(s) are responsible for coordination, observation, and verification of commissioning as defined in this section and Section 01 91 13. Neither Section 01 91 13 - Commissioning General Requirements nor Section 25 08 00 – Commissioning of Integrated Automation Systems shall relieve the Controls Contractor(s) from their obligations to complete all portions of work in a satisfactory and fully operational manner. Furthermore, Section 25 08 00 – Commissioning of Integrated Automation Systems shall not relieve the Electrical Contractor(s) or Controls Contractor(s) from any obligations set forth within Division 1, Division 25, Division 26, including Section 01 91 13 – Commissioning General Requirements.

1.3 DEFINITIONS

A. Controls Contractor(s): The term Controls Contractor(s) utilized herein refers to any and all subcontracting companies or venders whom are responsible for the construction or other provisions regarding any of the systems which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 25 of the specifications. Subcontracting parties outside of the scope of the Systems to be Included in Commissioning or outside of the scope of Division 25 are not included.

B. Equipment Manufacturer(s): The term Equipment Manufacturer(s) utilized herein refers to any and all subcontracting companies whom are responsible for the provision of equipment or components which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 25 of the specifications. Equipment Manufacturer(s) shall refer to the direct representative of the maker and/or distributor of the equipment or component being provided. This may include either the actual equipment manufacturer or the supplier thereof, under the provisions that the supplier has a thorough knowledge of the equipment or component and is recognized by the actual equipment manufacturer as being a proper representative.

1.4 SCOPE OF WORK

A. The Controls Contractor(s) shall be required to Commission all equipment, components and accessories of each of the commissioned systems as outlined within Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning. In order to accomplish a complete commissioning process, the Controls Contractor(s) shall be required to fulfill all requirements set forth within Specification 25 08 00 Section 1.5 – Roles and Responsibilities. Additionally, the Controls Contractor(s) shall be required to fulfill all requirements set forth within Specification 01 91 13.

B. Through the Commissioning Process, the Controls Contractor(s) shall accomplish thorough documentation, organized scheduling and coordination, detailed installation verification, and detailed system functional verification. For this, the Controls Contractor(s) must cooperate and coordinate with the Commissioning Agent.

1.5 ROLES AND RESPONSIBILITIES

A. In addition to the Commissioning Agent, Owner and System Design Professional(s), the Commissioning Team is comprised of a minimum of one individual to represent each contracting company or venders whom are responsible for the construction or other provisions regarding any of the systems which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 25 of the specifications. See Specification 01 91 13 Section 1.3 – Definitions for the definition of the Commissioning Team.

B. Contracting companies providing members shall include but not be limited to; HVAC, sheet metal, pipe and fitting, controls, test and balance, plumbing, chemical treatment and fire protection contractors whose responsibilities are defined herein.

C. In addition to all roles and responsibilities defined herein, all Controls Contractor(s) shall be required to fulfill all requirements described within Specification 01 91 13 Section 1.4 – Roles and Responsibilities.

D. Controls Contractor(s)
   1. General Requirements:
      a. Include all cost to complete commissioning requirements for Integrated Automation Systems in the contract price. Contractor costs shall be reflected within the Schedule of Values as specified within Specification 01 91 13 Section 2.2 – Schedule of Values.
      b. Ensure cooperation and participation of specialty Contractors and Sub-Contractors.

c. Ensure participation of major Equipment Manufacturers in appropriate start-up, testing and training activities.
d. Attend Commissioning Meetings for construction phase coordination as scheduled by the Commissioning Agent. Additionally, attend the Commissioning Kick-Off Meeting as scheduled by the Commissioning Agent.

2. Commissioning Schedule
   a. Prepare a Preliminary Schedule for Integrated Automation Systems and equipment, including component installation, start-up and checkout, and system start-up. Integrate commissioning activities into this Preliminary Schedule including Pre-Functional and Functional Performance Tests. Coordination of the commissioning activities and their integration into the schedule shall be conducted within the Commissioning Meetings.
   b. Update the Preliminary Schedule and submit a Final Schedule which shall reflect all items within the Preliminary Schedule and shall also include but not be limited to: inspections, O&M manual submission, training sessions, equipment start-up, and task completion. All Contractor(s) shall integrate schedule activities into one complete Final Schedule which shall be reflected within the Construction Manager's overall project schedule. The Final Schedule shall be continuously updated throughout the Construction Phase.
3. Submittal Requirements:
   a. Comply with all Submittal requirements as outlined within Specification 01 91 13 Section 2.3 – Submittals.
   b. Comply with all requirements as outlined within Specification 01 91 13 Section 2.5 – Start-Up and Test Reports.
   c. Provide a complete set of O&M manuals to the A/E and the Commissioning Agent.
   d. Provide the following documentation to the Commissioning Agent for the purpose of construction updates:
      1) General construction progress and status reports
      2) Updated Architect, Owner, System Design Professional, and Contractor deficiency logs
      3) Minutes from all construction and coordination meetings not otherwise conducted by the Commissioning Agent
      4) Pre Start-Up and Start-Up procedures
      5) Value Engineering Proposals and a list of all accepted VE items
      6) Pressure Test Reports, Flushing Reports and Start-Up Reports
      7) Construction document changes resulting from controls Requests for Information
4. Pre-Functional Checklist Requirements:
   a. Detailed installation verification shall be performed on all installed equipment and systems to ensure that the installations conform to the contract documents, local and applicable codes, and standard practice. This shall be accomplished through the completion of Pre-Functional Checklists. The creation, distribution, completion and maintenance of Pre-Functional Checklists are detailed in Specification 01 91 13 Section 2.4 – Pre-Functional Checklists.
   b. Complete Pre-Functional Checklists on all controls equipment and system components installed or provided by the Controls Contractors(s).
   c. Notify the Commissioning Agent a minimum of two weeks (14 days) in advance, so that witnessing Equipment and System Start-Up can begin.
   d. Provide written notification to the Commissioning Agent for each system listed in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, that the system installation is complete in its entirety and that the system is fully operational, online, and ready for Functional Performance Testing.
5. Equipment and Systems Start-Up
   a. Perform all initial check-out and start-up procedures as outlined within the specifications and as per the Equipment Manufacturer's recommendations. Provide full documentation of all start-up and check-out procedures and results. Documentations is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist.

6. Functional Performance Test Requirements:
    a. Detailed testing shall be performed on all installed equipment and systems to ensure that operation and performance conform to contract documents, local and applicable codes, and standard practice. This shall be accomplished through the completion of Functional Performance Tests. The creation, distribution and completion of Functional Performance Tests are detailed in Specification 01 91 13 Section 2.6 – Functional Performance Tests.
    b. Provide all appropriate equipment and materials as necessary to execute and complete all Functional Performance Tests. Comply with all requirements as outlined within Specification 01 91 13 Section 2.8 – Test Equipment.
    c. Provide appropriate technicians for participation during system verification and functional performance testing. Technicians shall demonstrate system performance to Commissioning Agent including all modes of system operation (e.g. normal, abnormal, emergency, etc.)
    d. Verify all functional performance tests prior to requesting test witness by the Commissioning Agent, demonstrate all Functional Performance test tasks in the presence of the Commissioning Agent and assist the Commissioning Agent in all verification and functional performance tests.
    e. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Commissioning Agent for verification or diagnostic purposes. Typically, TAB Verification shall occur in conjunction with Functional Performance Testing.
    f. Cancellation or delays of any system tests or Functional Performance Testing upon the day of that particular scheduled test, due to lack of preparation or status of installation shall be considered a failed test due to the additional time required by the Commissioning Agent to witness electrical testing. These additional tests shall be treated in accordance with Specification 01 91 13 Section 3.6-A.
7. Training Requirements:
    a. Comprehensive training of O&M personnel shall be performed by the Controls Contractor(s) and Equipment Manufacturer(s) prior to turnover of the systems to the Owner. Training shall include but not be limited to classroom instruction and hands-on instruction of the installed equipment and systems. Training shall be coordinated by the Commissioning Agent via review and approval of the Contractor(s) Training Plan, Forms and Schedule. Alternately, the Commissioning Agent may provide a Training Plan including all forms for completion by the Controls Contractor(s).
    b. The Training Schedule is to be coordinated and completed by the Controls Contractor(s). The Training Schedule is to be updated and maintained as construction progresses. The Training Schedule and all updates shall be coordinated with and approved of by the Owner. A copy of the Training Schedule and all updates shall be provided to the Commissioning Agent.
    c. Contractor(s) responsible for the installation or provision of any piece of equipment or system shall attend, at minimum, the initial training session for that equipment or system.
    d. All Training Documentation shall be assembled and organized in a binder or set of binders. Coordinate with all other Contractor(s) to provide one complete bound Training Record. This requirement shall not be negated, unless other specific complete Project Training Record requirements, encompassing ALL project training documentation, is outlined elsewhere within the specifications.
    e. Contractor to make professional video recordings of all O&M staff training sessions.
8. Close-out Requirements:
    a. Remedy all deficiencies identified during commissioning. Provide all materials, equipment, labor, etc. to accomplish these remedies.
    b. Provide a complete set of Record Documents (As-Built Drawings and Specifications) to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval by the Commissioning Agent.

c. Provide a Project Training Record to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy of all Project Training Record for review and approval to the Commissioning Agent.
d. Provide a complete copy of Equipment and System Warranties to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval by the Commissioning Agent.
e. Provide to the Commissioning Agent, a complete record of Attic Stock as delivered to the Owner and as approved by the Owner.
f. Contractor to provide CMMS data and MAXIMO documentation to Owner as required by project specifications.

E. Additional Requirements of Controls Contractor(s):
1. Review design for controllability with respect to selected equipment:
2. Verify proper hardware specification exists for functional performance required by specification and sequence of operation.
3. Verify proper safeties and interlocks are included in design.
4. Verify proper sizing of control valves and actuators based on design pressure drops. Verify control valve authority to control coil properly.
5. Verify proper sizing of control dampers. Verify damper authority to control air stream. Verify proper damper positioning for mixing to prevent stratification. Verify actuator vs. damper sections for smooth operation.
6. Verify proper selection of sensor ranges.
7. In addition to all other submittal requirements outlined with in Specifications 01 91 13 and 25 08 00, provide the following submittals to the Commissioning Agent:
a. Hardware and software submittals
b. Control panel construction shop drawings
c. Narrative description of each control sequence for each piece of equipment controlled.
d. Diagrams showing all control points, sensor locations, point names, actuators, controllers and, where necessary, points of access, superimposed on diagrams of the physical equipment.
e. Logic diagrams showing the logic flow of the system.
f. A list of all control points, including analog inputs, analog outputs, digital inputs, and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
g. A complete control language program listing, including all software routines employed in operating the control system. Also provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.
h. Hardware Operation and Maintenance Manuals
i. Application software and project applications code manuals.
8. Provide controls graphics submittals to the Commissioning Agent and to the Owner and Owner’s Maintenance Personnel for approval. Do not proceed with controls graphics programming without integration of the Owner’s Maintenance Personnel commentsVerify proper installation and performance of controls / BAS hardware and software provided by others.
9. Issue a Statement of Calibration for each system which states that all system points and interfaces have been properly calibrated and adjusted.
10. Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system.
11. Demonstrate system performance to Commissioning Agent including all modes of system operation (e.g. normal, abnormal, emergency).
12. Provide control system technician for use during system verification and functional performance testing.
13. Provide system modifications as required.

14. Provide support and coordination with TAB contractor on all interfaces between their scopes of work. Provide all devices, such as portable operator's terminals, for TAB use in completing TAB procedures.
15. The Controls Contractor(s) shall provide trending as required to confirm, disconfirm or correct any deficiencies identified during Commissioning. Specific trend logs will be required to facilitate the commissioning process and documentation of Functional Performance Testing. The Controls Contractor(s) shall provide trends for all data points for the commissioned systems in graphed format.

F. Equipment Manufacturer(s):
1. Comply with all requirements as outlined within Specification 25 08 00 Section 1.5 Sub-Section D – Controls Contractor(s).
2. Assist in scheduling of training sessions. Provide training of Owner's Maintenance Personnel with adequacy required for full comprehension of equipment and maintenance procedures. Coordinate training with the Commissioning Agent. Training forms for Agenda and Training Record shall be provided by the Commissioning Agent. These forms are to be utilized for all Training Sessions. Manufacturer's standard training forms shall not be accepted as Training Records if Commissioning Forms are provided. Manufacturer standard training forms may be submitted as supplemental information, but the Commissioning Forms must be completed in their entirety.
3. Review installation for Equipment Manufacturer's specific requirements. Verify safeties, limits, relays and all other equipment specific settings are correct. Verify these settings optimize equipment performance and efficiencies.
4. Perform, approve and document all start-up services as outlined within the specifications for each piece of equipment, component and accessory. Perform all standard manufacturer services as outlined on manufacturer supplied forms. Additionally, perform all other requirements specifically called for within the project specifications, not otherwise performed in a manufacturer standard startup service. Provide additional documentation for these services on forms with manufacturer's letterhead.
5. Demonstrate performance of equipment as required within Functional Performance Tests.

1.6 DOCUMENTATION

A. The Commissioning Agent shall oversee and maintain the development of Commissioning Documentation. The Commissioning Documentation shall be kept in three ring binders, and organized by system and sub-system when practical. All pages shall be numbered, and a table of contents page(s) shall be provided. The Commissioning Documentation shall include the following which is to be maintained by the Contractor(s):
1. Start-Up and Check-Out Documentation: Organized and arranged with its associated Pre-Functional Checklist.
2. System and Component test: Organized and arranged with its associated Pre-Functional Checklist.
3. Pre-Functional Checklist: Organized and arranged as per provided by the Commissioning Agent. Typically these forms are organized by System and Sub-System and according to the order of standard specifications as outlined by American Institute of Architects (AIA.)
4. Functional Performance Tests: All tests performed by the installing contractors for internal checkout and for witness by the Commissioning Agent shall be kept by the Contractor(s), organized and arranged by System and Sub-System, and turned over to the Commissioning Agent for inclusion into the Final Commissioning Report.
5. Project Training Record: The Training Record shall be provided with a Table of Contents followed by the updated Training Schedule and finally followed by each Training Session Agenda and Record. The Training Session Agenda and Record shall be organized by System and Sub-System.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The appropriate Contractor(s) shall furnish all special tools and equipment required during the commissioning process. A list of all tools and equipment to be used during commissioning shall be submitted to the Commissioning Agent for approval. The owner shall furnish necessary utilities for the commissioning process. Additional test equipment requirements are found in Specification 01 91 13 Section 2.8 – Test Equipment.

2.2 TEST EQUIPMENT - PROPRIETARY

A. 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.

PART 3 - EXECUTION

3.1 GENERAL

A. A pre-construction meeting of all Commissioning Team members shall be held at a time and place designated by the General Contractor. The purpose shall be to familiarize all parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.

B. A Final Commissioning Plan shall be developed by the Commissioning Agent. The Controls Contractor(s) shall assist the Commissioning Agent in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation in a timely manner. If contractor initiated system changes have been made that alter the commissioning process, the Commissioning Agent shall notify the Owner.

C. The Commissioning Process shall follow the schedule and procedures set forth within the Final Commissioning Plan.

D. The Controls Contractor(s) shall complete all phases of work so the systems can be started, tested, balanced, and acceptance procedures undertaken. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, and change orders.

E. The Controls Contractor(s) shall coordinate all Commissioning Activities into the project as required herein and as outlined within the Commissioning Plan. The Controls Contractor(s) shall complete all required Commissioning and Construction Activities correctly and on schedule.

3.2 PARTICIPATION IN ACCEPTANCE PROCEDURES

A. The Controls Contractor(s) shall provide skilled technicians to start-up and debug all systems within Division 25. These same technicians shall be made available to assist the Commissioning Agent in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the Commissioning Agent and coordinated by the Controls Contractor(s). Controls Contractor(s) shall ensure that the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. System performance problems and discrepancies may require additional technician time, Commissioning Agent time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods, at no cost to the owner, until the required system performance is obtained.

C. The Commissioning Agent reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and willingness to work with the Commissioning Agent. The Controls Contractor(s) shall provide adequate documentation and tools to start-up and test the equipment, system, and/or sub-system.

3.3 DEFICIENCY RESOLUTION

A. In some systems, miss-adjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the Owner, with input from the contractor and equipment supplier. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the Owner and/or Architect shall have final jurisdiction over any additional work done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Any and all schedule items affected by this work shall be reflected on the Commissioning and Overall Project Schedules.

3.4 ADDITIONAL COMMISSIONING

A. The Controls Contractor, and associated sub-contractors, shall be responsible for any additional commissioning required as a result of failure of a pre-functional or a functional test. Incomplete or incorrect Pre-Functional Checklists reviewed by the Commissioning Agent shall require an additional inspection to verify the re-completed PFC is complete and accurate. Functional Performance Tests witnessed by the Commissioning Agent which fail, shall require retesting, again witnessed by the Commissioning Agent. These documents must be re-checked or re-witnessed in order for the system to be approved and accepted by the Commissioning Agent.

B. The Commissioning Agent will invoice the Owner for additional time required to witness any retesting due to failed PFC's or FPT's, plus expenses, and the Owner at his discretion will deduct this cost from the Construction Manager's Application for Payment. The Construction Manager may then back charge the party responsible for the test's failure. It is the Contractor's responsibility to properly de-bug systems and verify successful system performance prior to inviting the Commissioning Agent to witness the test.

3.5 SEASONAL COMMISSIONING

A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning shall be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. Heating equipment shall be tested during winter design extremes. Cooling equipment shall be tested during summer design extremes with a fully occupied building. Each contractor and supplier shall be responsible to participate in the initial and the alternate peak season tests of the systems as required to demonstrate performance.

3.6 PRE-FUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTS

A. The Commissioning Agent shall be responsible for preparing the Pre-Functional Checklist. The Controls Contractor(s) shall be responsible for completing their applicable sections. Detailed descriptions of Pre-Functional Checklists are outlined in Section 01 91 13-2.4.

B. The Commissioning Agent shall be responsible for preparing the Functional Performance Tests. The Commissioning Agent and Contractor (s) shall schedule the tests and assemble the commissioning team members who shall be responsible for the tests. Participating contractors, manufacturers, suppliers, etc. shall include all costs to do the work involved in these tests in their proposals. Detailed descriptions of Functional Performance Tests are outlined in Section 01 91 13-2.6.

C. Following is a list of tasks and supporting information that shall be required:
   1. HVAC Contractor(s) - provide the services of a technician(s) who is (are) familiar with the construction and operation of this system. Provide access to the contract plans, shop drawings, and equipment cut sheets of all installed equipment.
   2. Controls Contractor - provide the services of a controls engineer who is familiar with the details of the project. Provide details of the control system, schematics, and a narrative description of control sequences of operation.

D. Documentation and Reporting Requirements
   1. Any contractors with responsibilities related to the equipment to be installed, i.e. HVAC, electrical, TAB, controls, Construction Manager, shall be responsible for completing their related portion of the Pre-Functional Checklist and Functional Performance Test forms and shall sign off on its completion.

E. If deficiencies are identified during verification, the construction manager must be notified, and action taken to remedy the deficiency. The final tabulated checklist data sheets shall be reviewed by the Design Professional and the Commissioning Agent, to determine if verification is complete, and the operating system is functioning in accordance with the contract documents.

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SECTION 25 10 00
BUILDING AUTOMATION SYSTEM (BAS)

PART 1 - GENERAL

1.1 APPLICATION OF THIS SECTION

A. This Section applies to all heating, ventilating, and air conditioning work. Coordinate with applicable Sections as required.

B. Refer to other Sections in Division 23, 26 and 28 for general requirements pertaining to mechanical and electrical work.

1.2 SECTION INCLUDES

A. Building Automation System (BAS) hardware and software.

B. Instruments, sensors and controllers.

C. Panels and accessories.

D. Completely coordinate with work of other trades.

1.3 RELATED SECTIONS

A. Section 01 77 00 - Closeout Procedures and Submittals.

B. Division 23 Sections.

C. Division 25 Sections.

D. Division 26 Sections.

E. Division 28 Sections.

1.4 GENERAL REQUIREMENTS

A. The Building Automation System (BAS) shall be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown.

B. The BAS shall meet the functional requirements of this specification, the construction documents, and shall be capable of executing all control algorithms defined on contract control drawings and specification Section 25 90 00 - BAS Sequence of Operation. The BAS contractor shall provide a fully functional system.

C. The Building Automation System (BAS) contractor shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with proprietary communications capabilities as herein specified.

D. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, and controllers.

E. Devices of the same type shall be products of a single manufacturer. Each major component within the system shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products shall have been in a satisfactory commercial or industrial use for five years prior to use on this project. The five year use shall include applications of equipment and materials under similar circumstances and of similar size to this project. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components.

F. Provide 8 hours of dedicated labor to set up and assist Owner with developing trends. Provide Owner training in using the system tend capabilities.

G. Provide actuators for all control dampers furnished by Division 23.

H. All smoke dampers and combination fire/smoke dampers provided by Division 23 shall include integral damper actuators.

I. The contractor is responsible for reviewing the contract documents and applying the typical controls information specified in Division 25 to all HVAC and mechanical equipment shown or referenced in the contract documents.

J. Damper actuators shall be provided with internal feedback status for all control, smoke and fire/smoke dampers as indicated on the contract documents.

K. Provide 8 hours of dedicated labor to develop customized reports and assist the Owner with developing customized reports. This time is in addition to the time required to perform the functions specified herein.

L. Provide dedicated labor to support the 3rd party commissioning agent's commissioning of the BAS. Refer to Section 23 08 00 - Commissioning of HVAC Systems, for details.

M. Provide a BAS in accordance with UL 916 and with the following characteristics:
   1. The system shall perform supervisory monitoring and control functions including but not limited to Scheduling, Alarm Handling, Trending, and Report Generation as specified.
   2. The system shall include monitoring and control (M&C) software which shall allow for graphical navigation between systems, graphical representations of systems, access to real-time data for systems, ability to override points in a system, access to all supervisory monitoring and control functions.

N. After becoming familiar with all details of the work, verify all dimensions in the field, and shall advise the Construction Manager of any discrepancy before performing any work.

O. The contract drawings will not indicate all offsets, fittings, and accessories that may be required. Investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall provide all work necessary to meet such conditions.

P. Provide all control wiring for fan and pump VFDs and motor starters. Verify all control wiring prior to startup to ensure no damage to equipment or personnel. Ensure all BAS safeties and interlocks are wired correctly. Add and remove jumpers across BAS terminals, as needed, when various options are not being utilized.

Q. Provide a letter of substantial completion indicating that all performance verification tests (PVTs) have been completed and the BAS is ready for 3rd party commissioning.

R. All writeable object properties, and all other programming parameters needed to comply with the project specification shall be adjustable for devices at any network level, including those accessible with web-browser communication, and regardless of programming methods used to create the applications.

S. The BAS shall be connected to the Owner's IT network, whereby the BAS shall transmit e-mail alarm messages to the Owner's employees. The BAS contractor shall provide all equipment and labor necessary to ensure a fully functional remote notification system, including but not limited to the following: coordinate the content of the alarm messages, which alarms require messaging, which employees require the e-mails, and all technical aspects.

T. BAS to refer to contract drawings G-300, G-301 and G-302 for listing of associated rooms that require security barriers. Refer to detail 10 on drawing M-808. Under no circumstances shall copper wire penetrate a SCIF wall boundary.

U. Provide an Executive Summary with Bid, describing the Contractors understanding and approach of the Security Barrier Plans design referred to on contract drawings G-300, G-301 and G-302, including separation of systems, distribution techniques and special installation requirements. Distinguish where copper and fiber optics will be used and distributed, along with major network switches.

1.5 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Furnish control valves, sensor wells, and flow meters to Section 23 23 13 - Hydronic Piping Systems for installation.

B. Furnish duct-mounted airflow stations to Section 23 31 13 for installation.

C. Furnish application specific controllers (ASC), damper actuators, and flow sensors to Section 23 36 00 - Air Terminal Units for factory installation on all terminal units.

D. Furnish application specific controllers (ASC), Section 23 82 39 – Fan Coil Units for factory installation.

1.6 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Provide control wiring in conduit to the variable frequency drive controllers furnished under Section 25 23 00 - Variable Frequency Drives and Controls and motor starters furnished under Section 26 24 19.

B. Install room temperature sensors and provide control wiring for all fan coil units.

C. Install room temperature sensors and provide control wiring for all fan filter units.

D. Install room temperature sensors and provide control wiring for all air curtains.

E. Provide wiring between the chiller control panel and the associated differential pressure switches.

F. Provide wiring for the cooling tower sensors and equipment shipped loose. E.g. vibration switch, sump heater, level controls, etc. Coordinate with Section 23 for details.

G. Provide all wiring for boiler sensors and equipment shipped loose. E.g. Flow switches, boiler control sensors, pump control wiring, etc. Coordinate with Section 23 for details.

H. Provide wiring for the high pressure water humidification system equipment shipped loose. Coordinate with Section 23 for details.

I. Install devices provided with CRAC units and provide control wiring to CRAC unit controllers.

J. Install devices provided with Fuel Oil System and provide control wiring to Fuel Oil System control panels.

1.7 BAS INTEGRATION

A. Integrate to the systems listed in this section. Provide all wiring and conduit, hardware and labor to successfully integrate. Provide graphic screens for all of the systems integrated to the BAS. The graphic screens shall depict the equipment and all of the software points available.
   1. All fan and pump VFDs. In addition to hard wired points, wire to the network interface card which shall be provided with the VFDs. The card shall be able to communicate: BACnet MS/TP, or the BAS manufacturer's recommended protocol. The protocol shall be coordinated with the VFD manufacturer prior to purchasing the VFDs. All software points within the VFD shall be visible to the BAS for monitoring. At a minimum the following points shall be available to monitor via the communication card:
      a. KWH output.
      b. HOA switch out of "auto" position.
      c. Drive fault.
      d. Speed Feedback.
   2. Building Lighting System as defined in Section 26 09 23. Integrate the lighting system into the BAS. The operator shall be able to view and control the entire lighting system from any BAS operator workstation. Provide all hardware, wiring, software configuration and labor necessary for integration. There shall be a dedicated BACnet interface per floor.
   3. Boiler system as defined in Section 23 52 16. Refer to contract drawings for interface requirements.
   4. Chilled water system as defined in Section 23 64 16. Refer to contract drawings for interface requirements.
   5. Cooling Tower system as defined in Section 23 65 13. Refer to contract drawings for interface requirements.
   6. High pressure water humidification system. Interface shall be through a BACnet connection.
   7. CRAC units. Refer to contract drawings for interface requirements.
   8. Fuel Oil System as defined in Section 23 12 00. Refer to contract drawings for interface requirements.

1.8 QUALIFICATIONS

A. The BAS system shall be designed, installed, commissioned and serviced by manufacturer-employed, factory-trained personnel and qualified sub-contractors. Manufacturer shall have an in-place support facility within 50 miles of the job site with technical staff, spare parts inventory, and necessary test and diagnostic equipment. Provide 800 number access to 24-hour support center, staffed with factory-trained personnel to assist in troubleshooting and problem resolution. Distributors or licensed installing contractors are not acceptable. Provide out-sourced products as specified.

B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of building Automation systems for this type of facility and shall be manufacturer's latest standard design that complies with the specification requirements.

C. BAS shall comply with UL 916 PAZX and other subsystem listings as applicable, and herein specified, and be so listed at the time of bid. All control systems used for smoke control shall be listed in accordance with UL 864, category UUKL for their intended purpose, and installed in accordance with the applicable building code(s) for the project.

D. All electronic equipment shall conform to the requirements of FCC Part 15, Section 15, and Governing Radio Frequency Electromagnetic Interference and be so labeled.

E. The BAS contractor shall be regularly engaged in the manufacturing, installing and maintaining of BAS systems with similar size and complexity to this project.

F. The BAS contractor shall have a minimum of ten years of demonstrated technical expertise with laboratory projects.

G. The Building Automation System manufacturer shall provide documentation supporting compliance with ISO 9002 (Model for Quality Assurance in Production, Installation, and Servicing). The intent of this requirement is to ensure that products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

H. All electrical components shall be UL listed or labeled.

I. All equipment or piping in conditioned air streams, spaces or return plenums shall comply with NFPA 90A flame/smoke/fuel contribution rating 25/50/0 and all applicable building code requirements.

J. All wiring and cabling shall conform to the National Electrical Code.

K. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.

L. Provide enclosure and control to comply with NEMA Publication No. 250 and Standards ICS 1, 2, 3, and 6.

M. The following are the minimum personnel qualifications for the specific individuals assigned to this project.
   1. The project manager shall have at least 10 years' experience in the role of project Automation.
   2. Application Engineers shall have at least 10 years' experience engineering building automation systems in critical environments.
   3. Programmers shall have at least 10 years' experience writing and troubleshooting programming code.
   4. Field Technicians shall have at least 5 years' experience.

1.9 SUBMITTALS

A. The following shall be submitted in accordance with Section 01 33 00.

B. Resubmitted Shop Drawings: Provide typed responses to all comments. All changes shall be clearly identified with revision clouds and revision numbers. If all changes are not clearly identified, the submittal package will be rejected without review.

C. Shop Drawings: Design drawings shall be submitted in hard copy and on CDROM in Revit 2017 (version to be defined at the end of the project). The tagging shall follow the site standard for the building. Submit shop drawings and product data as single complete submission, partial submissions will be rejected. Control valve, damper, user interface graphics and air flow measuring station schedules with product data may be submitted separately.
   1. System Architecture: Show location of the server, workstations, Programmable System Controller (PSC), Supervisory Controller (SC), Application Specific Controller (ASC), Lighting Control Panels (LCP), Network Controllers (NC), routers, repeaters auxiliary equipment, I/O device, panel and other major system component. Indicate all network interface devices (gateways, drivers, open communication modules).
   2. Instrument Index: For all systems, provide a complete list of all instruments and final control elements (valves/dampers) furnished. Provide instrument description, manufacturer, and model number.
      a. Instrument List shall have (as a minimum) the following categories:

1) Vendor Tag Number: Provide a unique tag number to identify each device. Owner will use this number as reference to generate Owner tag numbers, and to account for each device. The device number shall conform to the following format: AAA-XXXXX-AAA-N. "A" designates an alpha identifier. "X" designates an alphanumeric identifier. "N" designates a numeric identifier. The first field shall be associated with equipment. The second field will identify the unique equipment and shall be consistent with the contract documents. The third field of alpha codes is for the device type, followed by a sequential number. Example: AHU-1234-PSL-1.
2) Description of Instrument: Define devices function (e.g., differential pressure transmitter, room temperature sensor, photocell etc.).
3) Instrument Manufacturer/Model Number.
4) Equipment Cross Reference: Where applicable, list equipment the instrument is associated with (e.g. freezer, incubator, room number etc.).
5) Instrument accuracy.
6) Instrument range.
7) Instrument display (engineering units).

3. System Flow Diagrams: Show location of devices, interconnections, wire numbers, pneumatic tubing, junction boxes, computer I/O connections, bulkheads, grounding, and terminals.
   a. Include indication of control algorithms or logic used for each system in the sequence of operation. Provide logic tables where ever possible to easily communicate interlock or failure logic
   b. Prepare 11 IN by 17 IN drawings at a minimum.
   c. Provide a unique flow diagram for each HVAC and mechanical system. Typical drawings are not acceptable. Each drawing shall identify each instrument with a unique tag number.
   d. Provide typical drawings for terminal equipment accompanied by a schedule listing the unique equipment information.
4. Electrical Diagrams: Show all wires and terminations. All terminals shall be identified in the as-built drawings. Include starter and Variable Frequency Drive wiring diagrams depicting safeties and automated start/stop contacts. Indicate hardwired interlocks.
5. System Sequence of Operation: Provide for all equipment controlled or monitored by the BAS. Submit unique sequences for each system, typical sequences are not acceptable. The sequence shall include the unique point identifier for each point referenced in the system. The identifier shall be in the body of the sequence and listed whenever the instrument or device is mentioned. E.g., "The reheat valve (TCV-RMSH1234-1) shall modulate to maintain the room temperature (TT-RMSH1234-1) at setpoint". Submittal should identify any changes or exceptions to the project sequence of operations. Submit Request for Information (RFI) forms when clarification is required. Refer to Section 25 90 00 for the sequence of operations.
6. Control Valve Schedules: Include valve curves (flow versus percent open), service (e.g., hot/chilled/condenser water or steam), quantity, actuator type and model number, spring range (where applicable), sizes, capacity in GPM for water (lbs/hour for steam), CV of valve, actual pressure drop across valve in psi, failed position, shutoff ratings, and valve characteristics (equal percent or linear).
7. Damper Schedules: Include damper leakage rating, service (e.g., 2-position vs. modulating), quantity, system served, indicate parallel or opposed blade, actuator type, spring ranges (where applicable), quantity of actuators per damper, damper actuator torque rating, damper section sizes (width by height), and shutoff leakage ratings. Coordinate sizes with Section 23 31 00 prior to procurement.
8. Air Flow Measuring Station Schedules: Include air flow measuring station width, height, depth, velocity pressure at setpoint, minimum allowable velocity pressure to accurately read flow, and maximum allowable velocity pressure. Coordinate sizes with Section 23 31 00 prior to procurement. Instrument Mounting/Field Connection Diagrams: Include duct mounting details of sensor types to be used.

9. Panel Layout/Diagrams: Panel Layout/Diagrams including bill of material and mounting details for recessed, semi-recessed, surface mounted and free standing panels. Provide installation details and mounting requirements. For panels installed in finished areas, provide a detail showing how the panels are arranged on the finished wall. Panel design shall be approved prior to fabrication and installation.
10. User Interface Graphics: Provide custom graphics for each individual piece of mechanical equipment being controlled. Include graphics for lighting, when integrated with the BAS.
11. Symbols, Definition and Abbreviations: Symbols, definitions, and engineering unit abbreviations used in information displays, submittals and reports shall be as shown in the contract drawings. Symbols, definitions and abbreviations not in the contract drawings shall conform at a minimum to IEEE Std. 100 and the ASHRAE FUN IP, as applicable.
12. System Units and Accuracy: System displays, print-outs and calculations shall be performed in English (IN-LB) units. Calculations shall have accuracy equal to or exceeding sensor accuracy as specified in this Section. Displays and printouts shall have precision and resolution equal to or exceeding the worst case sensor accuracy as specified in this Section.
13. Special Warranties: Provide warranties for all 3rd party equipment purchased by the contractor. Including but not limited to: gas detection systems. The duration of all third party warranties shall meet or exceed the warranty period specified in this section.

D. Product Data: Include technical bulletins and catalog data for each control system component. Clearly identify, by use of symbol or tag number, service of each item. Clearly identify model number of the device including any device options. Each product data sheet shall clearly reference page and paragraph number of specification section to which it applies. Failure to comply with this requirement will result in automatic rejection without review.
1. Submit complete data on controllers, and instrumentation. Include signal type, signal characteristics and ranges, installation instructions, calibration data, typical alarm printouts, advisory messages, logging formats, and other pertinent data archive information available on the proposed system. Include all commercial software required for servers, bridges, work stations and controllers including latest version numbers.
2. All products, material, and equipment shall be listed, labeled, or certified by Underwriters' Laboratory.

E. Verification Reports: Submit sample forms to be used for installation and operational verification reports. Submit the proposed performance verification tests to the Owner for review and approval prior to the start of testing. Submit the final completed reports to the A/E and Owner. The testing reports include:
1. Static System Checkout Sheets, as specified herein.
2. Dynamic Performance Test Sheets, as specified herein.
3. NIST traceable instrument calibration reports for test instrumentation used by the contractor to execute the Static System Checkout.

F. Operation and Maintenance Manuals (O&M): At the end of the project submit two copies of the Operation and Maintenance Manuals, indexed and in booklet form shall be submitted. The requirements are specified in this section.

G. Training Documentation: At the conclusion of the training sessions, training manuals shall be delivered for each trainee on the course attendee list with 2 additional copies delivered for archival at the project site. Two copies of the course attendee list shall be delivered with the archival copies. The Training Documentation may be submitted as a Technical Data Package.

H. Bandwidth Calculations: Provide bandwidth usage calculations for a heavily loaded control network. Perform the bandwidth usage calculation for all control networks.

I. I/O Points List: Provide a complete point list, which lists both physical I/O and resident software points. The point list shall be submitted for review and comment during the design phase of the project. The point list shall also be updated to reflect the as-built BAS and submitted in the as-built package

J. Alarm Matrix: Coordinate with Owner to determine which point types shall be alarmed and the alarm parameters for each type. Provide a comprehensive matrix of all points within the scope of this project which shall be alarmed. The matrix shall include: point name, node address, point description, associated room number, range of sensor, high alarm limit, low alarm limit, set point, time delays, and whether or not the point alarms remain active when the associated HVAC equipment is de-energized. The matrix shall be reviewed and approved by the Owner prior to implementation. Alarms and events shall be capable of having programmed time delays and high-low limits.

1.10 SEQUENCING AND SCHEDULING

A. Follow Section 01 10 00 – Summary of Work.

B. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

C. Coordinate work under provisions of Division 01 to ensure system is complete and fully commissioned.

D. Coordinate installation of system components with installation of mechanical systems equipment.

1.11 SURGE PROTECTION

A. Power-Line Surge Protection: Equipment connected to AC circuits shall be protected against or withstand power-line surges. Equipment protection shall meet the requirements of IEEE C62.41.1. Fuses shall not be used for surge protection.

B. Surge Protection for Transmitter and Control Wiring:
   1. DDC hardware shall be protected against or withstand surges induced on control and transmitter wiring installed outdoors and as shown. The equipment protection shall be protected against the following two waveforms:
      a. A waveform with a 10-microsecond rise time, a 1,000-microsecond decay time and a peak current of 60 amps.
      b. A waveform with an 8-microsecond rise time, a 20-microsecond decay time and a peak current of 500 amperes.

C. Transient Surge Protection:
   1. Provide each controller and sensor with means of suppression of transients from inductive devices in system, capable of generating or sustaining transients.
   2. Provide the server and workstations with immunity from electrical sags, surges, transients, noise and outages with uninterruptable power supplies.

1.12 DELIVERY AND STORAGE

A. Products shall be stored with protection from the weather, humidity, and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.13 OPERATION AND MAINTENANCE (O&M) MANUALS

A. The BAS Operation and Maintenance Instructions shall include:
   1. As-built Instrument List as specified in the "Shop Drawings" paragraph above for each piece of control equipment.
   2. HVAC control system sequences of operation formatted as specified.
   3. Procedures for the HVAC system start-up, operation and shut-down including the manufacturers' supplied procedures for each piece of equipment, and procedures for the overall HVAC system.
   4. Final As-Built Drawings shall be submitted in hard copy and on a thumb drive in pdf format. Two copies of all the same documents listed in "Shop Drawings" paragraph above shall be submitted.

5. Qualified service organization list.
6. Provide completed verification reports as specified herein.
   a. All Static Performance Test Sheets, refer to the “Verification Tests” paragraph in this section for details.
   b. All Dynamic Performance Test Sheets, refer to the “Verification Tests” paragraph in this section for details.
   c. NIST traceable instrument reports for test instrumentation used by the contractor to execute the Static System Checkout.
7. Provide a recommended spare parts list, accompanied by unit pricing.
8. If any portion of the secondary control network is wireless, provide a test report indicating that all transceivers communicated successfully at the conclusion of performance verification testing.

1.14 MAINTENANCE AND SERVICE

A. Beginning at the point of beneficial use, provide 12 months' full maintenance service by skilled, competent employees of the system manufacturer. Perform inspection, testing, cleaning, and part or component replacement as specified and as required to maintain the warranty. Work includes providing necessary preventive and unscheduled maintenance and repairs to keep the BAS operating as specified. Work shall comply with manufacturer's recommendations and industry standards. Provide technical support via telephone during regular working hours.

B. Working Hours: Working hours are from 7:30 A.M. to 4:00 P.M. (coordinate with Owner) local time Mondays through Fridays except national holidays.

C. Preventative Maintenance: Include quarterly (two 8 hour days each) preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required to maintain specified or normal operation. Use only parts and supplies as used in manufacturer and installation of original equipment.

D. Service Call Reception:
   1. An Owner representative will advise the BAS contractor by phone or in person of all maintenance and service requests.
   2. The contractor shall have procedures for receiving and responding to service calls 24 hours per day, seven days a week, including weekends and holidays. A single telephone number shall be provided by the contractor for receipt of service calls during regular working hours. Service calls shall be considered received by the contractor at the time and date the telephone call is placed by the authorized Owner representative.
   3. The contractor shall separately record each service call request. The completed form shall include the serial number identifying the component involved, its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion.
   4. The contractor shall respond to each service call request within two working hours. The status of any item of work must be provided within four hours of the inquiry during regular working hours, and within 16 hours after regular working hours.

E. Service Call Work Warranty: Provide an unconditional warranty on service call work. The warranty shall include labor and material necessary to restore the equipment involved in the initial service call to a fully operable condition. In the event that the contractor’s service call work causes damage to additional equipment, the contractor shall be liable for labor and material to restore the system to full operation. The contractor response to service call warranty work shall be the same as required by the initial service call.

F. System Modifications: Provide recommendations for system modification in writing to the Owner. No system modifications shall be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected. The contractor shall make available to the Owner software updates for all software furnished under this specification during the life of this contract. There shall be at least one scheduled update near the end of the contract period, at which time the contractor shall make available the latest released version of all software provided under this specification, and shall install and commissioning it upon approval by the Owner.

G. Continuing Maintenance Service: Provide a continuing maintenance proposal from installer to Owner, in form of a standard yearly (or other period) maintenance agreement, starting on the date the initial warranty period concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.15 SYSTEM ACCURACY

A. Input Accuracy: Sensors, transmitters and DDC Hardware shall be selected, installed and configured such that the maximum end-to-end error (from the sensor to the server) in the point value is less than 150 percent of the maximum allowable error specified for the sensor or instrumentation.

B. Control Stability and Accuracy:
1. Room differential pressures for laboratories, and specialized areas: plus or minus 0.01 IN w.c.
2. Airflows for laboratories, and specialized areas: plus or minus 5 percent.
3. Airflows for air handlers (controlling airflow): plus or minus 5 percent.
4. Airflow for office spaces, mechanical areas, and electrical areas: plus or minus 10 percent.
5. Space (or exhaust duct) temperatures for laboratories, and specialized areas: plus or minus 1 DEGF.
6. Space temperatures for offices, mechanical areas, and electrical areas: plus or minus 2 DEGF.
7. Space humidity (when trim humidifiers are used): plus or minus 5 percent.
8. Duct static pressure for air handlers and exhaust systems (controlling static pressure): plus or minus 0.05 IN w.c.
9. Relief plenum static pressure for air handlers: plus or minus 0.01 IN w.c.
10. Fluid temperatures in Hydronic systems: plus or minus 2 DEGF.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Johnson Controls Inc. Metasys Series

2.2 SYSTEM REQUIREMENTS

A. General Description: PC-based BAS system using an Ethernet Local Area Network (LAN). The BAS system includes networked BAS control panels, controllers, PC-based system management workstations and PC-based servers. System shall employ a modular design to facilitate expansion in functionality and capacity; and provide Internet access with programmable password security. System shall employ strategically located stand-alone controllers. System shall be provided with a hardwired network so that building shall be able to be stand-alone without internet access.

B. The communication speeds between ASCs, PSCs, and SCs shall be sufficient to ensure that no degradation of system response time shall occur under any operating condition of the facility.

C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each PSC shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device. System shall employ strategically located stand-alone controllers which shall include an Uninterruptible Power Supply (UPS) in each enclosure.

D. Interface the new DDC system with the site's existing Johnson Controls server and operator workstation located in building 20 and software including graphic creation, scheduling, alarming, and trending. The existing Johnson Controls system shall be extended to include the new building automation equipment under the scope of work for this project. The BAS equipment under this project shall be monitored and controlled from the existing server. Graphics, software databases, and programming shall be updated on the existing system to incorporate the new BAS. Only a qualified Johnson Controls technician shall incorporate the new system into the existing server.

E. Provide a sufficient quantity of SCs, PSCs, and ASCs to meet the physical and software I/O point requirements shown on the contract drawings, specified herein, and to meet the sequence of operations in Sections 25 90 00. Each SC and PSC shall contain all input/output points necessary to provide control and monitoring of the connected system in accordance with the sequence of operation. Provide at least 20 percent spare points in each SC and PSC for future expansion. Spare points shall contain a combination of all point types. Spare points of only one type per panel are not acceptable. List quantity and type of spare points available per controller on the shop drawing submittal. Under no circumstance shall all input/output points in a controller be completely used.

F. System performance shall ensure that any alarm occurring at any ASC, PSC, or SC (provided under the scope of this project) is annunciated at all workstations and all alarm printers within 15 seconds under all operating conditions of the facility.

G. System performance shall ensure that any point commanded from any operator workstation, PSC, or SC (provided under the scope of this project) shall commence within 2 seconds under all operating conditions of the facility, with some form of acknowledgment provided at that time.

H. System performance shall ensure that a change in value, greater than the change of variable (COV) limit, of any point within the system (provided under the scope of this project) is updated on all open graphic screens at all workstations within 5 seconds under all operating conditions of the facility.

I. The SCs shall poll the software points connected to its respective secondary level network for trend data. At least one SC shall be provided for each secondary level network. The trend data shall remain in the RAM of the SC until the server retrieves the data. The time intervals between retrievals shall be governed by two factors. The time interval shall not be so short that the communication speed of the network is hindered in any way, but shall not be so long that an interruption in the network for more than 7 days will cause the data in the controller to overwrite trend data which has not been retrieved. Using the server to poll software points directly for trend data is unacceptable.

J. The BAS shall synchronize all DDC hardware, which has a real-time clock, at least once per day. Provide automatic daylight savings time corrections.

K. Provide engineered BAS networks. The network bandwidth usage under a heavily loaded condition shall not exceed 60 percent for either the primary level network or the secondary level networks.
   1. A heavily loaded primary level network is characterized as one performing the following activities simultaneously:
      a. Transmitting batches of trend data for every point in the building in response to polling requests at 15-minute intervals.

   b. Transmitting 500 point values to the server in response to polling requests at 5-second intervals.
   c. Transmitting 100 point override commands from the server to every SC or PSC at 10 second intervals.
2. Heavily loaded secondary level networks are characterized as ones performing the following activities simultaneously:
   a. Transmitting trend data for every point on the secondary level network to the supervisory controller in response to polling requests at 5-minute intervals.
   b. Transmitting every point value to the supervisory controller in response to polling requests at 5-second intervals.
   c. Transmitting 100 point override commands from the supervisory controller to the Application Specific Controllers at 10 second intervals.

L. All writeable object properties, and all other programming parameters needed to comply with the project specification shall be adjustable for devices at any network level, including those accessible with web-browser communication, and regardless of programming methods used to create the applications.

M. Provide web-based system graphics viewable on browsers compatible with MS Internet Explorer 11 or greater using an industry-standard file format such as HTML, BMP, JPEG, or GIF.

N. Under no circumstances shall any copper wire penetrate a Sensitive Compartmented Information Facility (SCIF) wall/boundary. It is acceptable to penetrate a SCIF wall/boundary with fiber optic cable. However, penetrations shall be minimized to the fullest extent possible. Any penetration shall be clearly identified in the BAS shop drawings.

O. Pertaining to the SSA/SCIF areas, all copper based communication networks shall reside entirely in locked control enclosures. Only fiber optic cables shall be used for routing communication outside locked control enclosures.

P. Coordinate BAS communication protocols which will be utilized on the building level network and the system control networks with the Owner and A/E at the time of bid. The Owner and A/E shall approve the communication protocol.

2.3 NETWORK ARCHITECTURE

A. The design of the BAS shall be integrated onto the existing Johnson Controls network all servers, operator workstations, supervisory controllers (SC), Programmable System Controllers (PSC), Application Specific Controllers (ASC) and protocol gateways. The network architecture shall consist of two levels: a primary level network which shall be an Ethernet based network as specified herein and a secondary level network which shall be a twisted-pair type network as specified herein.

B. Primary Level Network:
1. The workstations, server, SCs, PSCs (depending on the manufacturer), and IP Routers shall reside on industry standard Ethernet utilizing standard IP protocols, IEEE Std.. 802.3.
2. The PSCs and SCs shall be able to communicate global data across the network, including but not limited to: outdoor air temperature / humidity / CO2, economizer mode changeover, humidity control in spaces, and restart after power failure.
3. The primary level network shall allow the SCs, and PSCs to access any data from, or send control commands and alarm reports directly to, any other SC or PSC or combination of multiple SCs and PSCs on the network without dependence upon a central or intermediate processing device.
4. SCs and PSCs shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any SC or PSC to access, edit, modify, add, delete, back up, restore all system point database and all programs.

5. The Ethernet network shall provide speeds of at least 100 Mbps on the entire network using the IP protocol. The Bit Error Rate (BER) of the data communications components shall be no greater than one error in 10E9 for the entire network. The Network shall use the following protocols for layers 1 through 7 as defined in the ISO OSI Model (at a minimum):
   a. OSI Layer 1. The physical layer shall be in conformance with IEEE Std. 802.3 (Ethernet) and operate at least 100 megabits per second Mbps (100Base-T). Higher speed protocols may be used. If higher speed physical layers are used, bridging hardware shall be provided to ensure compatibility with 100 Mbps devices.
   b. OSI Layer 2. The data-link layer shall be the IEEE Std. 802.2 Logical Link Control (LLC), Type 1, Class 1, in combination with the IEEE Std. 802.3 Protocol.
   c. OSI Layer 3. The network layer shall be the Internet Protocol (IP; RFC 791), the Internet Control Message Protocol (ICMP; RFC 792), and the Address Resolution Protocol (ARP; RFC 826).
   d. OSI Layers 4 - 7. Network shall support all layer 4 protocols supported by IP (RFC 791) including but not limited to ICMP (RFC 792), IGMP (RFC 1112), TCP (RFC 793), UDP (RFC 768), IGP (RFC 1371, and GRE (RFC 2784).
6. BACnet Communication Protocol:
   a. Provide a BAS which communicates BACnet protocol via the IP Ethernet based primary level network.
   b. The BAS shall be in accordance with ANSI/ASHRAE 135-2008. Minimum system functionality must include: monitoring, commanding, and alarming for daily operator functions from any operator workstation.
   c. The system shall be open in that it is designed and installed such that the Owner is able to perform repair, replacement, upgrades, and expansions of the system without further dependence on the original hardware vendor.
   d. All control equipment which communicates on the primary level network shall be BACnet laboratories Tested (BTL) certified.
   e. Minimize the use of proprietary BACnet objects and properties.
   f. Conform to the BACnet Testing Lab's Device Implementation Guidelines.
   g. Provide BACnet objects, properties, and services required to support the application and supervisory monitoring and control functionality including: System start/stop and overrides, Scheduling, Alarming, and Trending.
   h. All devices shall have a Protocol Implementation Conformance Statement (PICS) that identifies all of the portions of BACnet that are implemented. The PICS shall be submitted in the shop drawing package.
   i. All devices shall have BACnet Interoperability Area and associated BACnet Interoperability Building Blocks (BIBBS). The BIBBS shall be submitted in the shop drawing package.

C. Secondary Level Network: The secondary level network is a lower tier network connected to SCs and IP routers. This level of communication shall support a family of ASCs. Provide a fully functional secondary level network. All ASCs shall successfully communicate on the secondary level network.

D. The use of ASCs to control AHUs, HRUs, large pieces of HVAC equipment, and mechanical systems is not acceptable.

E. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

F. Each segment of the secondary level network will have a maximum number of nodes which can be accommodated. No more than 90 percent of the nodes on any given segment shall be utilized.

G. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over any network is not acceptable.

1. BACnet Communication Protocol:
    a. Provide a BAS which communicates the BACnet MS/TP protocol via the EIA-485 based secondary level network.
    b. All cable characteristics and wiring lengths shall conform to the manufacturer's cable and wiring specifications.
    c. The network shall have no control devices connected to it.
    d. Provide and power all necessary BACnet MS/TP repeaters.

2.4 NETWORK HARDWARE

A. Ethernet Switch: Switches shall be IEEE Std. 802.3 bridges which shall function as the center of a distributed-star architecture and shall be "learning" bridges with spanning tree algorithms per IEEE Std. 802.1D. The switch shall support the connected media types and shall have a minimum of 150 percent the required ports and no fewer than 4 ports. One port shall be switch selectable as an uplink port. Provide switches which are consistent with the IT switches and in accordance with Division 27.

B. Fiber Optic Patch Panel: In the event that fiber optic cable is provided as an Ethernet backbone, the cable shall be terminated on both ends at a fiber optic patch panel.
    1. A fiber optic patch cable shall be provided to connect the fiber optic patch panel to the Ethernet switch.
    2. The fiber Optic Patch Panels shall be wall mountable and designed to provide termination facilities for up to 24 fibers.
    3. Unit shall also have capability to be equipped with spliced trays, six packs (for adapters), and blank panels for easy termination of the fiber bundles and tube cables.
    4. Fiber-optic terminating equipment shall provide for mounting of ST or SC connectors on an optical patch panel.
    5. Fiber-cable Automation and cable-routing hardware shall be provided by the Contractor to assure conformance to minimum fiber and cable bend radii.
    6. Connectors on the patch panel shall be ST or SC feed through.
    7. Access to both sides of the panel shall be provided by the Contractor.
    8. The patch panel for the connectors shall be mounted to facilitate rearrangement and identification.
    9. Each apparatus shall have cabling and connection instructions associated with it.

C. Fiber Optic Media Converter: Fiber Optic media converter shall provide media conversion between layer 1 copper and fiber media to support data rates equal to the greater of the physical layer or 100 Mbps as specified in IEEE Std. 802.3.

D. IP Router: Provide IP router network equipment. The routers shall be fully configurable for protocol types, security, and routing selection of sub-networks. The router shall meet all requirements of RFC 1812.

2.5 NETWORK CONTROLLERS (NC)

A. Controllers, General:
    1. Stand-alone, multi-tasking, multi-user, minimum 16 bit CUP-based controllers. Clock speed: 16.67 MHZ. Memory: minimum 6MB.
    2. NC shall communicate on the building upper tier (Ethernet) network and shall connect to and coordinate a maximum 96 lower tier device nodes on a 19.2 K baud highway. All operating parameter of lower tier devices shall be communicated to the network station. All operator accessible parameters such set point adjustments etc. shall be communicated to each lower tier device.
    3. NC shall support dial-out communications via industry standard modem.
    4. NC units in system shall be connected by a common database. Permit access to any NC on data highway from any location. Total system information shall be available simultaneously to all Supervisory Station at any point on data highway.

2.6 CONTROLLERS

A. Supervisory Controller (SC):

1. Provide supervisory controllers (SCs) which comply with the following requirements. The SC shall have two components. The first is a communication interface between the primary level network and secondary level network. The second is supervisory interface which manages the BAS point database. Provide one controller with either components integral if the controller is available from the BAS manufacturer, or two separate components in the same enclosure.
   a. Communication Interface: Shall be the primary system point of contact between the secondary level network and the primary level network through which all communication traffic to/from the two networks passes. Communication interface shall communicate at a minimum of 10/100 Mbps on the primary level network.
   b. Supervisory Interface: Shall manage alarm and trend data. Trend data shall be stored at the supervisory interface and uploaded to the server when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. Uploading trend samples directly from the control device to the server is unacceptable.
      1) All trend data shall be available for use in 3rd party personal computer software.
      2) Include a minimum of 24 MB of memory. Maintain all trending information in non-volatile memory or 72 hour battery backed RAM. Each unit shall have an accurate real time clock that can be synchronized.
      3) Any point, physical or calculated, may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored.
2. The Secondary level network shall be engineered to meet the following criteria:
   a. For specialized systems, assume 1/4 of all the points on the secondary level network are being trended at 5 minute intervals, after 7 days no trend data stored in the SC connected to the secondary level network shall be overwritten.
   b. For office systems, assume 1/8 of all the points on the secondary level network are being trended at 5 minute intervals, after 7 days no trend data stored in the SC connected to the secondary level network shall be overwritten.
3. If an SC is available from the BAS manufacturer which has I/O point capacity, the SC may be provided with point (I/O) capacity as defined in the (PSC) specification section. The SCs shall also comply with all of the requirements of the Programmable System Controller (PSC) if the SC is provided with I/O point capacity.

B. Programmable System Controller (PSC):

1. General Requirements:
   a. The PSC shall reside on either the Secondary level network backbone or the Primary level network. PSCs communicating on the Secondary level network backbone shall communicate at a minimum rate of 76 kilobits per second (Kbps). PSCs communicating on the Primary level network shall communicate at a minimum rate of 10/100 Megabits per second (Mbps). Regardless of which network the PSC resides, all PSCs shall successfully communicate to the server and workstations.
   b. Provide one PSC per air handling unit (AHU), and Mechanical system. Refer to contract drawings for which systems shall be controlled from PSCs.
   c. Include minimum 1 MB of memory. Maintain programming, and point database in non-volatile memory (EEPROM) or 72 hour battery backed RAM. Each unit shall have an accurate real time clock that can be synchronized.
   d. Permit readout of variables, override of control, modification of attributes and scheduling changes while printing messages, trends, reports or alarms.
   e. Each PSC shall contain analog inputs (AI), digital inputs (DI), analog outputs (AO), or digital outputs (DO).
   f. Incorporate LED status lights in PSC to indicate operational position of digital outputs (ON/OFF).

g. PSC shall count multiple pulse type inputs (kW meters, steam flow meters, water meters and similar inputs) and convert those pulse signals into engineered values for control and read-out.
h. A PID control loop algorithm shall provide accurate control of sensed variable.
i. Transmit messages to other units on communication network. Messages transmitted shall be positively acknowledged as received or negatively acknowledged as not received. Negative acknowledgements shall immediately force retransmission of message.

2. Controllers:
   a. Stand-alone, multi-tasking, multi-user, minimum 16 bit CPU-based controllers for all applications. All controllers shall provide for direct interface to industry standard sensors and input devices.
   b. Control Loop Scan Frequency: Less than one second.
3. Points:
   a. Input Types:
      1) RTD (100 or 1000 ohm platinum).
      2) Thermistors
      3) Contact open/closed.
      4) 4-20 mA.
      5) 3-15 psi.
      6) 0-12 V DC.
      7) Pulse accumulator.
   b. Output Types:
      1) 0-12 V DC.
      2) Pulse-width modulation.
      3) Maintained/momentary on/off.
      4) 4-20 mA.
      5) 3-15 psi.
4. Software:
   a. Provide integral software with required control algorithms and alarm routines.
   b. Permit programming of PSC database from: a laptop, PSCs on the primary level network, server, or any operator workstation.
   c. Each PSC shall perform normal control and energy management routines as defined by the operator.
   d. Normal Control Routines:
      1) Distributed digital control of system temperature, humidity, pressure and flow.
      2) Three mode PID (proportional, integral and derivative) control.
      3) Logging and alarm logic.
      4) Normal Power restoration sequential restart program.
      5) Stand-by Power sequential start program.
      6) Non-volatile control strategies.
      7) High and low limits with alarms for analog input/output points of each controlled variable.
      8) Adjustable on-off delays.
      9) Totalization of analog/digital values.
      10) Pulse totalization.
      11) Reset of receiver controller setpoints.
      12) Trend information and storage.
      13) Equipment Alternation
   e. Energy Management Routines:
      1) Time of day scheduling.
      2) Start/stop time optimization.
      3) Peak demand limiting.
      4) Economizer control.
      5) Enthalpy changeover.

6) Event initiated programs.
7) Lighting Control Time based occupied/unoccupied modes.

f. Execute temperature control functions within unit. Execute loop control via direct digital control algorithms. Allow user to customize control strategies, sequences of control, define control loop algorithms and choose optimum loop parameters for loop control. Control loops shall support full proportional, integral and derivative control applications.

g. Permit creation, modification or removal of control algorithms within an PSC, while operating and performing other control functions. Each control loop shall be user definable in terms of:
   1) Sensors/actuators as part of control strategy.
   2) Control mode.
   3) Gain.
   4) Control action.
   5) Sampling time.

h. Permit user to create customized control strategies based upon arithmetic, Boolean or time delay logic. Arithmetic functions shall permit simple relationships between variables (i.e. +, -, /, x) as well as more complex relationships (i.e. square root).

i. Data Sharing: PSCs shall share appropriate point information such that control sequences or control loops, executed at one unit, receive input signals from appropriate sensors connected to other units within network. When data highway fails or other PSCs malfunction, control loop shall continue to function using last value received from network.

j. Fail-Safe Operation:
   1) Provide self-diagnostics that continuously monitor operation of unit. Automatically report malfunction of controller, distributed slave module, or associated communication link. Display failure condition with time and date.
   2) Upon detection of a memory error, each processor shall correct error or halt to prevent erroneous operation. Report "halts" as an alarm on the BAS. Upon communication being reconnected, a "Return to Normal" message shall be generated at both locations.
   3) Upon power restoration after failure, provide automatic sequential restart of equipment based on current program time and program requirements without operator intervention. Provide prioritized restart of systems and equipment as defined on Contract Documents.
   4) A dedicated fail-safe relay in PSC controller shall change state on a hardware and/or software fault. Relay contacts shall be used to set a fixed fail-safe position for designated output controlled devices.

k. Alarm Management:
   1) Monitor and direct alarm information to operator devices. Each PSC shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network communications traffic, and prevent alarms from being lost. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point.
   2) Direct alarms to the server and workstations for annunciation or printout, as directed by Owner. Provide the ability to acknowledge alarms from any workstation, as allowed by operator security settings. Provide time and date of acknowledgment.

l. PSC shall provide high resolution sampling capability for verification of control loop performance. Operator initiated automatic and manual loop tuning algorithms shall be provided for operator selected PID control loops. Provide ability to view or print trend and tuning reports.

1) In automatic mode, controller shall perform a step response test with a minimum one-second resolution, evaluate trend data, calculate new PID gains and input these values into the selected loop.
2) For troubleshooting in manual mode, operator shall be able to select variables to override default values. Calculated PID gains shall then be reviewed before they are inserted into the selected loop.
3) Loop tuning shall be capable of being initiated either locally at PSC, from the server or any workstation. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

m. PSC shall automatically accumulate and store run-time hours for all major mechanical equipment (AHU's, EF's, Pumps, etc.).
n. If PSCs are provided to control critical rooms (as defined in the sequence of operation in Sections 25 90 00 and contract drawings and as shown on the contract drawings), not more than 4 rooms shall be controlled from a single PSC. All terminal units in a given room which are required to operate in concert to execute a control strategy defined in the sequence of operations shall not be controlled from multiple controllers.

5. Nameplates: Laminated plastic nameplates shall be provided for each PSC.

C. Application Specific Controller (ASC):
1. Controllers:
a. ASC shall operate as a standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. ASC shall be a microprocessor based, multi-tasking, real time digital control processor. ASC shall provide control of the terminal device independent of the manufacturer of the terminal device. ASC shall not be used to control AHUs, HRUs, or major pieces of mechanical equipment, such as: Cooling Towers, Preheat or Reheat systems, or Exhaust Fan systems.
b. Provide each ASC with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM and EPROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.
c. Controller shall be part of a secondary level network for interface to industry standard air terminal equipment.
d. Provide wiring terminals, input/output points, local communication and electrical power.
e. Processor shall be minimum 12 bit, with communication rate of 9600 baud or higher.
f. Input/Output System: Provide required input/output point types necessary to accomplish sequence of operation in Sections 25 90 00 and contract drawings and 25 90 10. Floating point control shall not be permitted for constant volume applications unless the manufacturer provides hardware and documentation that clearly states that the airflow rates will not change during the re-calibration or resync cycle. This documentation must be submitted with the shop drawing submittal.
g. The installed application shall be suitable for the piece of equipment and shall function as specified in the sequence of operations.
h. Assign and change setpoints and control parameters using a laptop or through manual commands at any operator workstation.
i. Provide operator with ability to remotely monitor or adjust controlled variables.
j. The BAS shall provide power to all ASCs via a power trunk. No more than 80 percent of the capacity of any given transformer shall be utilized.
k. ASCs installed on terminal units which re-calibrate daily by modulating the terminal unit damper shall re-calibrate in a staggered fashion. The ASCs shall be programmed to re-calibrate in 5 minute increments so that no more than one ASC, associated with a system, re-calibrates at the same time. The programming shall be stored in non-volatile EEPROM and EPROM, or minimum of 72-hour battery backup shall be provided, the programming shall not be lost in the event of a power failure or controller failure.

l. ASCs installed on terminal units serving critical areas (such as laboratories) shall not re-calibrate daily by modulating the damper or the reheat valve. Provide ASCs which re-calibrate without disrupting the airflow or temperature in the critical area. If the BAS manufacturer does not offer this option, the terminal units shall be controlled by a PSC which does not utilize floating damper of floating reheat valve control.

2. Air Velocity Transducer:
   a. Air velocity sensor (Pitot-tube or "Cross-flow"), provided by terminal unit manufacturer (Section 23 36 00), connects to differential pressure transmitter, and measures average differential pressure. This value is converted to airflow through a square root function.
   b. Measurement Range: 400 to 4000 feet per minute (FPM).
   c. Measurement Resolution: Plus or minus 16 FPM.
   d. Measurement Repeatability: Plus or minus 32 FPM.
   e. Measurement Accuracy: 400 to 4000 FPM: Plus or minus 5 percent of measured value.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

A. Provide a designated project manager who will be responsible for the following:
   1. Construct and maintain project schedule.
   2. On-site coordination with all applicable trades, subcontractors, and other integration vendors.
   3. Authorized to accept and execute orders or instructions from Owner.
   4. Attend project meetings as necessary to avoid conflicts and delays
   5. Make necessary field decisions relating to this scope of work
   6. Coordination/Single point of contact

3.2 CONTROL SYSTEM INSTALLATION

A. General Installation Requirements:
   1. The BAS shall be completely installed, tested and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The BAS installation shall provide clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. The BAS installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.
   2. The control equipment shall be installed in a control enclosure mounted on the terminal unit, adjacent to the terminal unit in an accessible location, or flush mounted in finished corridors. The contractor’s responsibilities include but are not limited to: all interconnecting wiring, all interconnecting tubing, factory calibration, all field wiring, all field tubing, and all linkage connections between the actuator and the terminal unit.

B. Installation:
   1. Install electronic control system Operation and Maintenance Manuals, programming guides, network configuration tools, control shop drawings, as-builts, commissioning documentation, warranty letter, sequence of operations, alarmed warranty countdown clock, etc. All devices shall be installed in accordance with manufacturer's recommendations and as specified and shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used. Spare thermowells shall be installed adjacent to each thermowell containing a sensor and as shown.

2. All devices and instruments located outdoors shall be provided in NEMA 4 enclosures. All equipment installed outdoors shall be rated for the full range of outdoor ambient conditions.
3. All wall mounted sensors and thermostats shall be mounted so as to be accessible in accordance with ADA Guidelines, unless otherwise noted on the contract drawings. Coordinate final locations of all wall mounted sensors/thermostats with the Owner prior to installation.
4. All valves installed outdoors shall be provided with NEMA 4 actuator housings and heaters if required by the manufacturer.
5. Mount the sensors for monitoring outdoor air conditions (e.g., outdoor temperature and humidity transmitters) in an instrument shelter, located on roof. Refer to the contract document MH-103D1 for location.
6. Where control devices are to be surface-mounted on components scheduled to be insulated, provide insulation between device and component to prevent condensation or heat transfer.
7. Verify location of room thermostats, room temperature/humidity sensors, duct temperature/humidity transmitters, airflow stations, static pressure probes, control panels, and other exposed control equipment with contract drawings before installation. Provide an insulated backplate for thermostats and wall mounted temperature sensors installed on exterior walls.
8. Mount low limit temperature detectors (freezestats) using flanges and element holders. Wire multiple contacts in series. Mount thermostats on full width and height support rack within custom air handling units. Properly isolate capillary tubing so there is no direct contact with any metal components.
9. Duct Penetrations: Where instruments penetrate ductwork, provide gaskets, flanges, and apply sealant to create an air tight seal.
   a. Set cover plate in a bed of sealant at perimeter. Final finish exterior of cover place with a bead of sealant.
10. All BAS junction box wall penetrations in gypsum wall board (GWB) within containment areas provide the following:
    a. Conform to all means and methods specified in Division 26.
    b. Provide a finished GWB zip strip bead around the entire perimeter of the wall opening. The zip bead is to be finished with GWB spackle, at exposed wall surface, to be flush with adjacent surface.
    c. Maintain a 1/4 IN joint between the zip bead framing and exterior perimeter of the junction box. The 1/4 IN gap is to be in filled with a backer rod material and a minimum of 1/4 IN deep sealant at the exterior surface of the gap. Final finish of sealant to be flush with junction box.
    d. The final location of all junction boxes are to be mounted so that the edge of the box is flush with the final GWB finish, to allow the cover plate to be installed flush to the final finish.
    e. Provide cover plates to extend past the sealed perimeter joint by a minimum of 1/4 IN.
    f. Set cover plate in a bed of sealant at perimeter. Final finish exterior of cover place with a bead of sealant.
11. All BAS junction box wall penetrations in concrete masonry units (CMU) within containment areas provide the following:
    a. Conform to all means and methods specified in Division 26.
    b. Set junction box flush with final CMU finish. Set junction box in bed of mortar and infill perimeter joint solid and flush with final finish of CMU.
    c. Set cover plate in a bed of sealant at perimeter. Final finish exterior of cover place with a bead of sealant.
12. Provide cover plates to extend past the sealed perimeter joint by a minimum of 1/4 IN.
13. Provide multi-section dampers with interconnecting hardware or jackshaft for unison operation when required.

14. Mount SCs and PSCs controlling large pieces of HVAC and mechanical equipment adjacent to associated equipment on vibration free walls or freestanding angle iron supports. Do not mount on AHU housing. Coordinate final location of all Controllers and Enclosures with all other trades prior to installation. Provide nametags for instruments and controls inside the control enclosure and identify associated system on face of the enclosure. Mount a laminated copy of panel As-Built drawing(s) inside each cabinet.
15. Coordinate control wiring and safety contacts required for motor control centers and VFD controllers with Division 26 and shown on electrical details. Wire safeties so that they will not be overridden when hand-off-auto (HOA) switches are in hand position.
16. Contractor shall be fully responsible for coordinating the following:
    a. All control panel and controller locations with other trades.
    b. Power distribution to all control panels and controllers from Junction Boxes, including all control transformers. Refer to the electrical drawings for locations of junction boxes.
    c. Quantity of power circuits with Electrical contractor.
    d. Interface control and communication wiring with third-party equipment supplied by other trades. This includes power and voltage coordination and preferred communication protocols.

C. Software Installation:
1. Install software as follows:
    a. Operating System (OS): Install the OS on each Server and Workstation and configure user names and passwords.
    b. Office Automation Software: Install the office automation software on each server and workstation.
    c. Monitoring and Control Software: Install the monitoring and control software as shown. The server version of the software shall be installed on server hardware, and client versions shall be installed on the workstations.

D. Report Generation: Contractor will configure a minimum of 5 reports for the Owner as listed below:
1. Air Handler status report.
2. Exhaust Fans status report.
3. Chiller Status report.
4. Boiler status report.
5. VAV status report.
6. Energy consumption report.
7. Space temperature, humidity, and airflow report.
8. Specialty equipment status report

E. Control Enclosure Installation:
1. Unitized cabinet type for each system under automatic control. Provide quantity of enclosures required to house all relays, transducers, solenoid valves, pneumatic devices and other interface controls. Mount temperature, humidity, airflow and pressure indicators, (or operator interface display with keypad), pressure gauges, pilot lights, pushbuttons and switches flush on cabinet panel face. Provide laminated nameplates for all devices utilizing tag name as submitted on shop drawings. Mechanically fasten nameplates to panel. Self-adhesive type nameplates are not acceptable.
2. Provide NEMA-1 general purpose enclosure for all applications where panel will be installed indoors. Any control panel for use in wash-down locations or installed outdoors shall be rated NEMA-4. Enclosures installed outdoors shall be provided with heating or cooling to meet the operating temperature requirements of the equipment within the enclosure. All cabinets shall use a common key. Provide means of storing control system instructions and drawings inside cabinet.
3. Provide surface mounted or freestanding, steel supported types for mechanical equipment rooms. Provide fully recessed wall-mounted types elsewhere.

4. Interior arrangement of control enclosure components shall be such that tubing and wire raceways shall be separated and aligned horizontally and vertically, in a fashion that allows for an organized appearance and a practical means for the tubing/wire to exit the raceway to its intended component.
5. All tubing shall enter the enclosure through standard bulkhead compression fittings. All tubing lines shall be labeled using "Brady" markers or similar at both ends of the tubing.
6. All wire shall enter the enclosure via conduit fittings. All wires shall terminate on terminal blocks and then continue from the terminal block to the device. Direct connection to the device is not permitted. Use of wire nuts is not permitted, except in applications in which a control device is provided from the factory with "pigtails". All wires shall be labeled using "Brady" markers or similar at both ends of the terminal blocks.
7. Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.
8. Each enclosure shall include a convenience duplex receptacle, a circuit breaker, and a local disconnect.
9. Contractor is fully responsible for coordinating all panel locations with all other trades and Owner prior to installation. The A/E will not approve panel locations.

F. Provide a letter of substantial completion indicating that all performance verification tests (PVTs) have been completed and the BAS is ready for 3rd party commissioning. If the project schedule dictates, the contractor may provide a letter for each area once complete, e.g. if the BAS is complete for a given area and ready for commissioning, a letter can be provided for that area specifically. The letter(s) shall be accompanied by completed performance verification test forms specified in this section for the area which is complete. The letter shall be signed by an officer of the company and shall be notarized.

3.3 LEED- CI, NC, EB, CS CERTIFICATION SUPPORT

A. The Owner intends to pursue LEED certification for this project.

B. The design incorporates the BAS equipment and sequence of operations required to meet the LEED points the project is pursuing, however the contractor shall provide additional labor to support the document perpetration, data retrieval from the BAS, and BAS manipulation to fulfill these requirements. The contractor shall coordinate with the "LEED Project Administrator" and the Owner for specific requirements for each credit. The contractor shall support the project team in attaining the following credits:
1. EA Prerequisite 1 – Fundamental Commissioning of the Building Energy System.
2. EA Prerequisite 2 – Minimize Energy Performance.
3. EA Credit 1.3 – Optimize Energy Performance - HVAC.
4. EA Credit 3 – Enhanced Commissioning.
5. EA Credit 5 – Measurement & Verification.
6. IEQ Prerequisite 1 – Minimum IAQ Performance.
7. IEQ Credit 1 – Outdoor Air Delivery Monitoring.
8. IEQ Credit 2 – Increased Ventilation.
9. IEQ Credits 3.1 & 3.2 – Construction IAQ Management Plan – During Construction and Before Occupancy.
10. IEQ Credit 6.2 – Controllability of Systems, Thermal Comfort.
11. IEQ Credit 7.1 – Thermal Comfort, Design.
12. IEQ Credit 7.2 – Thermal Comfort - Verification.
13. ID Credit 1.1 – Innovation in Design.

3.4 WIRING INSTALLATION

A. Standard Wire and Cable:
   1. Wire and Cable shall be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Refer to Section 26 05 05 for means, methods and materials. Instrumentation grounding shall be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Ground rods installed by the contractor shall be tested as specified in IEEE Std. 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings. Wiring external to enclosures shall be run as follows:
      a. Wiring other than low-voltage control and low-voltage network wiring shall be installed in raceways.
      b. Low-voltage control and low-voltage network wiring not in suspended ceilings over occupied spaces shall be installed in raceways, except that nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.
      c. Low-voltage control and low-voltage network wiring in suspended ceilings over occupied spaces shall be installed in raceways, except:
         1) Nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.
         2) Plenum rated cable in suspended ceilings over occupied spaces may be run without raceways.
      d. Per NEC Article 725 (excluding thermocouple wiring). Control or signal circuits not run entirely in conduit, in areas classified as plenum space and vertical shafts shall be energized from listed Class 2 power supplies and shall be installed in Type "CL2P" listed plenum cable exclusively. Plenum rated cable shall be permitted in applications above an accessible ceiling or in between drywall where there is no insulation.
      e. For Hazardous location circuits, refer to NFPA Article 500 for installation requirements.
   2. All wiring in plenums and above a suspended ceiling shall be secured to the structure and routed through J-hooks. Under no circumstances may the cabling be laid upon the top of a suspended ceiling.

B. Control Wiring for Digital/Analog Signals: Provide the manufacturer recommended wire type for all analog and digital control signals. Control Wiring for Analog Signals shall be copper, single or multiple-twisted, minimum 2 IN lay of twist, 100 percent shielded pairs (as required), and shall have a 300-volt insulation. If shielding is required by the manufacturer, the cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall tinned-copper cable drain wire, and overall cable insulation. Acceptable Manufacturers: Anixter or Belden. Substitutions require approval prior to installation.

C. Wiring for 120-Volt Circuits: Division 26 shall provide junction boxes at locations shown on the power drawings. Extend power to all control equipment from the junction boxes. Provide emergency power to all controllers, devices, and instruments. Wiring for 120-volt circuits shall be 14 AWG or thicker stranded copper and shall be rated for 600-volt service.

D. Primary Level Network Wiring Specification:
   1. Provide all cables, switches, and signal repeaters to ensure a fully functional Ethernet network.
   2. Design the network to accommodate all of the PSCs, SCs, Ethernet gateways, and workstations/servers provided for the BAS system. The appropriate quantity of switches and signal repeaters shall be provided to meet the network requirements; the locations shall be coordinated with the A/E and other trades. Provide 120VAC to all network equipment. If any portion of the BAS is on UPS, than all network hardware shall be UPS powered.

3. Interior LAN Copper Cable: Interior Copper LAN cable shall meet or exceed all requirements of Category 6 cable as specified in TIA/CEA-568-B.1. Terminations, patch panels, and other hardware shall meet or exceed Category 6 specifications and shall be as specified in Division 27. Cabling products shall be tested and certified for use at data speeds up to at least 100 Mbps. Other types of media commonly used within IEEE Std. 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with media. Short lengths of media and transceivers may be used in these applications. Provide separately orderable media, taps and connectors.
4. Coordinate: node names, IP addresses, access privileges, and system configuration with the Owner prior to start-up.
5. Provide modular 8-pin, Category 6 information outlets at all controllers communicating on the primary level network. The cable shall be terminated inside the field panel at the information outlet. A patch cable shall be provided to connect the field panel to the information outlet.
6. Ethernet cable shall be provided to connect the operator workstation/server to each PSC. The Ethernet network shall meet the following criteria:
    a. Do not exceed 100 meters (328 ft) from the PSC to the nearest hub, router, switch, or signal repeater. This shall include the length of the patch cable between the information outlet and the PSC.
    b. All new Ethernet networks shall be a minimum of Category 6 certified 1Mb Base-T Ethernet cable, for future expansion.
    c. Use plenum-certified Ethernet cable when run through a plenum.
    d. Ethernet cable shall only be buried in an insulated electrical tunnel. Ethernet wiring is not certified for direct burial.

E. Secondary Level Control Network:
1. Provide all wires, and network equipment to ensure a fully functional secondary network.
2. All cable characteristics and wiring lengths shall conform to the manufacturer’s cable and wiring specifications.

3.5 CONTROLLER INTEGRATION TO EXISTING BAS NETWORK

A. Confirm there are no duplicate software point names between the existing BAS and new BAS. Confirm no node names or addresses are duplicated. Confirm that the existing BAS is 100 percent compatible with the new BAS. Take corrective action to resolve all potential problems with the integration process prior to physically connecting the two systems together and coordinate any shutdown activities with the end user.

B. Once the new BAS is commissioned, the contractor shall assist the owner’s representative to make the physical connection to the existing network.

C. Once the tie-in is complete, confirm communication with the existing server.

D. Upload all data to the existing server. Preferably upload one controller at a time until all controller information is uploaded to the existing server.

E. Verify there were no anomalies created during the integration process and that no new alarms or failed points were created. If so, take corrective action to resolve issues.

F. Create graphics, trends, alarm definitions and reports as specified herein.

3.6 CONTROLLER TUNING

A. Tune each controller in a manner consistent with that described in the ASHRAE Fundamentals Handbook. Tuning shall consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop shall be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable shall settle out at the new setpoint with no more than two (2) oscillations above and below set point. Upon settling out at the new set point the controller output shall be steady.

3.7 TESTING AND BALANCING SUPPORT

A. Provide 40 hours of dedicated labor to support and verify work performed by the testing and balancing (TAB) contractor. Provide interface software to the TAB, so that the TAB can access and manipulate the air flow values of all DDC hardware provided for this project.

B. Provide a trend report, by each AHU/EF system, listing all the supply and exhaust air valve airflows. Include the air valve set points and output position signals. Trends shall be provided per area/floor summarizing the airflow quantities to assist the building TAB contractor in determining any duct leakage or the building peak zone static pressure requirements.

C. Assist TAB contractor to perform system pressure mapping to identify pressure reading used to determine system static set points. Assist TAB contractor to make adjustments with balancing devices in distribution systems to provide uniform static pressure profile. Terminal boxes/valves, etc. will not be allowed to be used as pressure reducing devices.

3.8 VERIFICATION TEST

A. Perform the following performance verification tests (PVT) for each control system to ensure that the described control system components are installed and functioning per this specification.

B. Verification test procedures, testing and activities shall be developed and conducted so as not to cause personal injury, damage to components, damage to systems, or damage the building or other property.

C. General Requirements:
   1. Intent of the PVT procedure is to demonstrate that the exact functions of control systems meet requirements outlined by approved shop drawings and written Sequence of Operation.
   2. Verify each air handling unit, equipment system, steam and hydronic system in automatic mode of operation, utilizing actual field devices and final control elements. Tune each control loop.
   3. Indicate type and cause of failures, as well as required remedial actions, on test report. Requested tests, not outlined herein, will be evaluated for feasibility and impact on schedule and cost prior to implementation.
   4. Systems will not be accepted by the Owner or A/E without approval of tests and required remedial action.
   5. Provide a schedule to the Owner for execution of the PVT. The Owner shall participate in any or all of the contractor's PVT at the Owner's discretion.

D. Control System Static Check:
   1. Prior to static check of system, identify each SC, PSC, and ASC by description, tag number, and address. Verify proper system communication with these devices, as well as values indicated.
   2. Operational static check shall include verification of all field wiring associated with SCs, PSCs, and ASCs. Include continuity testing between wiring from field device (sensor, actuator, or other components) to appropriate block on terminal strip in appropriate enclosure. Verify control loop wiring diagrams and panel wiring diagrams for the following:

a. Digital Inputs: Energize each digital input (smoke detector, end switch, control relay, flow switch, differential pressure switch, or other components) in field. Verify at panel.
b. Digital Outputs: Force on each digital output (solenoid valve, motor starter, control relay, or other components) at control panel. Field verify corresponding final element for proper stroke/status.
c. Analog Inputs: Compare field reading of each analog input (transmitters, thermistor, or other components) with that displayed on graphic screens, and auxiliary panels.
d. Analog Outputs: Force each analog output (I/P) to values of 0 percent, 25 percent, 50 percent, 75 percent and 100 percent. Field verify corresponding final element (valve or damper) positions from fully closed to open, based upon stated spring range.

3. Calibration of Test Instruments: Use calibrated test instruments for all point checks as specified herein. The calibration of the test instruments shall be traceable to the National Institute of Standards and Technology (NIST) standards. A static system checkout shall be performed on a BAS instrument if the date of the test instrument calibration is within one year of the date of the check. Recalibrate test instruments annually and submit the NIST traceable instrument reports along with the static system checkout sheets.

E. Control System Dynamic Check:

1. Operational dynamic check shall include verification that control system, including sensors and actuators, performed as specified while interconnected to the process.
2. Verify proper system communication with controllers and the ability to reset setpoints remotely from operator workstations.
3. Verify the operation of each air handling unit, equipment system, and hydronic systems in automatic.
4. Test: system failures, start-up sequences for air handling units, exhaust fans, and Hydronic systems. Verify warnings and fail to start logic. Simulate power failure and restart software for controlled equipment and systems.
5. Verify and demonstrate that operator workstation interface graphic screens are displayed consistent with the drawings. Verify the status of each digital and analog value on every graphic screen is consistent with expected color convention and actual field device reading. Use only graphic screens accepted by the A/E and Owner.
6. Test each control loop to verify that it indicates proper percent of scale and correct scaling of engineering units.
7. Verify stability of all control loops. Record and print graphical trends for each control loop to verify loop stability is within specified limits. Each trend shall be in 2 minute increments for no less than 12 hours.

F. Performance Reports:

1. Provide static system checkout sheets which lists every physical point in the BAS in a tabular format. The list shall include the following fields: unique point identifier, software address, associated PSC or SC, associated room number (where applicable), check column indicating ID tag affixed and information is correct, actual value, initials of person performing verification, and date verification was completed successfully. The actual value is sensed by a testing instrument (for analog points) and visual indication (for digital points).
2. Submit Dynamic Performance Test Sheets indicating operating conditions after detailed dynamic checkout of the systems. The dynamic performance test sheets shall represent the contractor's sequence of operations. Each paragraph shall be tested, upon successful completion of the dynamic test the person performing verification shall initial and date verification test form adjacent to the paragraph tested. Once all of the sequences are tested, the test sheets shall be submitted for record.

G. Alarms:

1. Test each alarm identified in the contract documents. Verify that control system displays proper indication. Test and verify proper acknowledgement of alarms from operator workstation.

3.9 TRAINING

A. Provide system demonstration and instructions under provisions of Section 01 75 00 – Starting and Adjusting.

B. For each system, demonstrate:
   1. Cold start.
   2. Sequence of operation.
   3. Seasonal control.

C. Provide complete demonstration of equipment or systems requiring seasonal operation, during operating season. Perform multiple demonstrations when required within six months.

D. Provide an additional 8 hours of training on-site, within one year of Owner acceptance of BAS installation. Scheduling will be at discretion of Owner; training days may not be consecutive.

E. Provide experienced instructor(s) to teach Owner's personnel operation, adjustment, testing, trouble shooting and maintenance of the system. Include detailed instruction manuals which contain any operations specific to this project.

F. Videotape demonstrations and instructional sessions. Provide one copy of each videotape to Owner.

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SECTION 25 23 00
VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Variable Frequency Drives, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Manufacturer shall have a minimum of seven (7) years in manufacture and operation of PWM drives in size indicated.

B. UL and or Electrical Testing Laboratories listed and labeled.

C. Tested to ANSI/UL-508A.

D. Plenum rated applications: Tested to ANSI/UL-508C.

E. Meet requirements of IEEE Standard 519, latest edition, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters".

F. Local service representative's qualifications:
  1. Provide and maintain field service personnel authorized by Manufacturer to perform service both in and out of warranty.
  2. Maintain full stock of service parts for all units furnished.
  3. Provide in-depth training in operation of all units.

G. Manufacturers to ISO 9000 certified.

1.3 SUBMITTALS

A. Shop Drawings: For each VFD
  1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
     a. Each installed unit's type and details.
     b. Nameplate legends.
     c. Short circuit current rating of integrated unit.
     d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
  2. Wiring Diagrams: Power, signal, and control wiring for VFD. Provide schematic wiring diagram for each type of VFD. Clearly identify all terminal blocks for interface with Section 25 10 00.

B. Product Data: For each type of VFD. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

C. Project Information:
  1. Factory test reports.
  2. Certificates: Burn in time and factory performance tests for drives.
  3. Start-Up Report.
  4. Demonstration and Instruction Statement from Owner.
  5. Operation and Maintenance Data submitted to Owner prior to equipment delivery.

6. Special Warranty: Provide five year manufacturer's warranty on entire package from day of start-up. Include all materials, parts and labor.
7. Technical drawings, programming and codes as required by Owner.

D. Harmonic Analysis:
1. A harmonic distortion analysis shall be performed and priced as a separate line item by the AC Drive manufacturer based upon documentation supplied by the Contractor. The documentation shall consist of one-line diagrams with feeder lengths, distribution transformer information (kVA, ad X/R ratio and emergency standby generator performance specifications. The harmonic distortion analysis report shall be part of the approved drawing process, submitted to the Engineer for approval.
2. If the calculations determine that harmonic distortion values are higher than the voltage and current values specified, the drive manufacturer shall provide additional components such as isolation transformers, or harmonic suppressors to meet the intent of IEEE 519-1992 guidelines.
3. The contractor and drive manufacturer shall perform the harmonic analysis on those components installed as part of this project. The following will be defined as points of common coupling for the purpose of harmonic analysis; when supplied from the utility source and when operating on the on-site standby generator.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.5 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Spare Fuses: Furnish set of three of each type and rating.
2. Indicating Lights: Two of each type installed.

1.6 SYSTEM DESCRIPTION

A. Variable speed drives for each piece of equipment as scheduled.

B. Control signals from BAS (Section 25 10 00) to each variable speed drive shall automatically sequence units and modulate speed in response to system dynamics.

C. Components and accessories as required for BAS interface and control per Section 25 10 00 and the Contract Drawings for a complete and operable system.

1.7 CONTRACT CLOSEOUT INFORMATION

A. Operation and Maintenance Data.

B. Owner instruction report.

C. Factory start-up and field test reports.

D. Warranty.

1.8 WARRANTY

A. Warranty:
1. 12 months from date of startup, not to exceed 18 months from date of shipment.
   a. Include all parts, labor, travel time and expenses.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Variable Frequency Drives:
   1. Base:
      a. Asea Brown Boveri.
   2. Optional:
      a. Allen-Bradley.

B. Fuses:
   1. Base:
      a. Bussmann.
      b. Shawmut.
      c. Rockwell Automation.

2.2 MATERIALS

A. General:
   1. Variable frequency drives (VFD): Provided with full wave inverters (rectifiers) to convert three-phase, 60 Hz AC power to DC power, and inverters to "invert" DC power back to a variable frequency, three-phase AC power.
      a. Line side input terminals: 60 Hz AC, 3-phase, fused and provided by VFD manufacturer.
         1) Provide fast-acting semiconductor type, Class T, fuses, 200,000 AIC RMS.
   2. Inverter section:
      a. Pulse width modulated voltage source inverter (PWM).
      b. Variable voltage and variable frequency using insulated gate bipolar transistors (IGBT).
   3. Convert section:
      a. Full wave diode bridge rectifier or SCR type rectifier.
      b. SCR type units shall not be phase controlled.
   4. DC bus linking converter and inverter.
   5. General requirement for variable frequency drives:
      a. Variable frequency in proportion to output speed.
      b. Variable output voltage with constant volts/Hz over a variable torque output range.
      c. Supply full rated current at frequency within a variable torque output range.
      d. Develop full shaft power needed.
   6. Verify variable frequency drives are checked against each motor's total amperage.
   7. Total harmonic distortion on voltage waveform: Not to exceed 5 PCT per IEEE 519 at point of common coupling.
   8. Drives shall have RFI/EMI filters.
   9. Minimum output frequency at full rated output amperage: 4 kHz.
   10. Drive to be seismic rated.
   11. The drive shall provide single-phase motor protection.

B. Variable Frequency Drives (VFD's):
   1. Variable frequency drives (VFD's): Solid state, with a pulse width modulated (PWM) output waveform.
      a. VVI, six-step, and current source drives are not acceptable.
      b. Enclosures:
         1) As a minimum, the following closure types are to be used unless noted otherwise on plans:
            a) General purpose such as locations within mechanical rooms: NEMA 1.
            b) Outdoors: NEMA 3R.

2) Use the following closure types where specifically indicated on plans:
   a) Dusty or corrosive atmospheres: NEMA 12 or better; sealed, non-ventilated, airtight.
   b) High ambient temperature environments: NEMA 12 enclosure with air conditioner option.
3) Enclosure, including accessories, to be completely assembled and tested or all components provided in a single factory supplied racking system with components and accessories assembled, wired and factory tested.

c. Employ full wave rectifier designed to prevent line notching.
   1) Drives 7.5 hp and greater:
      a) Provide AC line or DC bus reactors.
         (1) Minimum impedance: 5 PCT impedance.
   2) GTO's are not acceptable.
d. Drive efficiency: 97 PCT or greater at full speed and full load.
e. Displacement power factor: 0.98 at all speeds and loads.

2. Printed circuit boards:
   a. Tested and burned-in before assembly in completed variable frequency drive.
   b. Subject variable frequency drive to a preliminary functional test, eight hour burn-in, and computerized final test.
   c. Burn-in shall be at 104 DEGF, at full rated load, or cycled load.
   d. Drive input power: Continuously cycled for maximum stress and thermal variation.
3. Environmental operating conditions:
   a. 32 to 104 DEGF at 4kHz switching frequency.
   b. 0 to 3300 FT above sea level, less than 95 PCT humidity, non-condensing.
   c. Atmosphere: Standard equipment room environment.
4. Additional requirements:
   a. Provide same control interface and connections regardless of horsepower rating.
   b. On loss of input signal:
      1) Display a fault condition.
      2) Maintain last output speed prior to loss of signal.
   c. Utilize digital display (LCD or LED).
   d. Automatically restart after an overcurrent, overvoltage, under-voltage, loss of input signal protective trip or any other fault.
      1) Number of restart attempts and trial time to be programmable.
   e. Capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage.
   f. Provide an automatic extended power loss ride-through circuit which will utilize inertia of load to keep drive powered.
      1) Minimum power loss ride-through: One-cycle or extended time.
   g. Control terminal strip: Isolated from line and ground.
   h. Provide prewired 3-position Hand-Off-Auto switch, manual speed adjustment (keypad or potentiometer) and local-remote switch to control VFD.
      1) When in "Hand" position, VFD will be started.
      2) When in "Off" position, VFD will be stopped.
      3) When in "Auto" position, VFD will start via an external contact closure.
      4) When local-remote switch is in "Local" position, speed will be controlled by manual speed.
      5) When local-remote switch is in "Remote" position, speed will be controlled by external speed reference.
      6) Operate local-remote switch independently of HOA switch for maximum flexibility.
         a) Control speed by manual speed adjustment or external speed reference by selecting "Local" or "Remote" regardless of whether HOA is in "Hand" or "Auto" position.

5. Provide following adjustments:
   a. A minimum of 3 critical frequency lockout ranges to prevent variable frequency drive from continuously operating at an unstable speed.
      1) Width of each frequency range: Field adjustable.
   b. Two programmable analog inputs: Accept a current or voltage signal for speed reference, or for reference and actual signals for PI controller.
      1) Minimum and maximum values (gain and offset): Adjustable within range of 0-20 mA and 0-10 Volts.
   c. Programmable analog outputs: Proportional to frequency, motor speed, output voltage, output current, motor torque, motor power, or DC bus voltage.
   d. Relay outputs:
      1) Rated for maximum switching current 8 amps at 24 VDC and 0.4 amps at 250 VAC; Maximum voltage 300 VDC and 250 VAC; Continuous current rating 2 amps RMS.
   e. Independently adjustable accelerate and decelerate rates (1-600 seconds).
   f. Ramp or coast to a stop, as selected by user.
6. Operational information display will list the following as a minimum:
   a. Output Frequency.
   b. Motor current.
   c. Output voltage.
7. Protection circuits: In case of a protective trip, stop drive and display fault condition.
   a. Overcurrent trip: 200 PCT of VFD's variable torque current rating.
   b. Overvoltage trip: 130 PCT of VFD's rated voltage.
   c. Undervoltage trip: 60 PCT of VFD's rated voltage.
   d. Overtemperature: Plus 158 DEGF.
   e. Adaptable electronic motor overload protection:
      1) Protect motor based on speed, load curve, and external fan parameter.
      2) Circuits which are not speed dependent are unacceptable.
8. Speed command input:
   a. Keypad or manual speed potentiometer.
   b. Analog inputs: Each capable of accepting a 0-20 mA 4-20 mA, 0-10 V, 2-10 V signal.
      a) Input: Isolated from ground, and programmable via keypad for different uses.
      b) Provide programmable filter to remove any oscillation of the reference signal.
      c) Able to be inverted, so that minimum reference corresponds to maximum speed, and maximum reference corresponds to minimum speed.
      d) Minimum and maximum values (gain and offset): Adjustable within range of 0-20 mA and 0-10 Volts.
9. Accessories:
   a. Interlock terminal strip:
      1) Provide separate terminal strip for connection of freeze, fire, smoke contacts, and external start command.
      2) External interlocks and start/stop contacts: Remain fully functional whether drive is in Hand or Auto.
   b. All wires to be individually numbered at both ends for ease of troubleshooting.
   c. Door interlocked magnetic circuit breaker: Disconnect all input power from drive and all internally mounted options.
      1) Disconnect handle: Thru-the-door type, padlockable in "Off" position.
   d. The VFD shall be supplied with BACnet/RS-485 interface and integration card compatible with Building Automation System.
      1) Coordinate with Section 25 10 00.

C. Factory startup test:
   1. Provide a certified factory start-up for each drive by factory authorized service center.
      a. Certified start-up form: Filled out for each drive with a copy provided to Owner, and a copy kept on file at Manufacturer.

2.3 BUILDING AUTOMATION SYSTEM (BAS) AND CONTROL INTERFACE

A. All connections to be by a quick disconnect, removable control I/O terminal block to simplify control wiring procedures.

B. VFD shall include two independent analog inputs. One shall be 0-10 VDC. The other shall be programmable for either 0-10 VDC or 4-20 mA. Either input shall respond to a programmable bias and gain.

C. VFD shall include a minimum of seven multi-function digital input terminals, capable of being programmed to determine the function on a change of state. These terminals shall provide up to 30 functions, including but not limited to:
   1. Remote/local operation selection.
   2. Detection of external fault condition.
   3. Remote reset.
   4. Multi-step speed commands.
   5. Run permissive.

D. VFD shall include two 0-10 VDC analog output for monitoring, or "speed tracking" the VFD. The analog output signal will be proportional to output frequency, output current, output power, PID (Proportional, Integral, Derivative control) feedback or DC bus voltage.

E. VFD shall provide terminals for remote input contact closure to allow starting in the automatic mode.

F. VFD shall include at least one external fault input, which shall be programmable for a normally open or normally closed contact. These terminals can be used for connection of firestats, freezestats, high pressure limits or similar safety devices. Design unit so that hen operating in hand position, any actuated safety device will disable unit.

G. VFD shall include two form "A" contacts and one form "C" contact capable of being programmed to determine conditions that must be met in order for them to change state. These output relay contacts shall be rated for at least 1A at 250 VAC. One set of contacts shall be programmed to transfer upon any of the following conditions:
   1. Missing frequency reference detection.
   2. Loss of load.
   3. Drive faulted.

H. Contacts wired to shut down unit on signal from remote disconnect.

I. Provide two terminals for isolation damper interlock. The VFD shall close the contacts once the VFD is enabled via the HOA switch or BAS. The contacts shall be rated to handle a 120VAC at 100VA.

J. Provide two terminals for monitoring the isolation damper limit switch. The VFD shall not energize the fan until the limit switch contacts close, indicating the isolation damper is open.

K. VFD shall have embedded Building Automation System (BAS) protocols for network communications; Johnson Controls Metasys N2. These protocols shall be accessible via an RS-122/485 communication port. Coordinate with Section 25 10 00 for appropriate BAS manufacturer.

L. BAS System Interface (Each Drive):
   1. Coordinate with Section 25 10 00 to provide compatible isolated or non-isolated I/O points.
   2. Following signals shall be hardwired from BAS Controller to VFD:
      a. Fan start permissive (digital input).
      b. Speed control signal for fan applications (analog input).

3. Following signals, as a minimum, may use the network interface for direct communications, or provide for hardwired connections per point:
    a. Provide system alarm circuit for remote alarm signal of general failure (digital output).
    b. Individual fan status, based on positive feedback on loadside of motor (digital output) to BAS via current sensing relays. Relays to be provided with drive. Current switch to distinguish between low speed and a broken belt.
    c. Output frequency or percent speed output (analog output).
    d. VED H-O-A in Auto Position (digital output).
    e. KWII (totalized signal).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's installation instructions and as specified.

B. Install free standing units on 4 IN housekeeping pads.

C. Install wall mounted units to room walls, or on free standing pedestals.

D. Where AFD's are mounted on air handling unit casing(s), provide bracing and coordinate with air handling unit manufacturer.

E. Cover and protect units from installation dust and contamination until environment is cleaned and ready for operation.

F. Cables installed between the VFD and the motor shall be rated for VFD applications.

3.2 TESTING AND START UP

A. Field start up and testing:
    1. Provide services of a factory trained representative at site to supervise installation and startup.
    2. Test machines under operation through full speed range and record data at full load, 75 PCT load, 50 PCT load and 25 PCT load, for a minimum of 1 HR at each load.
    3. Field test according to ANSI Standards.
    4. Start-up tech shall ensure drives are clean, trouble free and lugs tightened and electrical connections torqued per manufacturers recommendations.

3.3 OWNER INSTRUCTIONS

A. Provide services of manufacturer's representative for 8 HRS to instruct Owner's operating personnel.
    1. Instruction hours shall be in addition to testing and startup hours.

B. Schedule this period when equipment is completely installed and tested and can be operated under normal load.

C. Provide instruction on each system type.

END OF SECTION

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SECTION 25 30 00
BAS FIELD EQUIPMENT

PART 1 - GENERAL

1.1 APPLICATION OF THIS SECTION

A. This Section applies to all heating, ventilating, and air conditioning work. Coordinate with applicable Sections as required.

B. Refer to other Sections in Divisions 20, 23, and 26 for general requirements pertaining to mechanical and electrical work.

1.2 SECTION INCLUDES

A. Instruments, sensors and controllers.

B. Panels and accessories.

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Furnish control valves, sensor wells, flow meters, and pressure taps to Section 23 21 13 for installation.

B. Furnish duct-mounted airflow stations and static pressure probes to Section 23 31 13 for installation.

C. Furnish air terminal device controllers (ASC), transformers, differential pressure (flow) transmitters and enclosure, along with control wiring and tubing diagrams, to Section 23 36 00 for factory installation.

D. Furnish face velocity monitor to Section 11 53 13 for factory installation.

E. Furnish control dampers to Section 23 73 23 for factory installation.

1.4 RELATED SECTIONS

A. Section 28 31 00 - Fire Alarm and System.

B. Section 20 05 00 - Special Mechanical Requirements.

C. Section 20 08 00 - Testing and Balancing.

D. Section 23 21 13 - Hydronic Piping Systems.

E. Section 25 10 00 - Building Automation System.

F. Section 25 23 00 - Variable Frequency Drives.

G. Section 25 90 00 - Building Automation System Sequence of Operations.

H. Section 26 00 10 - Electrical General Requirements.

I. Section 26 05 19 - Low Voltage Electrical Power Conductors and Cables.

J. Section 26 05 33 - Conduits.

K. Section 26 27 26 - Wiring Devices.

L. Section 26 32 13 - Diesel Engine Driven Generator Sets.

1.5 SUBMITTALS

A. Follow Sections 01 33 00 and 25 10 00.

PART 2 - PRODUCTS

2.1 ELECTRONIC SENSORS

A. Temperature Transmitter:
   1. Platinum RTD element (100 ohm) with integral, loop-powered 4-20 mA DC linear output transmitter.
   2. Accuracy: Plus or minus 0.5 percent of span.
   3. Select sensors which result in design operating temperatures located in mid-span of sensor range (minimum span: 50 DEGF).
   4. Pipe mounted sensors shall be insertion type into standard Thermowell. Provide brass thermowell for non-corrosive liquids and temperatures below 250 DEGF. For steam/corrosive fluids and temperatures greater than 250 DEGF, use 304 stainless steel. Thermowell shall be filled with conductive gel. Strap-on type sensors are not permitted.
   5. Provide transmitter with zero and span adjustments.
   6. Provide polarity reversal protection.
   7. Non-transmitting or thermistor types are not acceptable.
   8. Provide NEMA 4 enclosure for devices located outdoors.
   9. Electronic Space Sensors: Thermistor-type room temperature sensor with adjustable set point capability (range programmed via software), temperature indication and integral Unoccupied override pushbutton. Room thermostats shall be limited to a plus or minus 2 DEGF. Temperature adjustment, through software.

B. Duct Relative Humidity Sensors (For Central Air Distribution Systems):
   1. Factory calibrated, industrial grade, mounted minimum 5 FT after calculated humidifier vapor trail. Provide 2-wire loop powered transmitter to measure relative humidity with a hygromer capacitive sensor, or bulk polymer sensor.
      a. Design Standard Manufacturer: VAISALA. Substitutions subject to Section 01 61 00 are:
         1) Rotronic.
         2) General Eastern.
         3) Other substitutions are not permitted.
      b. Measurement Range: 0-100 percent RH.
      c. Output: 4-20 mA linear to stated measurement range.
      d. Accuracy (including linearity and repeatability at 77 DEGF): Plus or minus 2.0 percent of span between 0 to 90 percent RH; plus or minus 3 percent of span between 0 to 100 percent RH.
      e. Power Requirement: 8-35 VDC or 20 mA.
      f. Stability: Within 1 percent RH per year.
      g. Accessories: Duct-mounting plate, quick mount duct flange adapter, sensor dust filter, and single point calibrator for on-line/on-site calibration.
      h. Provide NEMA 4 enclosure for devices located outdoors.
      i. Select probe lengths suitable for sensor location at center of duct.

C. Duct Averaging Temperature Elements and Transmitters:
   1. Design Standard Manufacturers:
      a. Automated Logic.
      b. Distech.
      c. Johnson Controls.
      d. Honeywell.
      e. Other Substitutions are permitted.
   2. 100 Ohm RTD Type with 4-20mA Transmitter.
   3. RTD Element Accuracy: Plus or minus 0.1 DEGF.
   4. Total Assembly Accuracy (Element and Transmitter): Plus or minus 2 DEGF.
   5. Stability: plus/minus 0.15 percent degree C/Yr.

6. Bendable averaging sensor shall be of sufficient length as follows:
   a. Minimum of 12 IN in length for each 2 SQFT of duct area where velocity is less than 1000 FT/min.
   b. Minimum of 12 IN in length for each 4 SQFT of duct area where velocity is greater than 1000 FT/min.
   c. Custom lengths may be required where there are multiple, staggered coils. Coordinate with approved AHU shop drawings for coil information.

D. Room Humidity Transmitter:
   1. Design Standard Manufacturer: VAISALA Series HMW60Y. Substitutions subject to Section 01 61 00 are:
      a. Rotronic.
      b. General Eastern.
      c. Hycal.
      d. Other substitutions are not permitted.
   2. Factory calibrated, industrial grade, 2-wire loop powered transmitter measures relative humidity with a hygrometer capacitive sensor or bulk polymer sensor. Humidity transmitter shall output a linear 4-20 mA DC control signal over stated range.
   3. Measurement Range: 0 to 100 percent RH.
      a. Output: 4 to 20 mA linear to stated measurement range.
      b. Accuracy (including linearity and repeatability at 77 DEGF): Plus or minus 2.0 percent of span 0 to 90 percent RH) plus or minus 3 percent of span between 0 to 100 percent RH.
      c. Power Requirement: 8-35 V DC or 20 mA.
      d. Stability: Within 1 percent RH per year.

E. Outdoor Temperature, Relative Humidity and Carbon Dioxide Station:
   1. Hygroscopic Humidity Sensing Element:
      a. RTD temperature sensing element.
      b. Range: minus 22 to plus 150 Deg F; 0-100 Percent R.H.
      c. Accuracy: Plus or minus 0.4 Deg F; Plus or minus 0.5 Percent RH plus 1.5 Percent Reading.
      d. Outputs: Selectable 0-10 VDC, 4-20 mA each for temperature and R.H.
      e. Power: 24 VAC.
      f. Housing: Aluminum, weather tight with radiation shield for probe. Provide 1-1/2 IN pipe stanchion for vertical mounting. Coordinate mounting location with Engineer.
      g. Basis of Design: Rotronic Hygroflex M with M1 series transmitter.
   2. CO2 Transmitter:
      a. Carbon dioxide (CO2) sensors shall measure CO2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersive infrared (NDIR) technology with an accuracy of plus/minus 75 ppm and a maximum response time of 1 minute.
      b. The sensor shall be rated for operation at ambient air temperatures within the range of 32 to 122 DEGF and relative humidity within the range of 0 to 95 percent (non-condensing).
      c. The sensor shall have a maximum drift of 2 percent.
      d. The sensor chamber shall be manufactured with a non-corrosive material (such as gold-plating) that does not affect carbon dioxide sample concentration.
   3. Weather Shelter:
      a. The temperature, humidity, and CO2 sensors shall be housed in an instrument shelter.
      b. The sides shall be horizontally slatted for free airflow while providing protection from sun, wind, and rain.
      c. The shelter shall have a double roof to minimize direct solar radiation.
      d. Mount on unistrut which is secured to the structure or provide with free standing legs.

2.2 COMMERCIAL QUALITY CONTROL VALVES

A. Applications:
   1. Reheat Coil Control – Ball Valve.
   2. Fan Coil Unit Control – Ball Valve.
   3. Chilled Beam Control – Ball/Globe Valve.
   4. Air Handler Valves – Ball/Globe Valve.
   5. Isolation Valves - Butterfly Valve.
   6. Chilled Water Bypass Valve - Globe Valve.
   7. Chiller System Make-up Water - Ball Valve.
   8. Heat Exchanger, Hot Water, Condenser Water and Chilled Water Control Valves - Globe Valve

B. Valve Classification:
   1. The valve classification shall be consistent with the piping classification for the system at the location where the valve is installed.
   2. The chilled water control valves shall be class 300.

C. General Requirements:
   1. Two (2) IN and Smaller: Ball type.
   2. Larger than 2 IN: Globe type.
   3. Chilled beam control valves shall be sized to accommodate the total volume of water required for all chilled beams down stream of valve. Refer to Mechanical floor plans for design flows. Note: the mechanical schedules provide generic information about the chilled beams and shall not be used for sizing the control valves.

D. Ball Valve:
   1. Manufacturers: Substitutions are permitted subject to Section 01 61 00.
      a. Belimo.
      b. Other substitutions are permitted.
   2. Two-way valves 1/2 IN to 2 IN: Commercial quality cast iron body, full port, with threaded or soldered ends for size listed.
   3. Service at minimum of 250 psi working pressure rating.
   4. Turndown shall be greater than 50:1
   5. Internal Construction:
      a. Chilled water: Stainless steel ball and stem.
      b. Hot water applications: Stainless steel ball and stem.
      c. Handle: Stainless steel with stainless steel nut and vinyl grip.
      d. All ball valves shall have blowout proof stem design, PTFE or Teflon thrust seal washer and stuffing box ring. Valves suitable for water shall incorporate an anti-condensation cap thermal break in stem.
      e. MSS SP-110.

E. Globe Valve:
   1. Design Standard Manufacturer: Belimo. Substitutions are permitted.
   2. Two-way valves 2-1/2 IN and larger in size shall be a single-seat type globe valves with flanged cast iron body.
   3. Three-way mixing or diverting valves 2 IN and smaller in size shall be 250 PSI three-port valves with threaded bronze body.
   4. Three-way mixing or diverting valves 2-1/2 IN and larger in size shall be three-port valves with flanged cast iron body.
   5. Turndown shall be greater than 50:1.
   6. Replaceable plugs and seats.
   7. Internal Construction:
      a. Chilled water: stainless steel stem with EPDM packing and brass seat.
      b. Hot water applications: stainless steel stem with Teflon packing, and stainless steel trim.
   8. Globe valves shall be re-packable under pressure.

F. Butterfly Valves:
   1. Design Standard Manufacturers:
      a. Basis of Design: Bray Series 31.
   2. Valve Classification: The valve classification shall be consistent with the piping classification for the system at the location where the valve is installed. The chilled water system shall be class 250, the reheat systems shall be class 150. MSS SP-67, Type I.
   3. Valves 4 IN to 16 IN: ANSI 150 pound rated threaded lug type with ASTM A 126 cast iron body, 304 stainless steel disc, stainless steel shaft, with EDPM seat. Provide extended neck for applications requiring pipe insulation.
   4. Three-Way Valves: Provide three way butterfly valve where shown. Valve shall be mounted on cast iron tee with appropriate linkage and actuator, factory set. Valve specifications shall be identical to straight-through valves.

G. Water System Service:
   1. Two-way valves shall have equal percentage characteristics, three-way valves linear characteristics.
   2. Two position applications shall require a line size valve with negligible pressure drop.
   3. The pressure drop across a full open valve shall be between 3 and 5 psi.

H. Electric Valve Actuators:
   1. Actuator shall be floating, two position, or spring return, as indicated in the control sequence and on the control diagrams. Fail-safe where specified, shall require either mechanical spring return, or battery back-up located near the building automation control panel for ease of maintenance. Battery back-up units or capacitor type units within the individual actuators are not acceptable. Actuators shall have a visible position indicator.
   2. Modulating valves shall respond to a 2-10 VDC or 4-20 mA signal (with the addition of a 500 ohm resistor). There shall be a visual valve position indicator and a limit switch to indicate valve full open position to the BAS. The actuator shall have the capability of adding auxiliary switches or feedback potentiometers if required. Powering shall be either by 120 VAC, 24 VAC or 24 VDC, and power consumption shall not exceed 12 watts at 24 VAC without auxiliary switches and 12 watts at 24 VAC with auxiliary switches, and 12 watts at 120 VAC without auxiliary switches and 12 watts at 120 VAC with auxiliary switches.
   3. The actuator shall provide the minimum torque required to close off against the system pressure in all operating modes, with an approximate running time no greater than 2 minutes for full stroke. The actuator shall be designed with current limiting motor protection. End of travel switches are not acceptable. A release button on the actuator shall be provided to allow for manual override.
   4. Valves installed outdoors shall be provided with NEMA 4 or NEMA 3R actuator housings. Provide heaters as required.
   5. All valves shall have a minimum resolution of 40 to 1.
   6. All actuators shall be UL listed.

2.3 ELECTRIC ACTUATORS FOR DAMPERS

A. Actuator Design Standard Manufacturer: BELIMO. Substitutions are permitted subject to Section 01 61 00.

B. Actuator shall be modulating, two-position, or spring return, as indicated in the control sequence. Fail-safe where specified, shall require either mechanical spring return, or battery back-up located near the Building Automation control panel for ease of maintenance. Battery back-up units or capacitor type units within the individual actuators are not acceptable.

C. Modulating valve actuator shall be positive positioning, responding to a 2-10 VDC or 4-20 mA signal (with the addition of a 500 ohm resistor). There shall be a visual valve position indicator and an actuator generated 2-10 VDC valve position output signal for electronic feedback to the control panel. The actuator shall have the capability of adding auxiliary switches or feedback potentiometers if required. Powering shall be either by 120 VAC, 24 VAC or 24 VDC, and power consumption shall not exceed 12 watts at 24 VAC without auxiliary switches and 12 watts at 24 VAC with auxiliary switches, and 12 watts at 120 VAC without auxiliary switches and 12 watts at 120 VAC with auxiliary switches.

D. The actuator shall provide the minimum torque required for proper valve close off, with an approximate running time of 2 minutes for full stroke. The actuator shall be designed with current limiting motor protection. End of travel switches are not acceptable. A release button on the actuator shall be provided to allow for manual override.

E. All actuators shall be UL listed.

F. Valves installed outdoors shall be provided with NEMA 4 or NEMA 3R actuator housings. Provide heaters as required.

G. All valves shall have a minimum resolution of 40 to 1.

2.4 STATIC PRESSURE PROBE (PITOT TUBE)

A. Manufacturers: Products listed are acceptable. Substitutions are not permitted.
   1. Tek-Air.
   2. Air Monitor Corporation.

B. Provide duct insertion probes capable of continuously monitoring air flow volume or duct static pressure. Probe material to match duct material.
   1. Each traverse probe shall contain multiple total and static pressure sensors located along exterior surface of a cylindrical probe and internally connected to their respective averaging manifolds.
   2. Provide static pressure probe as shown on Contract Documents. Install probes with threaded end support rod and nut, mounting plate and gasket.
   3. Pitot traverse probe shall not produce a measurable pressure drop. Sound level within duct shall not be amplified by presence of probe in air stream.

2.5 DIFFERENTIAL PRESSURE TRANSMITTERS

A. Manufacturers: Products listed are acceptable. Substitutions are not permitted.
   1. Tek-Air.
   2. Ashcroft.
   3. Setra.

B. Differential pressure transmitters shall receive positive or negative pressure signals from room or duct static pressure probes and amplify these signals into a two-wire, 4 to 20 mA signal.

C. Transmitter Performance Criteria:
   1. Calibrated Spans: Between 0.1 IN and 10.0 IN w.g., calibrated for design conditions.
   2. Output: 4 to 20 mA loop powered, 600 ohms at 24 VDC.
   3. Calibrated Accuracy: Plus or minus 0.25 percent of calibrated span including repeatability, and non-linearity.
   4. Dead Band: None.
   5. Zero Adjustment: Minus 100 to plus 50 percent of span.
   6. Vibration Effect: None.
   7. Position Effect: None.

D. Electronically isolate output signal from transmitter.

E. When used for duct pressure measurements, calibrate transmitter so maximum (20 mA) value is not over 20 percent more than expected system maximum pressure.

2.6 LIQUID PRESSURE TRANSMITTER

A. Design Standard Manufacturer:
   1. Setra.
   2. Dwyer.
   3. Substitutions are permitted.

B. Solid state piezo resistance sensor assembly, adjustable span and zero, 4-20 mA DC output signal, 2-wire loop powered enclosure.

C. Rangeability: 10:1 while maintaining minimum plus or minus 0.5 percent of calibrated span.

D. Accuracy: Plus or minimum 0.25 percent of calibrated span (includes hysteresis, linearity and repeatability).

E. Design transmitter to withstand minimum 150 percent of rated static pressure conditions. Select suitable transmitter ranges acceptable to A/E.

F. Factory calibrate transmitters at normal operating range.

G. For differential pressure transmitters: Provide 3-valve manifold with sensor to allow for calibration and removal from the system.

H. For gauge pressure transmitters: Provide hand valve with sensor to allow for calibration and removal from the system.

2.7 REFRIGERANT LEAK DETECTION SYSTEM

A. Manufacturers: Substitutions are not permitted.
   1. Haloguard II by Thermal Gas Systems.
   2. Multi-point Sampling System by General Analysis Corporation.
   3. Chillgard IR by Mine Safety Appliance.
   4. General Analysis Corporation.

B. Refrigerant leak detection system shall be complete with controller, sensors, and accessories for the purpose of detecting and measuring a refrigerant leak.

C. Provide quantity of sensors as recommended by leak detection system manufacturer for complete area coverage. System shall meet or exceed the latest ASHRAE 15-1994 requirement and EPA standard 608 CFR. System shall incorporate all the latest revisions.

D. Provide local readout of each sensor sample in parts per million (ppm) or percent 0_2.

E. Each sensor input (channel) shall have independent, user-adjustable high and low alarm set points, with each alarm level driving a relay containing Form C contacts rated for a minimum of 3A at 120 VAC.

F. Controller shall be powered by 115 V, 60 Hz electrical supply.

G. Provide auxiliary dry contacts for remote alarm indication to the Building Automation System.

H. Provide an analog output (0-10 VOC or 4-20 mA) for remote indication to the Building Automation System.

I. Range: 0-300 ppm for R123 or 0-25 percent (Oxygen Depletion) for R134a.

J. Controller shall be wall mounted and include audible alarm silence pushbutton.

K. Furnish the following options/accessories for mounting at each mechanical room door exit.

L. Local audible alarm (120 db).

M. Blue Strobe Alarm light.

2.8 FUME HOOD FACE VELOCITY MONITOR

A. Manufacturer: TSI, Model 8610-AS EVERWATCH Siemens Series FHM-546-00303: Tek-Air Series FVC-2500 and Triatek Series HMS-1600.

B. Alarm shall signal an unsafe operating condition when face velocity falls below a pre-set level. Calibrate alarm set-point after desired face velocity has been set and measured. System shall consist of:
   1. Digital display to register face velocities between 0 and 150 FT per minute. Include transformer, if required, to power monitor. Provide transformer with fuses on primary and secondary sides.
   2. Audible alarm emitting sound level not less than 85 dB.
   3. Green LED indicator for "normal" operation.
   4. Red LED indicator with audible alarm for both high and low alarm.
   5. Audible alarm silencer switch, with yellow LED indicator for mute. Operation of switch shall not cancel red warning light.
   6. Test mode to simultaneously test LED function and alarm set-point.
   7. Reset button.
   8. Face velocity sensing technology shall have temperature compensation over a range of 60-80 DEGF, and capable of measuring velocities between 0-1000 FT per minute.

2.9 CARBON DIOXIDE MONITOR

A. Manufacturer: Substitutions are not permitted.
   1. Kele.
   2. Johnson Controls.

B. Carbon Dioxide detector shall have the following attributes.
   1. Range: 0-2000 ppm.
   2. Accuracy: Plus / Minus 2.5 percent of reading.
   3. Repeatability: Plus / Minus 20 ppm.
   4. Output: 0-10 VDC or 4-20 mA.
   5. For Wall mounted Carbon Dioxide detector: If possible provide as an option on rooms local thermostat.

2.10 GAS MONITORING SYSTEM

A. Basis of Design: Drager. Substitutions not permitted.

B. General: Wall mounted, NEMA 4X polycarbonate enclosure, UL Classified and CSA certified with multi-channel microprocessor-based controller gas monitoring system. Refer to contract drawings for quantity of room sensors.

C. Coordinate quantity and location of sensors, alarms and strobes with manufacturer and Owner EH&S for complete room coverage.

D. Remote mounted sensor shall provide an analog signal to monitoring panel. Provide visual three-digit display of concentration on front of sensor. Alarm shall be silenced by pressing button on controller mounted on wall in vicinity of room. Provide a single calibration kit.

E. Sensor to provide sensor alarm activation and a trouble alarm to BAS.

F. Performance:
   1. Sensor Power 7 – 30 V DC
   2. Analog Output 4-20mA
   3. Range: As required for application refer to control details and Section 25 90 00. Review with vendor (By Volume)
      a. Gases to be monitored:
         1) Oxygen Depletion
         2) Carbon Monoxide

        3) Carbon Dioxide
        4) Nitrogen Dioxide
        5) Ozone
    4. Sensor Life Two Year minimum
    5. Repeatability plus/minus 1 percent Full Scale

2.11 STROBE WARNING LIGHT AND HORN (WALL MOUNTED, FOR NON-HAZARDOUS LOCATIONS)

A. Proprietary Manufacturer: FEDERAL SIGNAL CORP., Visalert Strobe Light Model VALS. No substitutions.

B. Strobes shall have 80 flashes per minute and 108,000 peak candlepower, red colored lens. Provide where indicated on contract Drawings. For strobes with horn, provide with integral Model 350 horn.

C. Strobe/horn arrangement shall be UL-listed.

2.12 DIFFERENTIAL AIR PRESSURE SWITCH

A. Diaphragm operated with minimum 4 IN diaphragm to actuate a SPDT snap acting switch. A field adjustable pressure set point with a range shall allow switch operation suitable for air flow status. Provide range suitable for each application. Provide sensing tubes connected to tips specifically designed for air flow sensing. The operating range shall be 0.07 IN w.c. to 0.22 IN w.c. The deadband shall be 0.05 IN w.c. Differential pressure switches shall be used to control the isolation dampers for fan systems with multiple fans, as shown on the contract drawings. The switches shall be automatic reset type.
    1. Dwyer 1800 Series.

2.13 ELECTRIC RELAYS

A. Minimum two (2) sets of Form C contacts rated for application in accordance with NEMA ICS 1, dust proof enclosure, equipped to limit transients to 150 percent of rated coil voltage. Minimum contact rating: 20 A inductive at 120 VAC.

2.14 SELECTOR SWITCHES

A. With indicating nameplates. Manual operation, two-position type with SPDT contacts rated for application. Acceptable manufacturers: Allen-Bradley, Square D, Cutler-Hammer.

2.15 DAMPER LIMIT SWITCH

A. Momentary type, adjustable limit switch for monitoring motion of damper at a prescribed arc of rotation. Switch shall have oil tight contacts that operate by way of a trip lever. Switch shall have a DPDT contact arrangement that exceeds load requirements for voltage and current. Submit installation detail on how trip lever mechanism will be actuated for approval prior to installation.
    1. Manufacturers: Products listed are acceptable. Substitutions are permitted subject to Section 01 61 00.
        a. Square D.
        b. Allen-Bradley.
        c. Cutler-Hammer.

2.16 CURRENT-PRESSURE TRANSDUCER

A. Transducer shall accept a standard 4 to 20 mA current input signal and provide a proportional 3 to 15 psig pneumatic signal. Device shall have an integral manual override adjustment knob with output pressure gauge; TRIATEK Series CP-3000. Substitutions are permitted subject to Section 01 61 00.

2.17 CONTROL TRANSFORMERS

A. UL-listed, Class II with 120 VAC primary and 24 VAC secondary. Provide with integral manual reset circuit breaker.

2.18 HIGH STATIC PRESSURE SWITCH

A. Design Standard Manufacturer:
   1. Cleveland.
   2. Dwyer.

B. Diaphragm operated to actuate a single pole, double throw, snap action switch.

C. Motion of diaphragm shall be restrained by a calibrated spring that can be adjusted to set exact pressure differential at which electrical switch will be actuated.

D. Set Point Adjustment: Screw type with set point indicated on a visual scale.

E. Select pressure switch range for specific fan application.

F. Provide switch with a manual reset function.

G. Differential pressure switches shall not contain mercury.

H. The set point shall not be in the upper or lower quarters of the range.

I. The over pressure rating shall be a minimum of 150 percent of the highest design pressure of either input to the sensor.

J. The switch shall have two sets of contacts (DPDT) and each contact shall have a rating greater than its connected load.

K. The pressure switch shall have a repeatability of plus/minus 3.0 percent. Contacts shall open or close upon rise of pressure above the set point or drop of pressure below the set point as shown.

L. Differential pressure switches shall be used for monitoring fan high static pressure and fan low static pressure. The switches shall be manual reset type.

2.19 DIFFERENTIAL PRESSURE SWITCH (ISOLATION DAMPER CONTROL)

A. Design Standard Manufacturer:
   a. Cleveland.
   b. Dwyer.

B. The minimum operating range shall be 0.15 IN w.c. to 0.50 IN w.c. The deadband shall be 0.05 IN w.c.

C. Differential pressure switches shall be used to control the isolation dampers for fan systems with multiple fans, as shown on the contract drawings. The switches shall be automatic reset type.

2.20 CURRENT TRANSDUCER

A. Analog output current sensors providing a signal corresponding to actual amperage draw of the monitored load. Provided in a wide range of amperages and available with convenient slide switch range selection.

B. Split core, amperage range: 0 to 100-300A or 0 to 300-800A depending on motor, AC adjustable, analog output transducer: 4-20mA output, loop powered, large size housing. UL listed.

C. Manufacturer: Veris Series H221/H321.

2.21 CURRENT SWITCH

A. Switch shall indicate loss of status when current falls below an adjustable trip point.

B. Switch shall indicate status via LED.

C. Manufacturer: Veris Series H708/H908.

2.22 EMERGENCY SHUTDOWN SWITCH

A. Basis of Design: Safety Technology International, Inc., Model SS-2000. Subject to compliance with requirements, the following manufacturers and products named are acceptable; substitutions of other unnamed manufacturers are permitted subject to Section 01 61 00.
   1. Allen-Bradley.
   2. General Electric.

B. Specifications:
   1. Flush, wall mounted in single gang receptacle.
   2. Bopper Stopper Cover (without horn) with octagonal button and blue wall plate with "EMERGENCY". Provide with custom label, "[CHILLER] [BOILER] SYSTEM SHUTDOWN" for MER application and custom label for the application.
   3. Interchangeable or replaceable N.O. or N.C. SPST gold-plated contact blocks rated for 3A at 600 VAC or 1A at 250 VDC.
   4. Accessory: Provide clear carbonate cover, Model Mini Stopper (STI-6500).

2.23 FREEZE PROTECTION THERMOSTATS

A. Snap acting, single pole, single throw, manual reset switch which trips if temperature sensed across any 12 IN of bulb length is equal to or below set point; requiring minimum 20 FT length of bulb. Provide one thermostat for every 20 SQFT of coil surface.

2.24 UNINTERRUPTIBLE POWER SOURCE (UPS)

A. Design Standard Manufacturer:
   1. Powerware.
   2. Liebert.
   3. APC.
   4. Other substitutions are permitted subject to Section 01 61 00.

B. Provide a UPS for each controller and workstation which are fed from normal power.

C. Provide protection from power surges, spikes, blackouts and brownouts.

D. Provide immunity from electrical sags, surges, transients, noise, and outages.

E. Performance:
   1. Output Voltage Regulation: Plus/minus 5 percent.
   2. Output Frequency Regulation: Plus/minus 1 percent.
   3. Output Harmonic Distortion: 5 percent total, 3 percent single harmonic.
   4. Output Overload Capability: 125 percent for 1 second causes shutdown without hardware damage.
   5. Transient Suppression: Tested to IEEE 587.
   6. Battery Reserve: 15 minute typical at full load of controller served; 10-15 minutes with a typical PC load for workstations.
   7. EMI/RFI: Complies with FCC Part 15J, Class A.

F. Electrical:
   1. Input Voltage: Single Phase, two-wire plus ground.
   2. Input Frequency: Plus/minus 1 percent.
   3. For Supervisory Stations, provide UPS with quantity of outlets for CPU, Monitor, and printers.

G. Environmental:
   1. Operating Temperature: 0 to 35 DEGC.
   2. Relative Humidity: 0 to 90 percent non-condensing.

H. Battery: Internal, sealed, captive electrolyte, non-corrosive, no flammable gases.

I. Provide a manual bypass switch permitting scheduled maintenance or UPS replacement without power disruption.

2.25 LEAK DETECTION SYSTEM

A. Manufacturer: Liebert Cable Model LT500Y with point sensor Liqui-tect 410. Substitutions are permitted subject to Section 01 25 00.

B. Non-kink design makes cable easy to position around equipment.

C. Length suitable for area.

D. Material to resist corrosion and abrasion.

E. Thermally bonded cable rated for 176 degrees F and plenum rated.

F. Isolated dry contact alarm output signal to BAS upon detection of liquid.

2.26 COPPER-TO-FIBER CONVERTER FOR DIGITAL SIGNALS

A. Provide a pair of converters; one transmitter (Tx) and one receiver (Rx).

B. Transmitter and receiver shall each be powered by separate 24 VDC power sources, to maintain high voltage isolation.

C. Devices shall accept up to 4 separate contact closures and transmit over a single fiber..

D. Devices shall accept single-mode or multi-mode fiber, as determined by the contractor based on the application and distance

E. Provide screw terminals for all wire connections

F. Provide internal surge protection on both Transmitter and Receiver

G. On Receiver, include alarm contact which closes on loss of fiber signal.

H. On Receiver, include LED status indicators for Relay condition, power and fiber carrier receive

I. Operating Temperature Range: Minus 10 degrees F to plus 140 degrees F.

J. Provide enclosures for mounting of converters.

K. Provide Loss calculations, with minimum 3dB overhead

L. Basis of Design: RLH Industries- Fiber Optic Link

2.27 COPPER-TO-FIBER CONVERTER FOR ANALOG SIGNALS

A. Provide a pair of converters; one transmitter (Tx) and one receiver (Rx).

B. Transmitter and receiver shall each be powered by separate 24 VDC power sources, to maintain high voltage isolation.

C. Devices shall accept up to 4 separate analog signals (4-20mA or 0-10 volts) and transmit over a single fiber. Each signal type shall be selectable on the converters.

D. Devices shall accept single-mode or multi-mode fiber, as determined by the contractor based on the application and distance

E. Provide screw terminals for all wire connections.

F. Provide internal surge protection on both Transmitter and Receiver

G. On Receiver, include alarm contact which closes on loss of fiber signal.

H. On Receiver, include LED status indicators for power and fiber carrier receive

I. Operating Temperature Range: Minus 10 degrees F to plus 140 degrees F.

J. Provide enclosures for mounting of converters.

K. Provide Loss calculations, with minimum 3dB overhead

L. Basis of Design: RLH Industries- Fiber Optic Link

2.28 FLOW SENSORS

A. Airflow Measurement Station (AMS):
  1. Design Standard Manufacturer: Ebtron Series GTX116. Substitutions are not permitted.
  2. Provide one thermal dispersion airflow measuring station (AMS) at each location indicated on the drawings.
  3. Each AMS shall consist of two to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in an anodized, aluminum 6000 series alloy.
  4. Each sensor node shall consist of two thermistors.
  5. Sensor Density Requirements:
     a. Provide the sensor density (#/area) required for accurate airflow measurement at the location shown on the contract documents.
     b. Provide flow conditioning elements (flow straighteners), if there is an insufficient length of straight pipe runs upstream or downstream of the flow meter, to ensure the proper inlet conditions for accurate flow measurement.
  6. Each sensing node shall be individually calibrated.
  7. Duct applications: 6063 aluminum alloy tube construction with 304 S.S. stainless steel sensor mounting blocks. Provide quantity of measuring elements in accordance with manufacturer’s directions. Calibrated range = 0-5,000 FPM. Manufacturer: Ebtron, Model SP1.
  8. Fan inlet applications: Cadminum plated steel support rods. Calibrated range = 0-10,000 FPM. Manufacturer: Ebtron, Model GF1.
  9. Measurement Performance:
     a. Each sensing node shall have a temperature accuracy of plus/minus 0.15 degrees F over the entire operating temperature range of minus 20 degrees F to 160 degrees F.
     b. Each sensing node shall have a minimum airflow accuracy of plus/minus 3 percent of reading.
     c. The ATMD shall be capable of measuring airflow rates over the full range of 0 to 5,000 FPM between minus 20 to 160 degrees F.
  10. Integral Transmitter and Communications:
     a. The transmitter shall be powered by 24 VAC, be over-voltage and over-current protected, and have a watchdog circuit to provide continuous operation after power failures and/or brown-outs.
     b. The transmitter shall have at least one isolated 4-20mA analog output signal.
     c. UL listed.
  11. BAS contractor shall provide all field mounting, control and power wiring and setup/calibration in coordination with Section 20 08 00.

B. Magnetic Water Flow Meter:
  1. Accuracy: Plus or minus 0.2% of rate from 1.6 to 33 ft/s.
  2. Temperature Range: Minus 4 to 140 degrees F.
  3. Maximum Pressure: 580 psi.
  4. Wetted Parts: Electrode 316 stainless steel; lining Teflon.
  5. Output Signal: Totalized 4-20 mA and pulse 14 to 30 vdc.
  6. Enclosure Classification: NEMA 6.
  7. Flanges: 316 stainless steel, class 150.

8. Electronics: Mounted on metal body.
9. Include register for non-volatile totalization.
10. Electronics to be UL listed.
11. Vibration Effect: Meets IEC 770 pipeline installation conditions.
12. Grounding Rings: 316 stainless steel.
13. Electrodes to be field removable for periodic inspection and cleaning.
14. Manufacturers: Onicon F3100 matched to BTU meter: System 10 series.

C. Vortex Shedding Steam Flow Meter:
1. Accuracy: Plus or minus 1 percent of reading.
2. Repeatability: Plus or minus 0.2 percent of reading.
3. Temperature Range: Minus 40 to 500 degrees F.
4. Wetted Parts: Stainless steel.
5. Output Signal: Totalized flow and temperature 4-20 mA and pulse 14 to VDC HART communication protocol.
6. Enclosure Classification: NEMA 4X water and dust tight.
7. Electrical Connections: 1/2 NPT.
8. Flanges: 316 stainless steel, class 300, 2 inches and above, or unions below 2 inches.
9. Electronics: Remote with dual display LCD indicator.
10. Electronics to be UL listed/FM Explosion Proof Certified.
11. Provide multivariable option.
12. Manufacturer: Yokogawa Model DYA Vortex with ITC. Substitutions not permitted.

2.29 FIELD EQUIPMENT PANELS

A. Unitized cabinet type for each system under automatic control. Provide quantity of enclosures required to house all relays, transducers, solenoid valves, pneumatic devices and other interface controls. Mount temperature, humidity, airflow and pressure indicators, (or operator interface display with keypad), pressure gauges, pilot lights, pushbuttons and switches flush on cabinet panel face. All transformers and power supplies shall be mounted outside of the central panel. Provide laminated nameplates for all devices utilizing tag name as submitted on shop drawings. Mechanically fasten nameplates to panel. Self-adhesive type nameplates are not acceptable.

B. Provide NEMA-1 general purpose enclosure for all applications where panel will be installed in labs and other relatively dust free and dry spaces. All control panels for use in mechanical rooms, wash-down locations or installed outdoors shall be rated NEMA-4. All cabinets shall use a common key. Provide means of storing control system instructions and drawings inside cabinet.

C. Finish: Factory applied enamel, except that panels in finished spaces shall be primed for field painting.

D. Provide surface mounted or freestanding, steel supported types for mechanical equipment rooms. Provide fully recessed wall-mounted types elsewhere.

E. All panels shall be fully recessed in walls in public spaces, where possible.

F. Interior arrangement of control panel components shall be such that tubing and wire raceways shall be separated and aligned horizontally and vertically, in a fashion that allows for an organized appearance and a practical means for the tubing/wire to be exit the raceway to its intended component.

G. All tubing shall enter the panel through standard bulkhead compression fittings. All tubing lines shall be labeled markers at both ends of the tubing.

H. All wire shall enter panels via conduit fittings. All wires shall terminate on terminal blocks and then continue from the terminal block to the device. Direct connection to the device is not permitted. Use of wire nuts is not permitted, except in applications in which a control device is provided from the factory with "pigtails". All wires shall be labeled at both ends of the terminal blocks. All penetrations of the BAS or outboard gear panels in mechanical rooms shall be from the bottom of the enclosure with wireway and conduit stubs from the wireway up to the panel.

I. Power Supplies:
  1. Provide a regulated, protected power supply as required with the ability to produce at least 33 percent more current than required by the transmitters and controls being installed. Output regulation shall be less than 0.5 mV. There shall be no overshoot on turn ON or OFF. Operating temperature shall be minus 20 to plus 70 DEGC.
  2. The BAS Contractor shall certify in writing at the time of shop drawing submittal that the DDC equipment provided will not cause, as a result of its operation, either directly or indirectly, electrical interference to be induced into the building's electrical power systems.
  3. Class II transformers shall be used.

2.30 ELECTRICAL EQUIPMENT AND WIRING

A. Refer to Divisions 20, 23, and 26 for means, methods and materials. Provide Emergency powered control circuits required for Control System use. Provide 120 volt power wiring from dedicated circuit breakers in electrical panels to BAS control panels. Provide necessary transformers. Coordinate with Division 26.

B. Control and Signal Circuits: Per NEC Article 725 (excluding thermocouple wiring). Control or signal circuits not run entirely in conduit, in areas classified as plenum space and vertical shafts shall be energized from listed Class 2 power supplies and shall be installed in Type "CL2P" listed plenum cable exclusively. Plenum rated cable shall be permitted in applications above an accessible ceiling or in between drywall where there is no insulation.

C. Provide all power and control wiring exposed outdoors, within rigid conduit properly labeled as BAS wiring. All power and control wiring above inaccessible ceilings within finished spaces, in drywall partitions with insulation or in block walls, in mechanical spaces and in vertical shafts shall be installed in electric metallic tubing (EMT).

D. Classify line (120 volt) and low (below 120 volt) voltage wiring from BAS and other control panels to control devices as control wiring.

E. Low Voltage Control Wiring: Wire shall be compatible with specific application and in accordance with Division 26.

F. For Hazardous location circuits, refer to NFPA Article 500 for installation requirements.

G. All cable shall be run parallel with structure, properly bundled and secured every 5 FT. Provide labels every 20 FT (minimum) to identify associated system (i.e., BAS)

2.31 SEQUENCE OF OPERATION

A. As specified in Section 25 90 00.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products in accordance with manufacturer's instructions.

B. Where control devices are to be surface-mounted on components scheduled to be insulated, provide insulation between device and component to prevent condensation or heat transfer. Use insulating materials and thicknesses specified in Section 20 07 00.

C. Verify location of duct temperature and humidity transmitters, static pressure probes, control panels, and other exposed control equipment with Drawings before installation. Provide an insulated backplate for thermostats mounted on exterior walls. Space temperature sensors shall be mounted 48 IN above finished floor, unless noted otherwise.

D. Mount freeze protection thermostats using flanges and element holders. Provide one thermostat for every 20 SQFT of coil surface. Wire multiple contacts in series. Mount thermostats on full width and height support rack within custom air handling units.

E. Provide temperature wells for liquid sensors and flanges for duct mounted sensors.

F. Provide multi-section dampers with interconnecting hardware or jackshaft for unison operation when required.

G. Coordinate control wiring and safety contacts required for motor control centers and VFD controllers with Division 26. Incorporate safeties so that they will not be overridden when hand-off-auto (HOA) switches are in hand position.

H. Coordinate required wiring for circuit interface relays at mechanical equipment motor control centers with building Fire Alarm System.

I. Where possible, instruments shall be provided with factory calibration certificates which shall be maintained and submitted to the Owner at project close out. All instruments shall be functionally tested in the field with submitted with the verification reports.

3.2 INSTALLATION AND COORDINATION OF AIRFLOW AND PRESSURE CONTROLS

A. Provide supervision of installation of duct mounted sensors to ensure conformity with manufacturer's instructions and reviewed submittals. Verify locations to ensure that accurate primary signals will be obtained. Coordinate installation with Section 23 31 13.

B. Provide minimum 3/8 IN pneumatic tubing for transmitter sensing lines.

C. Calibrate airflow sensors with readings obtained from Balancing Agency. Verify that indicators read-out same volume or pressure as monitored by BAS. Refer to Section 20 08 00.

D. Provide start-up, calibration, and adjustment of airflow and pressure controls.

3.3 MANUFACTURER'S FIELD SERVICES

A. Provide field services under provisions of Division 01.

B. Inspect duct temperature, humidity and pressure sensors for proper locations and installation. Verify controller indication matches transmitter output signal.

C. Tune each electronic controller and calibrate all transmitters, switches and control devices. Refer to Section 20 08 00.

D. Traverse each duct mounted airflow sensor to prove calibration accuracy of both gauge and electronic transmitter. Provide traverse holes in ductwork in accordance with Section 20 08 00.

E. Calibration of stations shall be witnessed by Owner’s commissioning agent. Notify Owner one week in advance of calibration. Refer to Section 20 08 00.

END OF SECTION

SECTION 25 57 00
UNDERGROUND DUCT SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Duct accessories.
   2. Precast manholes.
   3. Utility structure accessories.

1.3 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:
   1. Two or more ducts installed in parallel, with or without additional casing materials.
   2. Multiple duct banks.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include duct-bank materials, including spacers and miscellaneous components.
   2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
   3. Include accessories for manholes, and other utility structures.
   4. Include underground-line warning tape.

B. Shop Drawings:
   1. Precast or Factory-Fabricated Underground Utility Structures:
      a. Include plans, elevations, sections, details, attachments to other work, and accessories.
      b. Include duct entry provisions, including locations and duct sizes.
      c. Include reinforcement details.
      d. Include frame and cover design and manhole chimneys.
      e. Include ladder details.
      f. Include grounding details.
      g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
      h. Include joint details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
   2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

C. Product Certificates: For concrete and steel used in precast concrete manholes, as required by ASTM C 858.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 MAINTENANCE MATERIALS SUBMITTALS

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

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.8 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect no fewer than fourteen (14) calendar days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without the Architect's written permission.

B. Ground Water: See drawings for water table information.

PART 2 - PRODUCTS

2.1 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EB-20-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA C 3 by same manufacturer as duct.

B. Duct sections to be installed with a radius less than 35’, shall be composed of PREFORMED FACTORY-FABRICATED SEGMENTAL SECTIONS.

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Concrete Encasement: Minimum 3000 psi at 28 days.

E. Reinforcing Steel: ASTM A 615, Grade 60

F. Solvents and Adhesives: As recommended by conduit manufacturer.

G. Aggregate: #57 stone per AASHTO M 43.

H. Filter Fabric: Geotextile ASTM D 4751, grab strength 247 LBS.

I. Settlement Wall Bench: Structural member ASTM A 709, Gr. 50, galvanized. 3/4 IN bolt fasteners meeting ASTM A 307, Gr. A, galvanized.

2.2 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 26 05 53 "Identification for Electrical Systems.

2.3 PRECAST MANHOLES

A. Approved Manufacturer's
   1. Lakelands Quickset.
   2. Rotondo/Penn-Cast, Inc.
   3. Smith-Midland Corp.

B. Comply with ASTM C 858.

C. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

D. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 IN vertically and horizontally to accommodate alignment variations.
   1. Knockout panels shall be located no less than 6 IN from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls, see drawings for additional information location.
   2. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
   3. Knockout panel shall be framed with at least two additional No.3 steel reinforcing bars in concrete around each opening.
   4. Knockout panels shall be 1-1/2 to 2 IN thick.

E. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
   1. Type and size shall match fittings to duct to be terminated.
   2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.

F. Settlement Wall Bench: Threaded inserts shall be casted into the manhole wall at the designated duct entrance location as shown on the plans. The wall inserts are to align with the structural member 3/4 IN bolt fasteners.

G. Ground Rod Sleeve: Provide a 3 IN PVC sleeve in manhole floors 2 IN from the wall adjacent to, but not underneath, the duct entering the structure.

H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.4 UTILITY STRUCTURE ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
   1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces. Clear opening shall be 30 IN diameter.
      a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
      b. Cover Access Bolts: McGard 5/8 IN 11 or 1/2 IN 13 flat seat Manlocks. to be retrofitted into the approved frame and cover. Submit shop drawings for approval.
   2. Cover with cast-in Legend (6 IN high) Selected to suit system.
      a. Legend: "ELEC" for duct systems with power wires and cables.
      b. Legend: "UC" for duct systems with unclassified communication cables.
      c. Legend: "C" for duct systems with communications cables

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
    a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.
    b. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.

C. Manhole Floor Drain Frame and Grate: ASTM A48/A 48M, Class 30B, gray cast iron.

D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2 IN diameter eye, and 1-by-4 IN bolt.
    1. Working Load Embedded in 6 IN, 4000 PSI Concrete: 13,000 LBF minimum tension.

E. Pulling and Lifting Irons in Concrete Walls: 7/8 IN diameter hot-dipped galvanized, bent steel rod, stress relieved after forming, and fastened to reinforced rod. Exposed triangle shaped opening. Ultimate yield strength, 40,000-pound sheer, 60,000 pound tension
    1. Approved Manufacturer's: Condux 83813 Series or approved equal.

F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2 IN ID by 2-3/4 IN deep, flared to 1-1/4 IN minimum at base.
    1. Tested Ultimate Pullout Strength: 12,000 LBF minimum.

G. Ground Rod Sleeve: 3 IN PVC sleeve in manhole floors 2 IN from the wall adjacent to, but not underneath, the ducts routed from the facility.

H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2 IN bolt, 5300 LBF rated pullout strength, and minimum 6800 LBF rated shear strength.

I. Cable Rack Assembly: Components fabricated from nonconductive, fiberglass-reinforced polymer.
    1. Stanchions: Nominal 36 IN high by 4 IN wide, with provisions to connect to other sections to form a continuous unit, with minimum of nine (9) holes for arm attachment.
    2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 IN with 450 LB minimum capacity to 20 IN with 250 LB minimum capacity. Top of arm shall be nominally 4 IN wide, and arm shall have slots along full length for cable ties.
    3. Approved Manufacturer's: Underground Devices, Inc. or equal.

J. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 DEGF. Capable of withstanding temperature of 300 DEGF without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

K. Fixed Manhole Ladders: Arranged for attachment to roof/access chimney and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.

L. Cover Lifting Hooks: Condux 80230-00 or equal. Supply two (2) only.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 31 10 00 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 31 10 00 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical and Telecommunication Cables Type EPC-40 PVC, concrete-encased.

B. Stub-ups: Concrete-encased PVC, 48 IN radius sweeps.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Manholes: Precast concrete.
   1. Units shall be rated for H-20 structural load with 30 percent loading added for impact according to AASHTO HB 17.
   2. Units shall be in conformance with ANSI C 2, NESC and the ASTM C858.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 31 20 00 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Replace area immediately after backfilling is completed.

C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 92 00 "Turf and Grasses" and Section 32 93 00 "Plants."

E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to Design Documents.

3.5 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 35 FT, both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 DEGC. Where environmental temperatures are calculated to rise above 40 DEGC, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End Bell Entrances to Manholes: Use end bells with 2 IN duct clearances and for appropriate duct sizes.

H. Terminator Entrances to Manholes: Use manufactured, cast-in-place duct terminators, with entrances into structure walls, with 2 IN duct clearances and for appropriate duct sizes.

I. Building Wall Penetrations: Install RNC duct line slope away from the building and without forming a trap in the line. Install RNC penetrations of building walls as specified in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

K. Pulling Cord: Install 200 LBF test nylon cord in empty ducts.

L. Concrete-Encased Ducts and Duct Bank:
   1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 31 20 00 "Earth Moving".
   2. Width: Excavate trench 12 IN wider than duct on each side.
   3. Depth: Install so top of duct envelope is where indicated on the duct bank profiles.
   4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
   5. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 FT of duct. Place spacers within 24 IN of duct ends. Stagger spacers approximately 6 IN between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
   6. Minimum Space between Duct: 3 IN between edge of duct and exterior envelope wall, 2 IN between ducts.
   7. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
   8. Elbows: Use manufactured RNC elbows for stub-ups, at equipment pads, and at changes of direction in duct run.
      a. Stub-ups to Outdoor Equipment: Extend concrete-encased RNC to the underside of the equipment slabs.
         1) Stub-ups shall be minimum 4 IN above finished slab
   9. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
   10. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
   11. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4 IN reinforcing-rod dowels extending a minimum of 18 IN into concrete on both sides of joint near corners of envelope.

12. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.
13. Set elevation of bottom of duct bank below frost line.
14. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
15. Use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
16. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
17. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 IN over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 31 20 00 "Earth Moving" for installation of backfill materials.
    a. Place minimum 6 IN of engineered fill above concrete encasement of duct.

M. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 05 53 "Identification for Electrical Systems" no less than 12 IN above all concrete-encased duct and duct banks and approximately 12 IN below grade. Align tape parallel to and within 3 IN of centerline of duct bank. Provide an additional warning tape for each 12 IN increment of duct bank width over a nominal 18 IN. Space additional tapes 12 IN apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES

A. Precast Concrete Manhole Installation:
1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1 IN sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:
1. Manhole Roof: Install with roof slabs below finished grade per duct bank profiles.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 IN above finished grade..

C. Drainage: Install floor drains in bottom of manholes where indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.

2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Dampproofing: Apply dampproofing to exterior surfaces of manholes after concrete has cured at least three days. Dampproofing materials and installation are to be industry standard, shop applied coatings per ASTM E 96 test methods. After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

F. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

G. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

H. Field-Installed Bolting Anchors in Manholes: Do not drill deeper than 3-7/8 IN for manholes and 2 IN for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12 IN long mandrel equal to duct size minus 1/4 IN. If obstructions are indicated, remove obstructions and retest.
3. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.9 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.
1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

END OF SECTION

SECTION 25 90 00

BUILDING AUTOMATION SYSTEM (BAS) - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 REFERENCES

A. The publications listed below form a part of this section to the extent referenced. The publications are referred to within the text by the basic designation only.

B. Underwriters Laboratories (UL): UL 864 (2003; Rev thru May 2007) Control Units and Accessories for Fire Alarm Systems.

1.2 GENERAL REQUIREMENTS

A. All timing devices, alarm set points and control set points shall be adjustable. Set points listed herein for duct/room static pressure control, differential pressure control for discharge/intake isolation dampers, outside airflow control, return fan airflow tracking volume, and static pressure safeties are initial starting values.

B. Provide global outside air temperature, carbon dioxide and humidity for control and monitoring applications. Install sensors inside instrument shelter.

C. Provide software alarm points as follows:
   1. Digital points: Alarm upon change of state from normal condition.
   2. Analog points: Alarm upon a high or low value based on a deviation from set point as follows, unless otherwise noted.
   3. Temperature: Plus/Minus 2 DEGF.
   4. Duct Pressure: Plus/minus 0.75 IN w.c.
   5. Duct Humidity: Plus/Minus 10 percent RH.
   6. Room Humidity: Plus/Minus 5 percent RH.
   7. AHU Discharge Humidity: Alarm humidity at set point indicated in the sequence of operations for the respective AHU. Humidity alarms shall be suppressed in the event the outside air dewpoint is greater than 53 DEGF.
   8. All software alarms shall have a sliding deviation window which is directly linked to the set point, such that changing the set point shall automatically change the high and low alarm set points with the original deviation limits without operator intervention, unless the deviation band is required to be adjusted.
   9. All alarm points shall have a time delay adjustment from 0-300 seconds.

D. The BAS shall minimize the use of interposing relays. If the BAS contractor determines there is a need to use interposing relays, the contractor shall clearly document where the proposed relays will be used on the shop drawings.

E. There shall be a software point displayed at the operator workstation for each air handler and exhaust fan to indicate if the specific system is enabled or disabled. The operator shall be able to manually override the "system enable" from the operator workstation to shutdown the systems for maintenance. Only operators with the proper authorization shall be allowed to shutdown systems. The supply fan speed control shall be overridden and the fan speeds shall be commanded to minimum over a 5 minute time period. Once the AHU is at its minimum speed, BAS shall index the unit off and close its isolation dampers. Upon a restart, the AHU shall be commanded "on" as stated above.

F. There shall be a software point displayed at the operator workstation for each hydronic system to indicate if the specific system is enabled or disabled. The operator shall be able to manually override the "system enable" from the operator workstation to shutdown either system. Only operators with the proper authorization shall be allowed to shutdown systems.

G. The BAS shall monitor the status of each fan in the fan array through current switches. In the event the status of the VFD indicates that the fans should be operating and the dry contact indicates that one or more fans have not proved “ON”, an alarm shall be annunciated on the BAS.

H. The BAS shall monitor the run status of each VFD though a current switch. The enable/disable and speed signals shall be directly wired to the BAS controller associated with the fan or pump. The following conditions shall annunciate an alarm on the BAS:
   1. The fan or pump status does not coincide with the commanded state of the VFD after a 15 second delay.
   2. The drive indicates a VFD drive fault alarm.

I. The BAS shall monitor the run status of each pump and fan motor starter though a current switch. In the event the fan or pump status does not coincide with the commanded state of the motor starter after a 15 second delay an alarm shall be annunciated on the BAS.

J. Hand-Off-Auto selector switch shall be provided at each VFD. The BAS shall monitor the switch and shall provide an operator alarm when the fan or pump is out of the "Auto" position.

K. For systems where multiple fans are operating in unison with belt drives, an alarm shall be annunciated on the BAS in the event the run amps of any one operating fan is 20 percent greater or less than any other operating fan. The alarm shall be enabled 15 minutes after the fans have proven "ON". Note: This alarm shall indicate belt slippage.

L. No control loops shall be controlled over the communication network.

M. At a minimum, the BAS shall monitor and control all I/O points shown on the contract drawings and required to accomplish the sequence of operations specified herein.

N. Provide all coordination with Division 28 necessary to ensure that all systems are fully functional and operate in accordance with the sequence of operations specified herein.

O. Control Algorithms: In control algorithms which employ multiple sensors measuring the same medium, such as when system has multiple AHU duct static pressure sensors, a sensor not reporting or reporting a value deviating plus or minus 20 percent of specified control point shall be removed from the algorithm and an alarm shall be generated. Algorithm shall be adjusted to calculate on remaining sensors.

P. Unit Status and Alarm Reporting:
   1. All motors specified herein and/or shown to be under Building Automation System (BAS) command shall be monitored for status.
   2. Any air handling unit, exhaust fan or pump motor under control, which has been commanded to the On state and has failed to report On status within 10 seconds, or has been in the On state and has reported and Off status, shall be alarmed through the system to the operator console. Any failed motor shall be commanded off.

Q. Analog Alarm Limits: Any measured analog value shall be assigned alarm limits. Unless otherwise specified, any analog value exceeding plus or minus 15 percent of set point value shall generate an alarm. All alarm points shall be adjustable through software.

R. Filter Monitoring: Differential pressure shall be monitored across all air handling unit filters and exhaust filters. A maintenance alarm shall be generated upon excessive differential. Where multiple filters are combined in a bank, one monitor point shall be used.

S. Normal/Standby Power Modes: Upon loss of normal utility power, all systems shall return to respective specified off states. Systems designated on standby power shall be brought on line as specified with time delays after standby power has been established. Systems that shall be able to be used on standby power are AHU-4, AHU-6, CH-14-2, CT-14-1A, CHP-14-1E, CDP-14-2E, one boiler, HWP-14-5A, P-14, P-16, humidifier system and condenser piping heat trace.

T. Variable Frequency Drive Emergency Operation (Supply, Return and Exhaust Fans)
   1. All safety devices and interlocks required for normal operation must be effective when VFD control is manually indexed to "Hand", and "Auto" or "Bypass" (if required) mode. Provide required relay logic which will permit VFD operation in any mode only after all interlock and safety device requirements are met.
   2. If Bypass is required, BAS shall monitor status of "Drive in Bypass" contacts at VFD. Upon local manual indexing of VFD to "Bypass" mode, BAS shall command outdoor and discharge dampers open on air handling units, and suction isolation dampers open on exhaust fans. Damper limit switch contacts shall transfer to energize a run permissive relay with contacts in series with all unit safety device contacts. VFD bypass contactor shall then be enabled.
   3. Operation of any safety device or failure of any interlock relay shall immediately de-energize VFD in any run mode. All safety devices at fans shall be manual reset type only.

U. BAS shall monitor the supply AHU fire alarm relay. In the event the smoke detector located on the supply discharge of the unit, connected to the fire alarm system senses products of combustion, the BAS shall shutdown the unit. The specific smoke detectors which shutdown the AHU are defined on the fire alarm drawings.

V. BAS shall monitor the return AHU fire alarm relay. In the event the smoke detector located on the return of the unit, connected to the fire alarm system senses products of combustion, the BAS shall shutdown the unit. The specific smoke detectors which shutdown the AHU are defined on the fire alarm drawings.

W. Upon a utility power feed failure, indicated via a loss of power distribution to the building power monitoring contact, BAS shall alarm and interfaced AHU mechanical equipment is disabled. Equipment that is on standby power shall continue to operate.

X. Once power is restored to the building either standby or normal power monitoring contact, BAS shall automatically sequence mechanical equipment in a prioritized start-up schedule similar to initial start-up.

Y. Set Points:
   1. All set points given in the sequence of operations or in the drawings are for system startup and are preliminary. Initial setpoints shall be established during testing and balancing phase of the project by T&B, Commissioning contractors and design engineer. Optimum operating set points must be determined during actual occupancy and will be affected by many factors. These may include:
      a. Weather conditions.
      b. Building occupancy.
      c. Building utilization patterns.
      d. Variations in building construction.
      e. Variations in operating characteristics of actual installed building equipment.
   2. It is the responsibility of the building operators to determine those settings and operating methods which provide the best balance of operating efficiency and occupant comfort. This is an ongoing process. Optimum settings change as operating conditions change.

Z. Occupied/Unoccupied Control:
   1. The BAS shall be indexed to the occupied mode when ALL of the following conditions are met:
      a. The time-of-day (TOD) is between 6 am and 6 pm.
      b. The rest of the time, the BAS shall be indexed to the unoccupied mode.

AA. Most spaces have VAV boxes with reheat, and chilled beam. BAS shall provide room sequence to prevent heating and cooling simultaneously. Provide a minimum deadband of 5 DEGF (adjustable) to prevent simultaneous control of heating and cooling.

BB. Labs must be under either positive or negative pressure. For negative labs, labs supply terminal boxes shall track the labs exhaust terminal boxes. For positive labs, return/exhaust shall track the supply terminal box. This will be so that upon a failure of either supply or exhaust fans, labs shall remain negative/positive as the duct static pressure fluctuates due to fan failures. Lab exhaust must be monitored and fans shall be throttled back to allow for a safe egress (the pressure across the door is less than 30 ft/lb to open the door) from lab during a fan failure condition.

CC. Any GSEL and SES GSEL labs shall operate 24/7 with no unoccupied mode. ASC controllers for these labs shall be fed from standby power.

1.3 SUBMITTALS

A. Submittal requirements for this Section are specified in Section 25 10 00.

PART 2 - PRODUCTS

2.1 GENERAL

A. Refer to specification Section 25 30 00.

PART 3 - EXECUTION

3.1 AIR HANDLING UNIT AHU-4 (TYPICAL FOR AHU-6)

A. Refer to the Contract Drawings for a diagram of this system.

B. One PSC controller shall be provided for control of each air handler. Controlling multiple units from the same controller is unacceptable. The use of an Application Specific Controller (ASC) is unacceptable.

C. The AHUs are supply/return recirculating air systems. AHU shall operate to condition the air twenty-four (24) hours per day, seven (7) days per week to satisfy the associated area temperature and pressurization set points.

D. Air Handling Unit Fan Soft Start: Provide an unloaded fan start sequence (soft start) for each supply and return fan. This feature ensures the BAS slowly accelerates fan speed to a minimum speed upon initial startup. The VFD shall ramp fan speed to the control set point in a smooth, bumpless, trouble-free manner over a 5 minute time period. The BAS shall decelerate fan speed to minimum and disable control loops when system shuts down.

E. A system temperature deadband of 5 DEGF (adjustable) shall be provided so that the heating and cooling modes are not in operation simultaneously.

F. Air Handling Unit Startup:

1. Upon start-up of the air handler, the BAS shall start all supply fans in the array simultaneously. The VFD speeds shall be commanded to minimum.
2. The return fans shall be started 5 seconds after the supply fans prove "ON". The supply and return fan speed control shall then be enabled and the fans shall ramp in unison to their respective control points over a 5 minute time period.
3. When the supply fans are enabled through the HOA switch provided with the VFD or through the BAS when the VFD is in the "Auto" position, the following sequence shall occur:
    a. The AHU supply smoke isolation damper shall be hardwire-interlocked with the supply fan VFD. When the unit is commanded "ON" the isolation damper shall open, once the damper proves open with the associated limit switch the supply fan shall start. If at any point during operation, the limit switch indicates the damper is closing, the associated supply and return fan shall be shut down and commanded "OFF" by the BAS.

b. The AHU return smoke isolation damper shall be hardwire-interlocked with the supply fan VFD. When the unit is commanded "ON" the isolation damper shall open, once the damper proves open with the associated limit switch the supply fan shall start. If at any point during operation, the limit switch indicates the damper is closing, the associated supply and return fan shall be shut down and commanded "OFF" by the BAS.
c. When the return fans are enabled through the HOA switch provided with the VFD or through the BAS when the VFD is in the "Auto" position, the following sequence shall occur: The return fan shall be hardwire-interlocked to the supply fan via a set of auxiliary contacts in the supply fan VFD. In the event the supply fan is enabled, the return fans shall be allowed to operate.
d. Once both the supply and return fans are proven in operation, control loops shall be activated.
e. AHU-4: The outside air damper shall be commanded to its minimum outside air position once AHU is proven in operation. Once AHU is on, damper shall never go below its minimum outside air position.
f. AHU-6: The minimum outside air damper shall be commanded to its minimum outside air position once AHU is proven in operation. Once AHU is on, damper shall never go below its minimum outside air position.

G. Air Handling Unit Shutdown: In the event the AHU is disabled through the BAS or through a hardwire-interlock safety the following shall occur:
1. The supply and return fans are de-energized, the smoke dampers on the supply and return duct shall close, the outside air damper (minimum and maximum dampers for AHU-6 only), relief air damper, and cooling coil and humidifier control valves shall close. The return air damper shall remain open.
2. The BAS shall decelerate fan speed to minimum and disable control loops when the AHU shuts down.
3. Units preheat coil control valve shall close unless the outside air temperature is below 50 DEGF, then BAS shall modulate the preheat coil control valve to maintain 70 DEGF in the fan plenum. Once outside air temperature rises above 52 DEGF, for more than 15 minutes, valve shall close.

H. Air Handling Unit Supply Fan Pressure Control:
1. The supply fan speeds shall be controlled to maintain the discharge static pressure at set point. In the event that the discharge static pressure drops below set point, the speed of the fan array shall increase. Upon an increase in static pressure above set point, the reverse shall occur. BAS shall control all of the fans in the fan array simultaneously.
2. The BAS shall monitor downstream system static pressure at reference points in the supply ductwork as indicated on the contract drawings. The controller shall compare the static pressure signals to each of their corresponding set points (1.0 IN w.c. initially). Final set point shall be established by the system Testing and Balancing (TAB) contractor.
3. In the event that the static pressure controller fails to transmit a discharge static pressure set point to the PSC, the BAS shall alarm as the AHU shall control to the last known value.
4. The duct static pressure set point shall be reset as follows:
   a. The BAS shall continuously monitor all the rooms' terminal boxes damper positions.
   b. The BAS shall slowly reset the static pressure set point downwards until one or more of the primary air terminal boxes is 95 percent open (starved box strategy).
   c. As the controlling terminal device primary air damper approaches 100 percent open, the opposite shall occur.
   d. System static pressure is set at supervisory station.
   e. BAS operator shall be able to remove a terminal box(es) from the reset strategy.

I. Air Handling Unit Return Fan Airflow Tracking Control:
1. The BAS shall monitor the airflow at the outlet of supply and return fans.
2. BAS shall modulate return fans in unison to maintain the total return air volume equal to the total supply air volume minus an adjustable offset. Final offset shall be determined by the TAB contractor. BAS shall annunciate an alarm in the event the airflow CFM offset condition varies by 10 percent or more from set point, signaling the need for corrective action.

J. Air Handling Unit Outside Air Damper Control (AHU-4):
1. The unit shall consist of an outside air and return air damper. During unit start-up, the outside air damper shall open to minimum position and the return air damper shall remain open.
2. The damper control loops shall be enabled once the following conditions are met. The dampers shall modulate to their control set points over a 5-minute time period. The maximum outside air damper shall remain closed until the unit has been operating for a 5-minute time period.
3. The outside air damper shall modulate to maintain the outside airflow at set point. The outside air damper shall modulate open when outside airflow is below setpoint. The reverse shall occur when outside airflow is above setpoint. In the event the outside air damper is 100 percent open and the flow set point is not achieved, the return air damper shall modulate closed to achieve the outside airflow set point. An alarm shall be annunciated on the BAS if the outside airflow is 10 percent below set point.

K. Air Handling Unit Outside Air Damper Control (AHU-6):
1. The unit shall consist of a minimum and maximum outside air and return air damper. During unit start-up, the minimum outside air damper shall open as the maximum outside air damper remains closed and the return air damper shall remain open.
2. The damper control loops shall be enabled once the following conditions are met. The dampers shall modulate to their control set points over a 5-minute time period. The maximum outside air damper shall remain closed until the unit has been operating for a 5-minute time period.
3. The minimum outside air damper shall modulate to maintain the outside airflow at set point. The minimum outside air damper shall modulate open when outside airflow is below setpoint. The reverse shall occur when outside airflow is above setpoint. In the event the outside air damper is 100 percent open and the flow set point is not achieved, the return air damper shall modulate closed to achieve the outside airflow set point. An alarm shall be annunciated on the BAS if the outside airflow is 10 percent below set point.

L. Air Handling Unit Economizer Mode (AHU-4):
1. The unit shall consist of an outside air and return air damper. During unit start-up, the outside air damper shall open to minimum position and the return air damper shall remain open.
2. When outside air temperature is above 50 DEGF and less than or equal to the return air temperature minus 5 DEG, BAS shall modulate the outside air damper to full open position and return air damper to full closed position.
3. When outside air temperature is below 50 DEGF, BAS shall modulate return air damper in unison with outside air damper to maintain the mixed air temperature at set point. Upon an increase in mixed air temperature above its temperature set point, BAS shall modulate maximum outside air damper open and return air damper closed. Upon a decrease in mixed air temperature below set point, the reverse shall occur. The outside air damper shall never close beyond minimum position when unit is in operation.

M. Air Handling Unit Economizer Mode (AHU-6):
1. The unit shall consist of a maximum outside (economizer) air and return air damper. During unit start-up, the maximum outside air damper shall remain closed and the return air damper shall remain open.

2. When outside air temperature is above 50 DEGF and less than or equal to the return air temperature minus 5 DEG, BAS shall modulate the maximum outside air damper to full open position and return air damper to full closed position.
3. When outside air temperature is below 50 DEGF, BAS shall modulate return air damper in unison with maximum outside air damper to maintain the mixed air temperature at set point. Upon an increase in mixed air temperature above its temperature set point, BAS shall modulate maximum outside air damper open and return air damper closed. Upon a decrease in mixed air temperature below set point, the reverse shall occur.

N. Air Handling Unit Preheat Coil Control:
1. Upon a decrease in the preheat coil discharge air temperature, the pre-heat coil control valve shall begin to modulate open to increase the supply of hot water to the coil to maintain the coil discharge air at its set point. The set point shall be 2 DEG less than the unit discharge temperature set point. The reverse sequence shall occur on an increase in discharge air temperature.
2. Units preheat coil is provided with a freeze protection pump. When the outdoor air temperature drops below 45 DEGF, (adjustable) or whenever the preheat coil control valve begins to open, pump shall be activated. Pump shall be de-energized when outdoor air temperature is above 50 DEGF (adjustable) and the preheat coil control valve is closed. BAS shall monitor pumps status and alarm upon failure to operate.
3. Upon a freezestat alarm condition, BAS shall command the preheat coil to its 100 percent open position and freeze pump shall run. Once alarm condition has cleared, control loops shall be returned to normal operation.

O. Air Handling Unit Cooling Coil Control:
1. Upon starting the AHU the temperature control loops shall be enabled.
2. The cooling coil control valve shall modulate to maintain the unit discharge temperature at a set point of 50 DEGF (adjustable).
3. Unit discharge air temperature shall be reset linearly between 50 and 60 DEGF based on outside air temperature. When outside air temperature is 80 degrees or above, cooling coil discharge air temperature shall be 50 degrees. For every 6 degrees below 80 degrees outside air temperature, discharge air temperature shall be reset upwards 1 degree. When the outside air temperature is 50 degree or below, cooling coil discharge air temperature shall be 60 degrees.
4. In the event the discharge temperature is above set point the cooling coil control valve shall modulate open. The reverse sequence shall occur upon a drop in discharge air temperature.
5. Upon a freezestat alarm condition, BAS shall command the cooling coil control valve to its 50 percent position. Once alarm condition has cleared, control loops shall be returned to normal operation.

P. Air Handling Unit Relief Air Damper Control:
1. The BAS shall compare the relief static pressure signal with its corresponding set point of 0.15 IN w.c. and issue a control signal to modulate its relief air damper between its normally closed position and fully open position to maintain this static pressure set point.
2. Upon an increase in the relief air static pressure above its set point, the relief air damper shall modulate toward its open position to meet the desired set point. The reverse sequence shall occur upon a drop in this relief air static pressure below set point.
3. System shall have a damper to relieve air into the service vestibule. Damper shall be open when the AHU is on and closed when off.

Q. Airflow Monitoring:
1. BAS shall monitor supply, return, outside air flows (minimum OA for AHU-6) as shown on contract drawings.
2. BAS shall alarm when supply to return airflow tracking is not being maintained.
3. BAS shall monitor differential across filters, and alarm upon a high condition (0.9 IN w.c. for the pre-filters and 1.5 IN w.c. for the final filter), notifying operator of a potential filter problem.

R. Air Handling Unit Humidity Control:
   1. Upon starting fan system, the BAS shall delay activation of humidification control until after the units discharge temperature has stabilized (5 minute time-delay).
   2. BAS shall provide a start humidity control permissive enable/disable signal to each AHU GoFog system valve panel controller. BAS shall monitor the AHU return air humidity. Once indexed on, BAS shall supply a humidity demand control 4-20 Ma signal to each AHU GoFog humidity valve panel controller, which represents the 0-100% capacity required to maintain the return humidity at set point of 35% in the winter and 40% in the summer. GoFog humidity valve panel controller shall then turn on the appropriate stage to maintain the setpoint.
   3. Whenever supply humidity exceeds 85 percent RH, the BAS shall index the humidifier off and alarm shall be generated at the BAS Supervisory Station. Humidity control shall resume when the humidity drops below 78 percent RH.
   4. In the event that the discharge humidity drops below 10 percent, the sensor shall be assumed failed, the humidifier shall be commanded OFF and an alarm annunciated on the BAS.
   5. Humidifier system shall be off whenever the AHU is off.

S. Air Handling Unit Demand Control Ventilation:
   1. BAS shall monitor the return air CO2 and alarm upon a high condition of 1500 ppm (adjustable). Upon the alarm condition, the BAS operator can review the operating conditions and make the decision to allow the BAS system to increase OA if they can maintain discharge conditions with the additional OA being introduced into the system.
   2. To ensure adequate ventilation, the BAS shall increase the quantity of outside air based on CO2 concentrations within the space served.
   3. The CO2 shall be monitored on the BAS in locations where CO2 sensors are indicated on the mechanical drawings. In the event the CO2 sensor senses more than 700 ppm (adjustable), the associated VAV terminal unit (dedicated to the respective zone) air flow control shall be overridden and the airflow shall be reset upwards to maintain the CO2 below 700 ppm (adjustable).
   4. The BAS shall poll all CO2 sensors and associated VAV terminal units (served by the respective AHU system) once every 10 minutes. The polled information shall then be evaluated and the AHU shall control to the space with the highest concentration of CO2.
   5. In the event that the associated VAV terminal unit is 100 percent open and the CO2 concentration is greater than 700 ppm and less than 1400 ppm, the AHU minimum outside airflow set point shall be reset linearly from the scheduled minimum airflow to 50 percent of the maximum scheduled airflow.
   6. In the event the CO2 concentration is greater than 1400 ppm, the outside airflow shall remain the maximum and an alarm shall be annunciated on the BAS.
   7. The AHU minimum outside airflow set point shall remain constant until the next time the CO2 sensors and terminal units are polled. The set point shall be reset over a 1 minute time period.

T. Air Handling Unit Hardwired Safeties:
   1. All safeties shall be hardwire-interlocked with the supply fan VFDs. The return fan shall be hardwire-interlocked with the supply fan VFD.
   2. In the event the return fan does not prove "ON", an alarm shall be annunciated on the BAS and the supply fan speeds shall be reduced to minimum speed until the return fans proves "ON".
   3. A high static pressure condition at the supply fan array shall cause all fans to be de-energized and an alarm shall be annunciated in the BAS. The high static pressure set point shall be 1 inch greater than the total static pressure of the fan array, as indicated by the unit manufacturer. The switch shall be a manual reset type.
   4. A high low static pressure condition at the return fan array shall cause all fans to be de-energized and an alarm shall be annunciated in the BAS. The high static pressure set point shall be 1 inch greater than the total static pressure of the fan array, as indicated by the unit manufacturer. The switch shall be a manual reset type.

5. All low temperature detectors (freezestat) provided by the BAS contractor to adequately protect the cooling coil shall be wired in series to disable the supply and return fans associated with the AHU and annunciate and alarm on the BAS below a set point of 40 DEGF. The low temperature detectors shall be manual reset type.
6. The BAS shall monitor the fire alarm system (FAS) via a fire alarm relay on both the supply and return fans. In the event the FAS senses smoke and changes the state of the relay, an alarm shall be annunciated on the BAS and the associated supply and return fans shall be de-energized through a hardwired interlock in the FAS relay. AHU shall be shutdown.
7. Hardwired safety devices must be active in "Hand", "Auto", and "Bypass" (if required) positions. When a safety is activated, the system shall shutdown in a controlled manner.

U. Utility Power Failure:

1. Upon a utility power feed failure, indicated via a loss of power distribution to the building power monitoring contact, BAS shall alarm. Supply and exhaust fans shall be allowed to ride through transfer of power. If power is not transferred or available after 10 seconds, then interfaced mechanical equipment is disabled. Refer to the room controls to determine the failure positions of the supply and exhaust terminal box dampers. Supply terminal boxes shall close completely on negative rooms and open to a minimum position on positive rooms. Exhaust terminal boxes shall fail to their minimum open position on negative rooms and closed on positive rooms.
2. Once the standby power generator is proven in operation, If after the allotted 10 seconds either standby power, (indicated via Automatic Transfer Switch contact) or normal power is restored to either motor control center or power distribution panel power monitoring contact, BAS shall automatically sequence mechanical equipment that was in operation prior to the power failure back into operation in a prioritized start-up schedule similar to initial start-up. AHU-4 and AHU-6 units shall be able to operate during a standby power condition.
3. Once normal power is restored to the building normal power monitoring contact, BAS shall automatically sequence mechanical equipment in a prioritized start-up schedule similar to initial start-up.

V. Supply or Return fan failure:

1. Supply and Return fan system shall have multiple fans in a fan wall array, each fan shall be monitored by an individual current transducer. During normal operation all the fans shall operate simultaneously. Upon a failure of one of the fans in the fan array to operate, BAS shall alarm and increase the remaining operating fans speed to maintain the duct static pressure setpoint. Upon a failure of a second fan in the fan array, BAS shall alarm and shut down the system.

3.2 AIR HANDLING UNIT AHU-1 (TYPICAL FOR AHU-2, AHU-3, AHU-5, AND AHU-7)

A. Refer to the Contract Drawings for a diagram of this system.

B. One PSC controller shall be provided for control of each air handler. Controlling multiple units from the same controller is unacceptable. The use of an Application Specific Controller (ASC) is unacceptable.

C. BAS shall index the AHU-1/RAF-1 and the associated exhaust fans ON in the Building Occupied Mode, or OFF in the unoccupied mode using an owner defined time schedule for room occupied/unoccupied temperature control Once indexed into operation by the BAS system, unit factory provided controller BAS shall operate both heating, cooling and economizer modes. Once in the Unoccupied Mode, BAS shall shutdown the unit unless indexed into operation to meet building unoccupied temperature settings by a common building thermostat using the control sequence for the Warm-up/Cool-down modes. Once indexed into operation, unit shall run continuously to satisfy the associated area temperature and pressurization set points as floor shaft combination fire/smoke dampers are opened and terminal boxes are indexed into their occupied mode.

D. Air Handling Unit Fan Soft Start: Provide an unloaded fan start sequence (soft start) for each supply and return fan. This feature ensures the BAS slowly accelerates fan speed to a minimum speed upon initial startup. The VFD shall ramp fan speed to the control set point in a smooth, bumpless, trouble-free manner over a 5 minute time period. The BAS shall decelerate fan speed to minimum and disable control loops when system shuts down.

E. A system temperature deadband of 5 DEGF (adjustable) shall be provided so that the heating and cooling modes are not in operation simultaneously.

F. Air Handling Unit Startup:
   1. Upon start-up of the air handler, the BAS shall start all supply fans in the array simultaneously. The VFD speeds shall be commanded to minimum.
   2. The return fans shall be started 5 seconds after the supply fans prove "ON". The supply and return fan speed control shall then be enabled and the fans shall ramp in unison to their respective control points over a 5 minute time period.
   3. When the supply fans are enabled through the HOA switch provided with the VFD or through the BAS when the VFD is in the "Auto" position, the following sequence shall occur:
      a. The AHU supply smoke isolation damper shall be hardwire-interlocked with the supply fan VFD. When the unit is commanded "ON" the isolation damper shall open and once the damper proves open with the associated limit switch the supply fan shall start. If at any point during operation, the limit switch indicates the damper is closing, the associated supply and return fan shall be shut down and commanded "OFF" by the BAS.
      b. The AHU return smoke isolation damper shall be hardwire-interlocked with the supply fan VFD. When the unit is commanded "ON" the isolation damper shall open and once the damper proves open with the associated limit switch the supply fan shall start. If at any point during operation, the limit switch indicates the damper is closing, the associated supply and return fan shall be shut down and commanded "OFF" by the BAS.
      c. When the return fans are enabled through the HOA switch provided with the VFD or through the BAS when the VFD is in the "Auto" position, the following sequence shall occur: The return fan shall be hardwire-interlocked to the supply fan via a set of auxiliary contacts in the supply fan VFD. In the event the supply fan is enabled, the return fans shall be allowed to operate.
      d. Once both the supply and return fans are proven in operation, control loops shall be activated.
      e. The outside air damper shall be commanded to its minimum outside air position once AHU is proven in operation. Once AHU is on, damper shall never go below its minimum outside air position.

G. Air Handling Unit Shutdown: In the event the AHU is disabled through the BAS or through a hardwire-interlock safety the following shall occur:
   1. The supply and return fans are de-energized, the smoke dampers on the supply and return duct shall close, the outside air damper, relief air damper, and cooling coil and humidifier control valves shall close. The return air damper shall remain open.
   2. The BAS shall decelerate fan speed to minimum and disable control loops when the AHU shuts down. During shutdown, each isolation damper shall gradually close to prevent a high static pressure condition in the unit or duct.
   3. Units preheat coil control valve shall close unless the outside air temperature is below 50 DEGF, then BAS shall modulate the preheat coil control valve to maintain 70 DEGF in the fan plenum. Once outside air temperature rises above 52 DEGF, for more than 15 minutes, valve shall close.

H. Air Handling Unit Supply Fan Pressure Control:
   1. The supply fan speeds shall be controlled to maintain the discharge static pressure at set point. In the event that the discharge static pressure drops below set point, the speed of the fan array shall increase. Upon an increase in static pressure above set point, the reverse shall occur. BAS shall control all of the fans in the fan array simultaneously.
   2. The BAS shall monitor downstream system static pressure at reference points in the supply ductwork as indicated on the contract drawings. The controller shall compare the static pressure signals to each of their corresponding set points (1.0 IN w.c. initially). Final set point shall be established by the system Testing and Balancing (TAB) contractor.
   3. In the event that the static pressure controller fails to transmit a discharge static pressure set point to the PSC, the BAS shall alarm as the AHU shall control to the last known value.
   4. The duct static pressure set point shall be reset as follows:
      a. The BAS shall continuously monitor all the rooms' terminal boxes damper positions.
      b. The BAS shall slowly reset the static pressure set point downwards until one or more of the primary air terminal boxes is 95 percent open (starved box strategy).
      c. As the controlling terminal device primary air damper approaches 100 percent open, the opposite shall occur.
      d. System static pressure is set at supervisory station.
      e. BAS operator shall be able to remove a terminal box(es) from the reset strategy.

I. Air Handling Unit Return Fan Airflow Tracking Control:
   1. The BAS shall monitor the airflow at the outlet of supply and return fans.
   2. BAS shall modulate return fans in unison to maintain the total return air volume equal to the total supply air volume minus an adjustable offset. Final offset shall be determined by the TAB contractor. BAS shall annunciate an alarm in the event the airflow CFM offset condition varies by 10 percent or more from set point, signaling the need for corrective action.

J. Air Handling Unit Outside Air Damper Control:
   1. The unit shall consist of an outside air and return air damper. During unit start-up, the outside air damper shall open to minimum position and the return air damper shall remain open.
   2. The damper control loops shall be enabled once the following conditions are met. The dampers shall modulate to their control set points over a 5-minute time period. The maximum outside air damper shall remain closed until the unit has been operating for a 5-minute time period.
   3. The outside air damper shall modulate to maintain the outside airflow at set point. The outside air damper shall modulate open when outside airflow is below setpoint. The reverse shall occur when outside airflow is above setpoint. In the event the outside air damper is 100 percent open and the flow set point is not achieved, the return air damper shall modulate closed to achieve the outside airflow set point. An alarm shall be annunciated on the BAS if the outside airflow is 10 percent below set point.

K. Air Handling Unit Economizer Mode:
   1. The unit shall consist of an outside air and return air damper. During unit start-up, the outside air damper shall open to minimum position and the return air damper shall remain open.
   2. When outside air temperature is above 50 DEGF and less than or equal to the return air temperature minus 5 DEG, BAS shall modulate the outside air damper to full open position and return air damper to full closed position.
   3. When outside air temperature is below 50 DEGF, BAS shall modulate return air damper in unison with outside air damper to maintain the mixed air temperature at set point. Upon an increase in mixed air temperature above its temperature set point, BAS shall modulate maximum outside air damper open and return air damper closed. Upon a decrease in mixed air temperature below set point, the reverse shall occur. The outside air damper shall never close beyond minimum position when unit is in operation.

L. Air Handling Unit Preheat Coil Control:
   1. Upon a decrease in the preheat coil discharge air temperature, the pre-heat coil control valve shall begin to modulate open to increase the supply of hot water to the coil to maintain the coil discharge air at its set point. The set point shall be 2 DEG less than the unit discharge temperature set point. The reverse sequence shall occur on an increase in discharge air temperature.
   2. Units preheat coil is provided with a freeze protection pump. When the outdoor air temperature drops below 45 DEGF, (adjustable) or whenever the preheat coil control valve begins to open, pump shall be activated. Pump shall be de-energized when outdoor air temperature is above 50 DEGF (adjustable) and the preheat coil control valve is closed. BAS shall monitor pumps status and alarm upon failure to operate.
   3. Upon a freezestat alarm condition, BAS shall command the preheat coil to its 100 percent open position and freeze pump shall run. Once alarm condition has cleared, control loops shall be returned to normal operation.

M. Air Handling Unit Cooling Coil Control:
   1. Upon starting the AHU the temperature control loops shall be enabled.
   2. The cooling coil control valve shall modulate to maintain the unit discharge temperature at a set point of 50 DEGF (adjustable).
   3. Unit discharge air temperature shall be reset linearly between 50 and 60 DEGF based on outside air temperature. When outside air temperature is 80 degrees or above, cooling coil discharge air temperature shall be 50 degrees. For every 6 degrees below 80 degrees outside air temperature, discharge air temperature shall be reset upwards 1 degree. When the outside air temperature is 50 degree or below, cooling coil discharge air temperature shall be 60 degrees.
   4. In the event the discharge temperature is above set point the cooling coil control valve shall modulate open. The reverse sequence shall occur upon a drop in discharge air temperature.
   5. Upon a freezestat alarm condition, BAS shall command the cooling coil control valve to its 50 percent position. Once alarm condition has cleared, control loops shall be returned to normal operation.

N. Air Handling Unit Relief Air Damper Control:
   1. The BAS shall compare the relief static pressure signal with its corresponding set point of 0.15 IN w.c. and issue a control signal to modulate its relief air damper between its normally closed position and fully open position to maintain this static pressure set point.
   2. Upon an increase in the relief air static pressure above its set point, the relief air damper shall modulate toward its open position to meet the desired set point. The reverse sequence shall occur upon a drop in this relief air static pressure below set point.
   3. System shall have a damper to relieve air into the service vestibule. Damper shall be open when the AHU is on and closed when off.

O. Airflow Monitoring:
   1. BAS shall monitor supply, return and outside air flows as shown on contract drawings.
   2. BAS shall alarm when supply to return airflow tracking is not being maintained.
   3. BAS shall monitor differential across filters, and alarm upon a high condition (0.9 IN w.c. for the pre-filters and 1.5 IN w.c. for the final filter), notifying operator of a potential filter problem.

P. Air Handling Unit Humidity Control:
   1. Upon starting fan system, the BAS shall delay activation of humidification control until after the units discharge temperature has stabilized (5 minute time-delay).

2. BAS shall provide a start humidity control permissive enable/disable signal to each AHU GoFog system valve panel controller. BAS shall monitor the AHU return air humidity. Once indexed on, BAS shall supply a humidity demand control 4-20 Ma signal to each AHU GoFog humidity valve panel controller, which represents the 0-100% capacity required to maintain the return humidity at set point of 35% in the winter and 40% in the summer. GoFog humidity valve panel controller shall then turn on the appropriate stage to maintain the setpoint.
3. Whenever supply humidity exceeds 85 percent RH, the BAS shall index the humidifier off and alarm shall be generated at the BAS Supervisory Station. Humidity control shall resume when the humidity drops below 78 percent RH.
4. In the event that the discharge humidity drops below 10 percent, the sensor shall be assumed failed, the humidifier shall be commanded off and an alarm annunciated on the BAS.
5. Humidifier system shall be off whenever the AHU is off.

Q. Air Handling Unit Demand Control Ventilation:
1. BAS shall monitor the return air CO2 and alarm upon a high condition of 1500 ppm (adjustable). Upon the alarm condition, the BAS operator can review the operating conditions and make the decision to allow the BAS system to increase OA if they can maintain discharge conditions with the additional OA being introduced into the system.
2. To ensure adequate ventilation, the BAS shall increase the quantity of outside air based on CO2 concentrations within the space served.
3. The CO2 shall be monitored on the BAS in locations where CO2 sensors are indicated on the mechanical drawings. In the event the CO2 sensor senses more than 700 ppm (adjustable), the associated VAV terminal unit (dedicated to the respective zone) air flow control shall be overridden and the airflow shall be reset upwards to maintain the CO2 below 700 ppm (adjustable).
4. The BAS shall poll all CO2 sensors and associated VAV terminal units (served by the respective AHU system) once every 10 minutes. The polled information shall then be evaluated and the AHU shall control to the space with the highest concentration of CO2.
5. In the event that the associated VAV terminal unit is 100 percent open and the CO2 concentration is greater than 700 ppm and less than 1400 ppm, the AHU minimum outside airflow set point shall be reset linearly from the scheduled minimum airflow to 50 percent of the maximum scheduled airflow.
6. In the event the CO2 concentration is greater than 1400 ppm, the outside airflow shall remain the maximum and an alarm shall be annunciated on the BAS.
7. The AHU minimum outside airflow set point shall remain constant until the next time the CO2 sensors and terminal units are polled. The set point shall be reset over a 1 minute time period.

R. Air Handling Unit Hardwired Safeties:
1. All safeties shall be hardwire-interlocked with the supply fan VFDs. The return fan shall be hardwire-interlocked with the supply fan VFD.
2. In the event the return fan does not prove "ON", an alarm shall be annunciated on the BAS and the supply fan speeds shall be reduced to minimum speed until the return fans proves "ON".
3. A high static pressure condition at the supply fan array shall cause all fans to be de-energized and an alarm shall be annunciated in the BAS. The high static pressure set point shall be 1 inch greater than the total static pressure of the fan array, as indicated by the unit manufacturer. The switch shall be a manual reset type.
4. A high low static pressure condition at the return fan array shall cause all fans to be de-energized and an alarm shall be annunciated in the BAS. The high static pressure set point shall be 1 inch greater than the total static pressure of the fan array, as indicated by the unit manufacturer. The switch shall be a manual reset type.

5. All low temperature detectors (freezestat) provided by the BAS contractor to adequately protect the cooling coil shall be wired in series to disable the supply and return fans associated with the AHU and annunciate and alarm on the BAS below a set point of 40 DEGF. The low temperature detectors shall be manual reset type.
6. The BAS shall monitor the fire alarm system (FAS) via a fire alarm relay on both the supply and return fans. In the event the FAS senses smoke and changes the state of the relay, an alarm shall be annunciated on the BAS and the associated supply and return fans shall be de-energized through a hardwired interlock in the FAS relay. AHU shall be shutdown.
7. Hardwired safety devices must be active in "Hand", "Auto", and "Bypass" (if required) positions. When a safety is activated, the system shall shutdown in a controlled manner.

S. Occupied/Unoccupied Mode:
1. Occupied Mode: BAS indexes AHU\RF\EF's, VVB's, FCU's, FPB's and CVB's to their occupied temperature and flow set points.
2. Unoccupied Mode: BAS indexes AHU/RF/EF's OFF, VVB's to minimum air flow, and sets back room temperature to FCU's, FPB's and CVB's.

T. Warm-Up/Cool-Down Mode:
1. Start time of morning warm-up/cool-down mode by BAS shall be based on an optimum start program, using historical data, outside air temperature, and zone space temperature.
2. When system is in this mode, BAS signals the AHU to start unit and through a separate signal indexes the AHU to operate in occupied mode, except as follows:
   a. Outside air and relief dampers are fully closed, return damper is fully open.
   b. Mixed air temperature control loop is disabled and unit operates on 100 percent recirculation.
   c. For warm-up, discharge air temperature setpoint is 80 DEGF. For cool-down, discharge temperature remains at 53 DEGF.
   d. Unit transfers to full occupied mode when return temperature reaches occupied set point or scheduled occupied time is reached (BAS removing separate signal), whichever comes first.
   e. Exhaust fans are OFF.
   f. Return to supply fan CFM tracking differential shall be zero, with a limit of the supply fan CFM not to exceed that of the max return fan CFM.

U. Supply or Return fan failure:
1. Supply and Return fan system shall have multiple fans in a fan wall array, each fan shall be monitored by an individual current transducer. During normal operation all the fans shall operate simultaneously. Upon a failure of one of the fans in the fan array to operate, BAS shall alarm and increase the remaining operating fans speed to maintain the duct static pressure setpoint. Upon a failure of a second fan in the fan array, BAS shall alarm and shut down the system.

V. Utility Power Failure:
1. Upon a utility power feed failure, indicated via a loss of power distribution to the building power monitoring contact, BAS shall alarm. Supply and exhaust fans shall be allowed to ride through transfer of power. If power is not transferred or available after 10 seconds, then interfaced mechanical equipment is disabled. Supply terminal boxes shall close completely. Exhaust terminal boxes shall fail open.
2. Only AHU-4 and AHU-6 units shall be able to operate during a standby power condition, all other AHU's shall remain off.
3. Once normal power is restored to the building normal power monitoring contact, BAS shall automatically sequence mechanical equipment in a prioritized start-up schedule similar to initial start-up.

3.3 TOILET EXHAUST FANS EF-1 AND EF-2

A. Fan systems are single speed, constant volume type, and once indexed on, fan shall run continuously when their associated air handling units is in operation.

B. All fans shall have remote start/stop control and status monitoring by the BAS.

C. Upon a fan failure, the BAS shall be alarmed and the fan shall be indexed off.

D. BAS shall monitor the starter's hand-off-auto position switch and alarm when switch is not in the auto position.

3.4 EXHAUST FAN EF-8 CONTROL (TYPICAL FOR EF-10, EF-11, AND EF-13)

A. Refer to contract drawings for a diagram of this system.

B. All fans shall have remote start/stop control and status monitoring by the BAS. Once indexed into operation through the BAS, fan shall operate 24 hours a day 7 days a week.

C. Upon a failure of the exhaust fans air handling unit, rooms exhaust terminal boxes shall be indexed to its minimum open position and the exhaust fans speed shall be reduced to a setpoint established by the T&B contractor to allow a safe egress from the rooms.

D. Upon an exhaust fan failure, the BAS shall be alarmed and the fan shall be indexed off.

E. Exhaust fans shall be provided with a two-position isolation damper on the suction side of fan, which is controlled via the VFD. The associated fan's VFD control circuit shall energize the damper. Damper shall be proven in the open position, through the use of end switch, prior to fan starting.

F. Upon a low static pressure condition in exhaust duct, fan shall be shutdown and isolation damper closes. Static pressure switch is manually reset.

G. Fan speed control:
   1. A system static pressure probe, located in the branch ducts, shall forward static pressure signal to its static pressure transmitter. Output signal from pressure transmitters are sent to BAS.
   2. BAS compares static pressure signal against its set point of 2 IN w.c. (adjustable) and controls the fans speed via its VFD.
   3. BAS shall provide an unloaded fan start sequence (soft start). This feature ensures the VFD slowly accelerates fan speed to a minimum speed upon initial startup. VFD shall ramp fan speed to the control set point in a smooth, bumpless, trouble-free manner.
   4. VFD shall decelerate fan speed to minimum and disable control loops when system shuts down.

H. Upon an AHU or exhaust fan failure or shutdown, room associated supply terminal box shall be indexed to its minimum open position and the associated exhaust fans speed shall be reduced minimum, to allow for a safe egress from the room.

3.5 EXHAUST FAN EF-4 CONTROL (TYPICAL FOR EF-5, EF-6, AND EF-7)

A. Refer to contract drawings for a diagram of this system.

B. All fans shall have remote start/stop control and status monitoring by the BAS. BAS shall provide a local fan ON/OFF switch by the high bay outside door. BAS shall monitor the switches position and if indexed to the ON position, start the fan. If switch has been indexed to its OFF position, BAS shall stop the fan unless the fan is being indexed into operation from the gas monitoring panel. Under normal room controls, the fan shall be OFF.

C. EF-4, EF-5 and EF-6 exhaust shall be provided with a hose that shall be tied to the vehicle exhaust prior to the vehicle operation. Once hose has been installed onto the vehicle exhaust pipe, operator shall manually start the fan using the fan start switch.

D. High bay KMT/KMR shall have a return air damper to AHU-7 and an exhaust damper to EF-4.

E. BAS shall monitor the fans status, through a current sensor, and upon an exhaust fan failure, the BAS shall be alarmed and the fan shall be indexed off.

F. Exhaust fans shall be provided with a two-position isolation damper on the suction side of fan, which is controlled via the VFD. The associated fan's VFD control circuit shall energize the damper. Damper shall be proven in the open position, through the use of end switch, prior to fan starting.

G. Upon a low static pressure condition in exhaust duct, BAS shall alarm and fan shall be shut down and isolation damper closes. Static pressure switch is manually reset.

H. Fan speed control:
   1. Once fan is indexed on, BAS shall ramp the fan speed, through the VFD to a predetermined speed established by the T&B contractor.
   2. BAS shall provide an unloaded fan start sequence (soft start). This feature ensures the VFD slowly accelerates fan speed to a minimum speed upon initial startup. VFD shall ramp fan speed to the control set point in a smooth, bumpless, trouble-free manner.
   3. VFD shall decelerate fan speed to minimum and disable control loops when system shuts down.

I. The three homeland high bay areas shall be provided with a supply air terminal box. Once AHU-7 has been placed into operation, the supply air damper terminal box shall be modulated with the reheat coil control valve to maintain a room temperature and airflow setpoints. Upon the gas monitoring panel alarm being activated, or the exhaust fan being manually activated, the supply air terminal box damper shall go full open as the AHU increases its outside air damper to provide additional outside air the high bay. Normal operation shall commence once the gas monitoring panel alarm has cleared and exhaust fan is off.

J. The three homeland high bay areas shall be provided with a return air damper. Once AHU-7 has been placed into operation, the damper shall be opened. If the gas monitoring system alarm is activated or the exhaust fan has been manually activated, the damper shall close. Normal operation shall commence once the gas monitoring panel alarm has cleared and the exhaust fan is off.

K. The KMT/KMR high bay has a return damper and exhaust damper tied to the same duct. Under normal operation, once AHU-7 has been placed into operation, the KMT/KMR high bay supply air damper terminal box shall be modulated with the reheat coil control valve to maintain a room temperature and airflow setpoints. Under normal operation, the return air damper to AHU-7 shall be opened as the exhaust damper to EF-4 is closed. If the gas monitoring system alarm is activated or the exhaust fan has been manually activated, the supply air terminal box damper shall go full open as the AHU increases its outside air damper to provide additional outside air the high bay and the return damper shall close as the exhaust damper is opened. Normal operation shall commence once the gas monitoring panel alarm has cleared and the exhaust fan is off.

L. BAS shall provide damper open and closed end switches on all dampers. BAS shall alarm if the damper is to be open and it is closed or if the damper is to be closed and it is open.

M. BAS shall provide an oxygen depletion, carbon dioxide, carbon monoxide and nitric oxide monitoring system as referred to on contract drawings. Monitoring system shall function as follows:
   1. Sensors shall be located in the room at five foot above the finished floor. Final location and quantity to be coordinated with equipment manufacturer and Owner EH&S personnel.
   2. Local sensor shall provide a signal to a monitoring panel located outside of the room. BAS and FAS systems shall be alarmed upon detection that the room levels alarms have been activated. Monitoring panel shall also energize a horn/red strobe device above the doorway in the room and a red strobe to be located above the doorway in the corridor at each entrance to the room. Upon a carbon monoxide or nitric oxide alarm condition, monitoring panel shall energize into operation the exhaust fan dedicated to the room.
   3. Monitoring panel shall be provided with a horn silence pushbutton. Upon activation pushbutton shall silence the local horn alarm. Strobes and exhaust fan shall remain energized until alarm levels return to their normal state.

4. Mount strobe/horns centered above door frame and ceiling.
5. Strobe/horn shall be clearly identified as to its function.

N. BAS shall monitor a fault alarm from the monitoring panel and alarm when activated.

O. BAS shall monitor exhaust fan status and alarm when fan has been indexed on and it fails to operate.

3.6 EXHAUST FAN EF-3A AND EF-3B CONTROL

A. Exhaust fans are variable volume with a pressure reset, both fans are sized for 100 percent operation. Once system has been indexed into operation, BAS shall operate one fan as primary and second as standby, twenty-four (24) hours per day, and seven (7) days per week. Exhaust fan system shall be enabled and proven in operation prior to an AHU starting. Standby fan shall be off unless there is a failure of the primary fan. Fan with the least run time shall be the primary fan.

B. System startup:
   1. When a fan is enabled through the HOA switch provided with the VFD or through the BAS when the VFD is in the "Auto" position, the primary exhaust fans discharge air damper shall be commanded open through the VFD. After the damper is proven open at the VFD, VFD shall index the primary exhaust fan on and ramp the fan speed to 38 percent full speed through the BAS.
   2. The minimum speed setting in the VFD shall be set to the lowest safe operating value (as dictated by the manufacturer), most manufacturers allow 8 Hz.
   3. Once at 38 percent speed, the exhaust fan speed shall ramp to the control setpoint over a 5 minute time period to maintain duct static pressure.
   4. When a fan is enabled through the HOA switch provided with the VFD or through the BAS when the VFD is in the "Auto" position, the following sequence shall occur:
      a. The differential pressure across the EF's isolation damper shall be monitored with a differential pressure switch (DPS). In the event the differential pressure across the damper decreases below 0.25 IN w.c., the damper shall open. There shall be a minimum of 0.04 IN w.c. deadband between transitions. The DPS shall be hardwire-interlocked with the damper actuator and the VFD. The damper position shall be monitored on the BAS.

C. System Shutdown:
   1. In the event the exhaust system is disabled through the BAS the following shall occur. The BAS shall command all exhaust fan "off". During shutdown, each EF isolation damper shall gradually close and the fan VFDs shall allow the fans to freewheel to stop.
   2. Exhaust fan isolation damper shall close slowly over a 2 minute time period, to allow the "freewheel" effect of the exhaust fans to maintain a negative pressure in the spaces.

D. Exhaust Fan static Pressure Control:
   1. The BAS shall monitor system static pressure at a reference point in the exhaust ductwork as indicated on contract diagrams. The controller shall compare the static pressure signal to the corresponding set point (1.0 IN w.c. initially) and control the fans speed to maintain setpoint.
   2. The duct static pressure setpoint shall be reset as follows:
      a. The BAS shall continuously monitor the room's exhaust terminal boxes damper position of (35 percent) of the terminal boxes. Monitored terminal boxes should be a mix from all floors, exposures and space type.
      b. The BAS shall slowly reset the static pressure setpoint downwards until one or more of the primary air terminal boxes is 95 percent open (starved box strategy).
      c. As the controlling terminal device primary air damper approaches 100 percent open, the opposite shall occur.
      d. The duct static pressure setpoint shall be reset between adjustable low and high limits.

E. Exhaust Fan Shut down for Maintenance:
   1. There shall be a software point displayed at the operator workstation for the both EFs associated with a system indicating "Shut down for Maintenance". The operator with proper authorization shall command the "Shut down for Maintenance" which enables the following sequence:
   2. The primary EF remains operating.
   3. The secondary EF shall be started and its VFD speed control is increased over a 10 minute time period as the primary fans speed is decreased.
   4. The differential pressure across the isolation damper shall increase until the isolation damper closes, as indicated above. Once the isolation damper closes, the primary exhaust fan shall be commanded "OFF" as the standby now becomes the primary.
   5. Note: since the exhaust pressure shall be impacted minimally during the transition, the associated AHU shall operate normally.

F. Exhaust Fans Safeties:
   1. A low negative static pressure condition upstream of an exhaust fan shall cause the fan to be de-energized and an alarm generated. Hardwire low static pressure overrides to their respective fan VFD control circuit to shutdown the fan; provide separate alarm signal to BAS whenever the low static pressure set point is exceeded. The low static pressure set point shall be equal to the duct classification or damper classification whichever the worst case is. The switch shall be a manual reset type
   2. Safety devices shall be hardwired to the respective fans' VFD. Hardwired safety devices must be active in "Hand", and "Auto" positions. When a safety is activated, the system shall shutdown in a controlled manner.

G. Exhaust Fan Failure:
   1. Upon a failure of the primary exhaust fan to operate, the BAS shall alarm as it automatically starts the standby exhaust fan.
   2. Upon a failure of both exhaust fans, BAS shall shutdown the system and alarm on the BAS.

H. Exhaust Fan Alternating Sequence:
   1. There shall be a software point displayed at the operator workstation indicating which fan is the primary and which fan is the standby.
   2. The first Monday of every month at 9 am the fans shall automatically alternate. There shall be a smooth transition when the standby fan is enabled. There shall be minimal disruption to the system pressure and shall not to cause a drop in the differential pressure across the system. In the event the standby fan fails to start, the primary fan shall remain operating.
   3. Software shall alternate equipment to ensure a smooth and bumpless transfer to primary equipment. Prior to the system alternating the fan, a message shall be sent to the BAS system operator, notifying operator of the transition from primary to standby. Operator shall have the option of cancelling the alternation process until the next cycle. If the operator does not stop the alternation process within 15 minutes of the message, system shall automatically alternate the primary fan with the standby fan. Primary fan shall remain in operation. Standby fan shall start in a similar manner to the initial fan start sequence. BAS shall increase the standby fan speed until the standby fans suction isolation damper is opened. Once standby fans suction isolation damper is proven open, BAS shall slowly increase the standby fans speed as it lowers the primary fans speed. Once the standby fans suction isolation damper is no longer open, BAS shall de-energize the current primary fan as the standby now becomes a primary.
   4. There shall be a software point displayed at the operator workstation for the set of fans indicating "Rotate Primary Exhaust Fan". The operator shall be able to manually command the "Rotate Primary Exhaust Fan" which enables the transition sequence to flip the primary and standby fans for maintenance purposes. The fans shall be transitioned in a smooth manner as not to disrupt the system pressure.
   5. There shall be a software point displayed at the operator workstation for each fan indicating the totalized fan run time, since the timer was reset last.

6. In the event the fan status does not coincide with the commanded state of the fan after a 15 second delay, the fan shall be commanded “off” and locked out. The standby fan (if available to run) shall be energized and an alarm shall be annunciated on the BAS. The fans status shall be monitored via a current switch. The fan shall remain locked out until a manually initiated release from the BAS.

3.7 EXHAUST FAN EF-9 CONTROL

A. Refer to contract drawings for a diagram of this system.

B. Fan shall have remote start/stop control and status monitoring by the BAS. Once indexed into operation through the BAS, fan shall operate 24 hours a day 7 days a week.

C. Upon a failure of the exhaust fans air handling unit, rooms supply terminal box shall close and the exhaust terminal box shall be indexed to its minimum open position and the exhaust fan shall be shutdown, and the bypass damper indexed to an open position established by the T&B contractor to allow a safe egress from the lab.

D. Upon an exhaust fan failure, the BAS shall be alarmed, rooms supply terminal box shall close and the exhaust terminal box shall be indexed to its minimum open position and the fan shall be indexed off and the bypass damper indexed to an open position established by the T&B contractor to allow a safe egress from the lab.

E. Exhaust fan shall be provided with an outside air bleed damper, controlled by BAS. Upon startup of the fan, damper shall open. Once fan is in operation, damper shall be positioned to a open setting established by the T&B contractor to allow for any additional airflow required from the lab so that the total lab exhaust requirements is met.

F. Exhaust fans shall be provided with a two-position isolation damper on the suction side of fan, which is controlled via a starter. The associated fan's starter control circuit shall energize the damper. Damper shall be proven in the open position, through the use of end switch, prior to fan starting.

G. Upon a low static pressure condition in exhaust duct, fan shall be shut down and fans isolation damper, bypass damper and labs supply terminal boxes shall close and the exhaust terminal box is indexed to its minimum open position for a safe egress from the lab. Static pressure switch is manually reset.

3.8 CHILLED WATER SYSTEM

A. General:
1. Refer to the Contract Drawings for a diagram of this system.
2. Each chiller shall be controlled by its dedicated chiller control panel (provided by chiller manufacturer). BAS shall interface with each chiller control panel either through gateway or hardwired connections shown on control drawings.
3. Chiller system shall have a manifolded chillers and chilled/condenser water pump set, a primary for each chiller. During normal building operation, i.e. AHU’s are controlling the building cooling using their chilled water control valves (not economizer mode), one chiller CH-14-1A CH-14-1B, and one chilled water pump CHP-14-1A, CHP-14-1B, and one condenser water pump CDP-14-2A, CDP-14-2B shall be in operation. System has been designed to allow interchanging of any chiller or pump orientation for control.
4. Chiller system start permissive shall be issued from facility personnel via a manual command from BAS operator workstation. Once permissive has been given, chiller system shall work automatically to provide 42 DEG F. water. A software switch shall be provided on system workstation for each piece of equipment to allow system operator to lock out equipment during normal maintenance.
5. BAS shall identify which chiller/pump shall be the primary chiller/pump to be placed into operation. BAS shall provide the start/stop permissive to chiller control panels once both a condenser and chilled water pump are proven in operation via a current transducer in the VFD.

6. System is being provided with a third chiller CH-14-2 and a third chilled water pump CHP-14-1E for standby power operation and low load and economizer modes. During a standby power condition, BAS shall only operate chiller CH-14-2 and pump CHP-14-1E.
7. There shall be a software point displayed at the operator workstation for the chilled water system "Chilled Water System Enable/Disable". The operator shall be able to manually command the point which enables and disables the chilled water system. Only operators with proper authorization shall be able to startup and shutdown the system.
8. During the equipment startup, Division 23 and Division 25 shall provide joint startup, commission, and chiller plant optimization. The optimal minimum and maximum operating part loads shall be determined for each chiller and set based on the chilled water system parameters. The BAS shall not operate the chillers above or below the optimal operating range.

B. Chilled Water Pump Control:
1. Pump control shall be enabled manually or automatically through the BAS in the event that the "Chilled Water System Enable/Disable" point is enabled.
2. The chilled water system will have three chilled water pumps, all equipped with variable frequency drives (VFD). Pumps CHP-14-1A and CHP-14-1B shall operate during normal AHU cooling operation, whereas CHP-14-1E shall operate during standby power or low load or economizer modes. During normal operation, one pump, CHP-14-1A or CHP-14-1B shall operate as primary, with the second pump as standby. Standby shall operate upon a failure of the primary. Primary pump shall be the pump with the least run time. When the first chiller is to be enabled, the associated chilled water isolation valve shall slowly open over a 2 minute time period and the primary chilled water pump shall be started at 40 percent speed by the BAS for 30 seconds. Pump flow shall be proven by amperage draw of the pump. If the expected amperage draw is not sensed, the BAS shall designate that pump as a "pump failure". If the lead pump fails to start or the BAS designates a “pump failure”, that pump shall be shut down and the standby pump shall be started at 40 percent speed for 30 seconds.
3. When the chiller is enabled, pump speed will be determined by chilled water differential pressure sensed by sensor located in the Penthouse. This sensor will be read by the BAS for control of the chilled water pump. Pump speed will be increased until the set point is satisfied up to full speed.
4. If any pump fails, the standby pump will stage on and the failed pump will be removed from operation. There will always be at least one chilled water and condenser water pump in operation whenever a chiller in is operation. The designated staging order (user definable) of the pumps will rotate on one of the following conditions (user selectable):
   a. Manually through a software switch.
   b. If pump runtime (adj.) is exceeded.
   c. Daily.
   d. Weekly.
   e. Monthly.
5. Chiller evaporators shall have minimum acceptable flow of 900 gpm (adjustable). The BAS shall override the pressure control of the pump speed to maintain minimum flow. If the building mains do not require this much flow, then the by-pass control valve shall be modulated open to allow this flow.
6. Standby Power Operation:
   a. If a chiller is required to operate, Chiller CH-14-2 shall operate automatically during standby power. Refer to the chilled water system chiller or heat exchanger economizer operation for additional information.
   b. Chilled Water pump CHP-14-1E shall be provided with standby power or low load or economizer modes. In the event of a power outage, the BAS shall operate only this pump. If the standby power equipped pump does not start, the BAS shall alarm. When normal power is restored to the facility, the BAS shall restore the pumps to their normal operation.

7. The pumps differential pressure set points shall be reset as follows:
    a. The BAS shall continuously monitor all the AHU chilled water control valves positions.
    b. The BAS shall slowly reset the pumping system differential pressure set point downwards until any of the valves is at its 95 percent open position.
    c. Once any of the cooling coil control valves is less than its 80 percent open position and none are more than it's 95 percent open position, the BAS shall slowly reset the differential pressure setpoint upwards until all the valves are above 80 percent open.
    d. The pump differential pressure set point shall be reset between adjustable low and high limits.
    e. System differential pressure is set at supervisory station.
    f. Final setpoints shall be established by the T&B contractor.
8. There shall be a software point displayed at the operator workstation for each pump indicating the totalized pump run-time. Ensure run-timers are configured to track run-time up to 2x10^6 hours before resetting. Note: Since equalizing equipment run-time is based on the BAS run-timers, resetting the run-timers could detrimentally affect the equipment run-time equalization.
9. Pump Alternating Sequence:
    a. The first Monday of every month at 9:00 am the pumps shall automatically alternate. Prior to the system alternating the pumps, a message shall be sent to the BAS system operator, notifying operator of the transition from primary to standby. Operator shall have the option of reversing the alternation process. If the operator does not stop the alternation process within 15 minutes of the message, system shall automatically alternate the pumps. The standby pump shall be enabled and the primary pump shall be disabled. The pumps shall be transitioned in a smooth manner as not to disrupt the water flow to equipment. In the event the standby pump fails to start, the primary pump shall remain operating.
    b. There shall be a software point displayed at the operator workstation for the set of pumps indicating "Rotate Primary Pump". The operator shall be able to manually command the "Rotate Primary Pump" which enables the transition sequence to flip the primary and standby pumps for maintenance purposes. The pumps shall be transitioned in a smooth manner as not to disrupt the water flow to equipment.
10. Chiller/Pump Maintenance Shutdown:
    a. There shall be a software point displayed at the operator workstation for each pump indicating "Shutdown for Maintenance". The operator shall be able to manually command the point which enables the shutdown routine for the associated pump and shall automatically enable the startup routine for the next available pump.
    b. The pumps shall be transitioned in a smooth manner as not to disrupt the water flow through the distribution system.

C. Chiller Operation and Sequencing:
1. Once the system is enabled, the primary chiller shall maintain the chilled water supply temperature at a set point of 42 DEGF.
2. There shall be a software point displayed at the operator workstation for each chiller indicating the totalized chiller run-time. Ensure run-timers are configured to track run-time up to 2x10^6 hours before resetting.
3. In the event the BAS receives a trouble alarm from operating chiller or the chiller does not prove "on" after 30 seconds of being commanded "on", that chiller shall be commanded "off" and locked out. The standby chiller shall be enabled. The chiller shall remain locked out until a manually initiated release from the BAS.
4. The chilled water and condenser water isolation valves associated with the primary chiller shall be commanded open over a 2 minute time period.
5. Once the chiller isolation valves prove open, via limit switch, and chilled water and condenser water pumps have proven running, via current transducer, the chiller shall be commanded "on" through the BAS.

6. The chiller manufacturer's control panel shall monitor the flow across the evaporator bundle via the associated flow switch. Once flow is proven, the chiller shall be enabled to operate via its self-contained controls to maintain the supply water temperature at set point.
7. Once a chiller has been started, it will be operated by its internal controls to maintain outlet water temperature at set point. BAS will communicate with all chillers to be able to reset the chilled water set point.
8. Chiller shut down will proceed as a signal from the BAS to the chiller's microprocessor to shut down. After the chiller shutdown is completed by its internal controls, the chiller evaporator control valve and condenser control valve will be closed. Shut down of condenser water pumps will proceed as defined in their sequence.
9. Each chiller (CH) will transmit to the BAS the evaporator entering and leaving water temperatures, along with any alarms.
10. Once a month, BAS will send a message to the system operator to assign which chillers will be designated as primary and standby.
11. Chiller Alternating Sequence:
    a. The first Monday of every month at 8:00 am the pumps shall automatically alternate. Prior to the system alternating the chillers, a message shall be sent to the BAS system operator, notifying operator of the transition from primary to standby. Operator shall have the option of reversing the alternation process. If the operator does not stop the alternation process within 15 minutes of the message, system shall automatically alternate the chillers. The standby chiller shall be enabled and the primary chiller shall be disabled. The chillers shall be transitioned in a smooth manner as not to disrupt the water flow to equipment. In the event the standby chiller fails to start, the primary chiller shall remain operating.
    b. There shall be a software point displayed at the operator workstation for the set of chiller indicating "Rotate Primary Chiller". The operator shall be able to manually command the "Rotate Primary Chiller" which enables the transition sequence to flip the primary and standby chiller for maintenance purposes. The chillers shall be transitioned in a smooth manner as not to disrupt the water flow to equipment.
12. During the initial startup of the chilled water system, the chiller and the pump with the shortest amount of runtime shall be the primary chiller and primary pump.
13. Chiller Shutdown Routine:
    a. The chiller shall be commanded "off".
    b. Once chiller has been proven off, the chiller isolation valves shall be commanded closed over a 2 minute time period by BAS. Coordinate time delay with chiller manufacturer.
    c. Concurrently, the primary chilled water pump speed control shall be overridden and the pump speed shall be decreased over a 1 minute time period and the pump shall be commanded "off".
14. Chiller Maintenance Shutdown:
    a. There shall be a software point displayed at the operator workstation for each chiller indicating "CH-xx Shutdown for Maintenance". The operator shall be able to manually command the point which enables the shutdown routine for the associated Chiller and shall automatically enable the startup routine for the lag Chiller.
    b. The Chillers shall be transitioned in a smooth manner as not to disrupt the water flow through the operating Chiller(s).

D. There shall be two Chilled Water System Economizer Heat Exchangers, HX-14-10A and HX-14-10B.
   1. Heat exchangers shall provide the cooling source for the chilled water loop when the building is in an economizer mode.

2. As the outside air drops to or below 54 degrees F (adjustable), for more than 15 minutes, and the chilled water supply temperature to the building is below its setpoint of 42 degrees F for more than 15 minutes, BAS shall index into operation chiller CH-14-2 and chilled water pump CHP-14-1E and condenser water pump CDP-14-2E. Once chiller and pumps are proven in operation, BAS shall index off the operating main chiller and main chilled/condenser water pumps. Chiller shall operate to maintain the 42 degree F setpoint as BAS modulate the pumps speed to maintain the chilled water and condenser water pressure setpoints.
3. When all the AHU's are in their economizer mode, and the condenser water supply is 54 DEGF and below for more than 15 minutes, BAS shall index the economizer heat exchanger system into operation to maintain a building chilled water setpoint of 65 deg F. Once economizer heat exchanger is proven in operation, BAS shall shut down the chiller CH-14-2.
4. When condenser water temperature is 65 deg F (adjustable) and above for 15 minutes, BAS shall index chiller CH-14-2 into operation. Once chiller is proven in operation, BAS shall shutdown the economizer heat exchanger system. As the outside air temperature rises above 55 deg F for more than 15 minutes, and the chilled water supply temperature is above setpoint of 65 deg F for more than 15 minutes, BAS shall index into operation the chiller CH-14-1A or CH-14-1B, and pumps CHP-14-1A, CHP-14-1B, CDP-14-2A or CDP-14-2B, whichever has the least run time, as it shuts down the chiller CH-14-2 and pumps CHP-14-1E and CDP-14-2E.
5. System shall be supplied with two heat exchangers, both sized for 100% of the system load. The heat exchanger with the least run time shall be the primary. The second shall be off as the standby and shall operate upon a failure of the primary.
6. There shall be a software point displayed at the operator workstation for the chilled water system "Chilled Water Side Economizer Enable/Disable". The operator shall be able to manually command the point which enables and disables the water side economizer system. Only operators with proper authorization shall be able to startup and shutdown the system.
7. During this mode of operation, the main chillers CH-14-1A, CH-14-1B, CH-14-2, and pumps CHP-14-1A, CHP-14-1b, CDP-14-2A and CDP-14-2B shall be indexed off.
8. Water Side Economizer Heat Exchanger Control:
   a. BAS shall open the primary heat exchanger chilled water and condenser water isolation valves. Once valves are proven open, BAS shall index pumps CHP-14-1E and CDP-14-2E into operation.
   b. BAS shall open the chilled water Chiller By-Pass valve and close the chilled water Economizer by-pass valve to direct chilled water flow through the heat exchangers.
   c. BAS shall index the primary HX three way condenser water valve on the primary heat exchanger into operation and modulate the three way valve to maintain the chilled water temperature setpoint. BAS shall modulate the chilled water and condenser water pumps speed to maintain the system pressure setpoints.
   d. When economizer mode is terminated, BAS shall index the three way chilled water valve closed as the system starts the chiller CH-14-2.
   e. Once chiller CH-14-2 is proven in operation, BAS shall close the chilled water chiller by-pass valve and open the chilled water economizer by-pass valve to by-pass the heat exchangers and direct chilled water flow through the chillers. BAS shall close the heat exchangers isolation valves.
9. Alternating Equipment Control:
   a. BAS shall alternate heat exchangers to allow for equal wear every 240 hours.
   b. Alternating software shall be in accordance with an Owner defined schedule. Software shall alternate equipment during light load conditions to ensure a smooth and bumpless transfer to primary equipment. Stand heat exchanger shall be placed into operation while the primary is still operating. BAS shall slowly open the standby heat exchanger three way valve as it closes the primary heat exchanger valve. Once system temperature has stabilized for more than 10 minutes, standby heat exchanger shall become the primary and primary shall be indexed off and become the standby.

10. BAS shall monitor the chilled water system temperature, and when the economizer heat exchangers are in operation, and the chilled water temperature is more than 2 degrees above setpoint for more than ten minutes (adjustable), BAS shall alarm and index the standby heat exchanger into operation.

E. There shall be two Process Chilled Water Heat Exchangers, HX-14-20A and HX-14-20B with two process chilled water pumps.
   1. Heat exchangers shall provide the cooling source for the process chilled water loop.
   2. When the process chilled water system has been activated, BAS shall open the primary heat exchanger isolation valves.
   3. Once isolation valves are proven open, via end-switch, BAS shall modulate the primary heat exchanger three way valve to maintain a process chilled water system temperature setpoint.
   4. There shall be a software point displayed at the operator workstation for the process chilled water system "Process Chilled Water System Enable/Disable". The operator shall be able to manually command the point which enables and disables the process chilled water system. Only operators with proper authorization shall be able to startup and shutdown the system.
   5. Process Chilled Water Heat Exchanger /Pump Control:
      a. The process chilled water system shall have two chilled water pumps. All shall be equipped with variable frequency drives (VFD). One shall operate as a primary and the second shall be off as a standby. Standby shall operate upon a failure of the primary. Each pumps is sized for 100 percent operation. Once the system is enabled, the primary pump shall be energized. The pump shall ramp to set point over a 2-minute time period.
      b. Whenever either heat exchanger is enabled, the associated three way shall open slowly. When valve is greater than 25 % open, then the primary process chilled water pump shall be started at 40 percent speed by the BAS for 30 seconds. Pump flow shall be proven by amperage draw of the pump. If the expected amperage draw is not sensed, the BAS shall designate that pump as a "pump failure". If the lead pump fails to start or the BAS designates a “pump failure”, that pump shall be shut down and the standby pump shall be started at 40 percent speed for 30 seconds.
      c. Pump speed shall be controlled by the BAS, based upon differential pressure sensor readings measured at one location in the distribution system. The BAS shall modulate the pump speed to maintain the differential pressure at a set point of 5 psi initially. The final set point shall be dictated by the TAB. Upon a decrease in differential pressure below set point the pumps speed shall increase. Upon a rise the reverse shall occur.
      d. There shall be a software point displayed at the operator workstation for the pumps indicating "Primary/Standby Changeover". The operator shall be able to manually command the “Primary/Standby Changeover" which enables the transition sequence for the primary pump to the standby pump.
   6. Standby Power Operation:
      a. Process chilled water pump CHP-14-3A shall be provided with standby power. In the event of a power outage, the BAS shall operate this pump. If the pump does not start, the BAS shall alarm. When normal power is restored to the facility, the BAS shall restore the pumps to their normal operation.
   7. BAS shall monitor the process chilled water system temperature, and when the process chilled water temperature is more than 2 degrees above setpoint for more than ten minutes (adjustable), BAS shall alarm.
   8. Alternating Equipment Control:
      a. BAS shall alternate pumps and heat exchangers to allow for equal wear every 240 hours.
      b. Alternating software shall be in accordance with an Owner defined schedule. Software shall alternate equipment during light load conditions to ensure a smooth and bumpless transfer to primary equipment. Stand by pump shall start first. BAS shall slowly increase the standby pumps speed as it lowers the primary pumps speed. Once system pressure has stabilized, BAS shall de-energize the current primary pump as the standby is now the primary.

F. Chilled Beam Control System:
   1. General:
      a. There shall be a software point displayed at the operator workstation for the chilled beam heat exchanger system "Chilled Beam System Enable/Disable". The operator shall be able to manually command the point which enables and disables the system. Only operators with proper authorization shall be able to startup and shutdown the system.
      b. The system consists of two distribution pumps. Only one distribution pump shall be allowed to operate at any one time; the remaining pump shall provide 100 percent standby operation.
      c. All system signals, including the remote differential pressure sensor shall be wired to the same controller which is controlling the heat exchangers and pumps.
   2. Temperature Control:
      a. BAS shall modulate the chilled beam loop three way temperature control valve to maintain chilled beam loop chilled water supply temperature setpoint.
   3. Pump Control:
      a. Pumping system is being provided with two pumps, one shall operate as a primary and the second shall be off as a standby. Standby shall operate upon a failure of the primary. Each pumps is sized for 100 percent operation. Once the system is enabled, the primary pump shall be energized. The pump shall ramp to set point over a 2-minute time period.
      b. Pump speed shall be controlled by the BAS, based upon differential pressure sensor readings measured at one location in the distribution system. The BAS shall modulate the pump speed to maintain the differential pressure at a set point of 5 psi initially. The final set point shall be dictated by the TAB. Upon a decrease in differential pressure below set point the pumps speed shall increase. Upon a rise the reverse shall occur.
      c. There shall be a software point displayed at the operator workstation for the pumps indicating "Primary/Standby Changeover". The operator shall be able to manually command the "Primary/Standby Changeover" which enables the transition sequence for the primary pump to the standby pump.
      d. The first Monday of every month at 10 am the primary and the standby pump shall automatically alternate. There shall be a smooth transition when the standby pump is enabled. There shall be minimal disruption to the system pressure and shall not to cause a drop in the differential pressure across the heat exchangers. In the event the standby pump fails to start, the primary pump shall remain operating.
      e. There shall be a software point displayed at the operator workstation for each pump indicating the totalized pump run-time. Ensure run-timers are configured to track run-time up to 2x10^6 hours before resetting. Note: Since equalizing equipment run-time is based on the BAS run-timers, resetting the run-timers could detrimentally affect the equipment run-time equalization.
      f. In the event a pump status does not coincide with the commanded state of the pump after a 15 second delay, the pump shall be commanded "off" and locked out. The standby pump shall be energized and an alarm shall be annunciated on the BAS. The pump shall remain locked out until a manually initiated release from the BAS.

G. Process Cooling Water System Leak Monitoring:
   1. Refer to the Contract Drawings for a diagram of this system.
   2. Each floor shall consist of a flow transmitter in the supply line and a two position shut-off valve in both the supply and return branches of the process equipment cooling loop. Supply and return control valves shall be open whenever the process chilled water pumps have been energized, otherwise valves are closed.
   3. A flow transmitter and a two position shut-off valve shall be located in the process chilled water loop fill line. Should a flow be sensed in the fill line for more than twenty minutes, BAS shall alarm. Fill line control valve shall be open whenever the process chilled water pumps have been energized, otherwise valve is closed.

4. Should a flow be sensed in any equipment cooling loop supply that is 120% of the running 24 hour average flow for more than two minutes, and flow is sensed at the same time in the process system fill line, BAS shall alarm.
5. Should both flows continue for more than 5 minutes, or the flow in the supply line shall increase to 150% of the 24 hour average, BAS shall alarm and close the supply and return valves in that branch.
6. Should a flow be sensed in any equipment cooling loop supply that is 120% above the balanced flow, BAS shall alarm.

H. Chilled Water Flow Monitoring:
1. BAS shall monitor Primary chilled water supply water flow and BTU as shown on contract drawings.
2. BAS shall monitor Process chilled water supply water flow and BTU as shown on contract drawings.

3.9 COOLING TOWER SYSTEM

A. General:
1. There shall be two cooling tower cells, and two condenser water pumps each sized for 100% of the system load. Cells shall be capable of year round operation. When the chilled water system is operational, one tower and one pump shall be in operation as the primary and second off as the standby. Standby shall operate upon a failure of the primary.
2. Standby Power Operation: Cooling tower CT-14-1A and pump CDP-14-2E shall be provided with standby power and low load and economizer modes. In the event of a power outage, the BAS shall operate only this CT and pump. If one of the cells does not start, then the BAS shall start the other standby powered cell. When normal power is restored to the facility, the BAS shall restore the cooling towers to their normal operation.

B. Condenser Water Temperature Control:
1. Upon initial start-up, primary tower fill valve shall be commanded closed and the primary tower basin valve shall be commanded open and the system shall modulate the 3-way condenser water bypass valve open to bypass and slowly open the primary chiller condenser water isolation valve, and primary cooling tower isolation valve in the supply piping prior to initializing a primary condenser water pump, so that the pump is not dead headed. Once the primary pump is in operation, BAS shall allow the condenser water temperature loop to activate. Speed settings shall be established by the T&B contractor.
2. If the condenser water supply temperature, as measured by supply line mounted temperature sensor, falls to 65 DEGF or below, the BAS shall module the 3-way condenser water bypass control valve to maintain the supply water temperature at 65 DEGF. When the 3-way tower bypass control valve shall be fully open to the towers when the supply water temperature reaches 65 DEGF or above. Upon a further rise in temperature the BAS system shall modulate open the tower fill as it modulates closed basin of the operating towers.
3. When condenser water supply temperature is above 85 DEGF (adjustable), its temperature control shall be accomplished by allowing the water to go over the tower fill of the primary tower. Primary tower shall be the tower with the least run time. The BAS system shall modulate the operating primary cooling tower over the fill control valve to maintain setpoint. Tower fill and basin valve shall be slow opening so as not to starve a tower of water flow.
4. Each tower cell shall be equipped with a VFD for the tower fan motor. When the condenser water supply reaches 95 DEGF (adjustable), the BAS shall start the primary tower fan and modulate the fan speed to maintain supply water temperature set point.
5. If tower cell fan does not start, the BAS shall alarm and the standby tower shall be sequenced ON. The temperature of the water supply shall be measured in the supply main, and displayed and recorded by the BAS.
6. Provide a time delay between steps to prevent short cycling of the tower fans.

C. Economizer Temperature Control:

1. When then the condenser water system is in economizer mode, the 3-way condenser water by-pass valve, tower fill/basin valves and tower fan shall modulate in sequence to maintain a condenser water supply temperature of 55 DEGF.

D. Water Level Control:

1. Cooling tower basin water level may be equalized via a common equalization header. This header shall have a level control riser that shall have a level float switch per tower. The float switch shall provide a low water level signal to the BAS. Upon reading low level, BAS shall start a timer and if the alarm at operator station does not reset within 15 minutes, BAS shall alarm of a potential problem. Float switch shall open a make-up water valve to the tower. Once level has been maintained valve shall close as alarm is cleared on BAS.

E. Basin Heaters:

1. The cells have basin heaters with temperature switch to activate heater to maintain minimum 40 DEGF in tower basins, and low level cut-off switch provided by the cooling tower manufacturer. The BAS shall monitor the basin heater activation via auxiliary contacts provided by the basin heater manufacturer.

F. Condenser Water Pump Control:

1. The condenser water system shall have two condenser water pumps (CDP-14-2A and CDP-14-2B) for normal power and a third pump (CDP-14-2E) for operation during standby power or during the chilled water system economizer mode. All shall be equipped with variable frequency drives (VFD). When the primary chiller is enabled, the associated condenser water isolation valve shall open slowly and primary cooling tower cell fill valve shall close, the basin valve shall open and supply outlet isolation valve shall open slowly. The three way condenser water by-pass valve shall be open to by-pass.
2. When the isolation valves are proven open by end switch, then the primary condenser water pump shall be started at 40 percent speed by the BAS for 30 seconds. Pump flow shall be proven by amperage draw of the pump. If the expected amperage draw is not sensed, the BAS shall designate that pump as a "pump failure" and start the standby pump. If the standby pump shall be started at 40 percent speed for 30 seconds. If the standby pumps also fail, BAS shall alarm and shutdown the system.
3. Operating pump speed shall be determined by BAS using a setting that will be established by the T&B contractor condenser water differential pressure. BAS shall send a speed signal to the operating pumps VFD. Once setting is established pump shall maintain this constant speed. Differential pressure transmitter shall be located across the condenser water supply and return as shown on contract drawings. The condenser design full flow pressure differential shall be the initial set point (adjustable) for pump control.
4. When a condenser water pump operation is confirmed, after 30 seconds, the variable speed drive (VFD) shall increase the speed of the pump until the tower flow differential pressure set point is met. Then the primary chiller shall be enabled.
5. Alternate the primary pump operating sequence after each cycle so that all pumps have approximately equal run time.
6. Standby Power Operation:
   a. Condenser water pump CDP-14-2E shall be provided with standby power. In the event of a power outage, the BAS shall operate this pump once standby power is established. If the pump does not start, the BAS shall alarm. When normal power is restored to the facility, the BAS shall restore the pumps to their normal power operation.

G. Cooling Tower/Condenser Water Pumps Alternating Sequence:
   1. The first Monday of every month at 10:00 am (cooling towers) and 11:00 am (condenser water pumps) the cooling towers and condenser water pumps shall automatically alternate. Prior to the system alternating the towers and pumps, a message shall be sent to the BAS system operator, notifying operator of the transition from primary to standby. Operator shall have the option of reversing the alternation process. If the operator does not stop the alternation process within 15 minutes of the message, system shall automatically alternate the towers/pumps. The standby tower/pump shall be enabled and the primary tower/pump shall be disabled. The tower/pump shall be transitioned in a smooth manner as not to disrupt the water flow to equipment. In the event the standby tower/pump fails to start, the primary tower/pump shall remain operating.
   2. There shall be a software point displayed at the operator workstation for the set of chiller indicating "Rotate Primary Tower/Pump". The operator shall be able to manually command the "Rotate Primary Tower/Pump" which enables the transition sequence to flip the primary and standby tower/pump for maintenance purposes. The tower/pump shall be transitioned in a smooth manner as not to disrupt the water flow to equipment.

H. Condenser Water Flow Monitoring:
   1. BAS shall monitor supply water flow and BTU as shown on contract drawings.

3.10 MECHANICAL ROOM VENTILATION CONTROL

A. Refer to Detail on Contract Drawing for a diagram of this typical type of system.

B. Mechanical ventilation system outside air damper and EF-12 are classified as a two-position system. A system deadband shall be provided to prevent short cycling of fans.

C. System consists of supply air damper interlocked to the exhaust fan. Start/stop and status monitoring are controlled by a stand-alone distributed digital controller (DDC), which is part of the overall BAS.

D. Unit Safeties; Unit safeties are hardwired external to BAS.
   1. Prior to exhaust fan starting, isolation damper shall be opened by BAS and proven in the open position. Once fans isolation damper is proven open by the damper end switch, the fan shall start. Upon unit shutdown, fans isolation damper shall close.
   2. Safeties are proven in the automatic and manual mode of operation.

E. Temperature Control:
   1. Chiller room temperature shall be monitored by wall mounted temperature sensor.
   2. BAS shall index the outside air damper to open and index ON the exhaust fan to its minimum speed when ventilation is required. Speed shall be set by T&B contractor.
   3. When space temperature rises above 80 DEGF, BAS shall index system on until 75 DEGF is obtained. Fan shall then be indexed OFF and the associated dampers closed.
   4. If temperature sensor senses space temperature above 100 DEGF, or below 60 DEGF, BAS shall alarm.
   5. If fan fails to start when commanded on or fails during operation, BAS shall alarm and system shall be de-energized.
   6. BAS shall provide a time delay between fan start/stop signals to prevent short cycling of fans.

F. Refrigerant Monitoring System:
   1. A refrigerant leak detection monitoring system is provided and is monitored by the BAS.
   2. Under normal operation, outside air damper and exhaust fan EF-12 shall be under BAS temperature control.
   3. Upon an alarm condition from the refrigerant monitoring system, BAS shall override the system temperature control and index both the outside air damper to its open position and index the exhaust fan ON to its maximum air flow speed as determined by T&B contractor.
   4. Upon a refrigerant leak, the detection system shall energize all alarm devices and alarm to the BAS and Fire alarm System (FAS).

5. BAS shall monitor the leak detection system and shut down the chilled water system and the boiler system upon a leak.
6. Normal system temperature operation shall commence upon refrigerant alarm being cleared.
7. BAS shall provide local audible alarm (100db) and blue strobe alarm light and horn for mounting at each chiller room door exit. At each chiller room entrance, provide a blue strobe alarm light.
8. At chiller room main entrance provide two hand switches, one a hand off auto switch to be wired in parallel operation with chiller room ventilation exhaust fan. Second switch shall be for a manual emergency shutdown of mechanical equipment in chiller room, including the boilers. Switch shall be wired to BAS and when activated shutdown all equipment in chiller room. Switch shall be a push to activate with a key to reset switch. Provide a tamper-proof polycarbonate shield over switch to prevent accidental activation. Switches shall be clearly identified as to their specific operation.
9. Refrigerant sensors are located in the vicinity of the chillers in accordance with manufacturer recommendations.
10. An Alarm Silence Pushbutton shall be located on the refrigerant monitoring panel. Pressing the alarm silence pushbutton shall silence the horn only, as the strobes continue to flash, until the alarm condition clears.
11. If the Emergency Chiller Shutdown pushbutton is pressed, the BAS shall de-energize the entire chilled water and condenser water system and the boilers. The entire system shall remain shutdown until the Facility Operator manually resets the alarm condition on the BAS. Normal system operation shall commence upon alarm being cleared.

G. Carbon Monoxide Monitoring:
1. A carbon monoxide monitoring system is provided and monitored by the BAS.
2. Under normal operation, outside air damper and exhaust fan EF-12 shall be under BAS temperature control.
3. A sensor shall be located in the room at five foot above the finished floor as shown on contract drawings. Final location and quantity to be coordinated with equipment manufacturer and Owner EH&S personnel.
4. Local sensor shall provide a signal to a carbon monoxide monitoring panel located outside of the room. BAS and FAS systems shall be alarmed upon detection that the room carbon monoxide level is above a low alarm limit set point of 50 ppm. Monitoring panel shall also energize a red horn/strobe device above the doorway in the room and a red strobe to be located above the doorway in the corridor at each entrance to the room.
5. Monitoring panel shall be provided with a horn silence pushbutton. Upon activation pushbutton shall silence the local horn alarm. Strobes shall remain energized until alarm levels return to its normal state.
6. Mount strobe/horns centered above door frame and ceiling.
7. Strobe/horn shall be clearly identified as to its function.
8. Upon CO detection alarm being activated, BAS shall open the supply air damper and index exhaust fan EF-12 into operation. BAS shall also shut down the boiler and chilled water systems.
9. Normal system operation shall commence upon CO alarm being cleared.
10. BAS shall monitor a fault alarm from the monitoring panel and alarm when activated.

H. BAS shall provide a Ventilation auto/on/off switch in the room. The Ventilation system switch contacts are monitored and supervised. Normally the switch is in the AUTO position. When the switch is indexed to the OFF position, the BAS is alarmed, and the BAS indexes EF fan off. When the switch is indexed to ON, the BAS is alarmed, and the BAS indexes the outside air damper open and the fan ON. In the ON position, the BAS controls the fan in a similar manner as the refrigerant monitoring system alarm condition.

I. BAS shall monitor exhaust fan status and alarm when fan has been indexed on and it fails to operate.

3.11 HEATING HOT WATER SYSTEM

A. General:

1. There shall be a software point displayed at the operator workstation for the reheat system "Heating Hot Water System Enable/Disable". The operator shall be able to manually command the point which enables and disables the system. Only operators with proper authorization shall be able to startup and shutdown the system.
2. Hot water boilers provide the heat source for the entire hot water loop system, which includes the building hot water heaters, preheat system, reheat system, and fan coil units.
3. Main hot water system consists of two variable speed pumps, with a bypass to provide minimum flow for pump cooling.
4. BAS shall monitor the Boilers operations through hardwired and BACnet connection as shown on contract documents.
5. BAS shall monitor system supply and return temperature and return flow. BAS shall alarm on high/low software set points.
6. BAS shall monitor system differential pressure. BAS shall alarm on high/low software set points.
7. Each boiler shall have an isolation valve that shall be commanded open by the Boiler Control Panel when boiler is placed into operation, otherwise valve is closed.

B. Temperature Control:

1. Once the boiler system is ready to be indexed into operation, BAS system shall send an enable signal to the Boiler sequencing panel. BAS shall also send a signal to Boiler sequencing panel for either Boiler #1, Boiler #2 or Boiler #3 to be in operation. The Boiler sequencing panel shall then establish the amount of Boilers required to operate to provide 180 DEG hot water supply to the system.
2. The Boiler sequencing panel shall open the combustion air damper through hardwired interlock.
3. Once combustion air damper has proven open and flow has been established in the Boiler control panel, Boiler shall be indexed into operation by Boiler controls to maintain 180 DEG supply water temperature to system. Boiler sequencing panel shall index the amount of Boilers to be in operation to maintain the 180 DEGF.
4. When the supply temperature drops 10 DEGF below set point for more than 30 minutes, the BAS shall be alarmed, indicating a potential problem.

C. Pump Control:

1. System is designed so that whenever a Boiler is being placed into operation, BAS shall index one pump into operation. Both pumps are sized for 100 percent operation. The pumps with the least run time shall be the primary. The second shall be the standby and operate upon a failure of the primary, otherwise pump is off.
2. Once a boiler is being indexed into operation by the boiler sequencing panel, sequencing panel shall send a signal to BAS as to which boiler is being indexed ON. Once BAS receives this signal, BAS shall start the primary pump and modulate the pumps speed to maintain a system pressure setpoint. Setpoint shall be established by system balancer.
3. After a pump becomes operational and flow is proven via signal from VFD, the BAS shall send an enable signal to the boiler sequencing panel.
4. After being indexed on, should pump flow not be proven from VFD via a current sensing relay, after an adjustable time frame, or fails during operation, an alarm shall be initiated at the operator workstation. BAS shall automatically index the failed pump off and start the standby pump. If both pumps fail, the BAS shall remove the boiler enable signal.

5. System shall be furnished by BAS with an end-of-the-line bypass flow control valve. As system load is reduced, and pump speed is reduced through the VFD by BAS, BAS shall not index the pump speed lower than the pumps minimum speed profile required by pump manufacturer and begin to modulate this minimum flow control valve open to satisfy the system minimum flow pressure profile. Conversely, as the system demand increases, the minimum bypass flow control valve shall close. As the valves go closed and the system demand continues to increase, the pump speed shall again be increased by BAS to meet the demand.
6. Pump differential pressure setpoint shall be reset as follows:
   a. The BAS control system shall continuously monitor all preheat coil and reheat coil control valve positions through the BAS control system output signal.
   b. The differential pressure setpoint shall be reset between adjustable low limit of 15 psi and adjustable high limit of 20 psi.
   c. The BAS control system shall slowly reset the differential pressure setpoint upwards from low limit to high limit upon detection of any control valve having been commanded to greater than its 95 percent open position.
   d. The BAS control system shall slowly reset the differential pressure setpoint downwards upon detection of no control valve having been commanded to greater than its 80 percent open position and no control valve having been commanded to greater than its 95 percent open position.
   e. System differential pressure is set at BAS supervisory station.
   f. BAS control system operator shall be able to remove a control valve(s) from the reset strategy.
   g. BAS control system shall detect those control valves that may be excessively driving the reset logic and generate an alarm.
   h. Final setpoints shall be established during the T&B.

D. Alternating Equipment Control:
1. BAS shall alternate pumps to allow for equal wear every 240 hours.
2. Alternating software shall be in accordance with an Owner defined schedule. Software shall alternate equipment during light load conditions to ensure a smooth and bumpless transfer to primary equipment. Stand by pump shall start first. BAS shall slowly increase the standby pumps speed as it decreases the primary pump. Once system pressure has stabilized, BAS shall index the primary pump off, as the standby pump now becomes the primary pump.

E. Standby Power Operation:
1. Hot water pump HWP-14-5A and boiler BRL-14-1A shall be provided with standby power. In the event of a power outage, the BAS shall operate this pump and boiler. If the pump or boiler does not start, the BAS shall alarm. When normal power is restored to the facility, the BAS shall restore the pump and boiler system to its normal operation.

F. Hot Water Flow Monitoring:
1. BAS shall monitor supply water flow and BTU as shown on contract drawings.

G. Emergency Shutdown:
1. An "EMERGENCY BOILER SHUTDOWN" switch shall be provided by BAS at the room exits as shown on the plans.
2. Upon either switch being indexed, the BAS shall be alarmed and simultaneously the BAS shall shut down the entire boiler/hot water and the chilled water systems.
3. Switch shall be provided with a protective cover to prevent accidental activation. Switch shall require a key to reset.
4. Normal system operation shall commence upon alarm being cleared.

3.12 TYPICAL CAV LABORATORY CONTROL

A. Refer to the Contract Drawings for a diagram of this type of room control.

B. The terminal units are controlled independent of system pressure fluctuations by ASCs or PSCs using electric actuation. The space served by the terminal units is controlled in occupied and unoccupied modes. All the terminal units in a given laboratory shall operate in concert to maintain the laboratory pressure relative to the adjacent corridor at all times. Each laboratory shall be handled from a dedicated ASC or PSC. A PSC shall be provided for any Labs handling more than one supply and one exhaust terminal box.

C. Temperature Control:
   1. Occupied Mode: The VAV terminal unit is controlled at the scheduled supply airflows indicated on the mechanical schedules. The controller monitors the room temperature sensor and air velocity sensor and modulates the supply air damper in sequence with the exhaust air damper to maintain the room air flow at set point.
   2. The controller shall modulate the reheat coil control valve to maintain the room's temperature setpoint. The set point shall be dictated by the set point dial which is integral to the room temperature sensor. The dial shall be electronically limited between 68 and 76 DEGF. Supply air volume remains at minimum when HW reheat valve is modulated.
   3. Initial set points shall be 68 DEGF in the heating mode and 76 DEGF in the cooling mode.

D. Supply Terminal Unit:
   1. The BAS shall sum all exhaust airflows and shall sum all supply airflows.
   2. The supply airflow set point shall be continually calculated as follows: (Supply airflow set point) = (TOTAL exhaust airflow) - (Lab differential airflow offset). Note: If the VAV fume hood sash is not lowered fully, the supply air valve will not achieve the scheduled "unoccupied" airflow set point.
   3. The supply air terminal shall modulate to maintain the supply airflow at set point. The supply air terminal shall respond to a change in set point as quickly as the fume hood controller to maintain laboratory pressurization as the fume hood sash is being raised and lowered.

E. Occupied/Unoccupied Control:
   1. The room shall be indexed to the occupied mode when ALL of the following conditions are met:
      a. The time-of-day (TOD) is between 6 am and 6 pm.
      b. The rest of the time, the room shall be indexed to the unoccupied mode.
   2. During the building occupied hours, room temperature control shall remain in the occupied mode regardless if the lights are on or off.
   3. The rest of the time, the BAS shall be indexed to the unoccupied mode. If system operator needs to the lab to remain in its occupied mode for an extended period of time, Lab operator shall call the BAS system operator, and request the room remain in the occupied mode for the extended time period.
   4. The final occupied schedule shall be coordinated with the Owner.
   5. Any GSEL and SES GSEL labs shall operate 24/7 with no unoccupied mode. ASC controllers for these labs shall be fed from standby power.

F. Unoccupied Temperature Set Points: Between 6 pm and 6 am.
   1. In cooling, the room temperature set point shall be overridden, and the set point shall be reset to 80 DEGF. The reheat coil control valve shall remain closed.
   2. In heating, the room temperature set point shall be overridden, and the set point shall be reset to 65 DEGF.
   3. The space shall be indexed into and out of occupied mode based on the local occupancy sensor which shall be coordinated with the Owner. The zone shall remain in the occupied mode for 30 minutes after occupants were last sensed.

3.13 TYPICAL VAV LABORATORY CONTROL

A. Refer to the Contract Drawings for a diagram of this type of room control. Not all labs require both supply and return terminal boxes. Refer to plan drawings and schedules for Lab requirements.

B. The terminal units are controlled independent of system pressure fluctuations by a ASCs or PSCs using electric actuation. The space served by the terminal units is controlled in occupied and unoccupied modes. All the terminal units in a given laboratory shall operate in concert to maintain the laboratory pressure relative to the adjacent corridor at all times. Each laboratory shall be handled from a dedicated ASC or PSC. A PSC shall be provided for any Labs handling more than one supply and one exhaust terminal box.

C. Temperature Control:
  1. Occupied Mode: The VAV terminal unit is controlled within the maximum and minimum supply airflows indicated on the mechanical schedules. The controller monitors the room temperature sensor and air velocity sensor and modulates the supply air damper in sequence with the reheat valve to maintain the room temperature at set point. The set point shall be dictated by the set point dial which is integral to the room temperature sensor. The dial shall be electronically limited between 68 and 76 DEGF. Supply air volume remains at minimum when HW reheat valve is modulated.
  2. Initial set points shall be 68 DEGF in the heating mode and 76 DEGF in the cooling mode.

D. Fume Hood Control:
  1. The fume hood controller shall continuously calculate the total fume hood open area based upon the fume hood's fixed openings, bypass opening, and sash position as indicated by the sash sensor(s). The fume hood controller shall also continuously calculate the fume hood exhaust air volume required to maintain the average face velocity set point based upon the total open area of the fume hood and the average face velocity set point. The fume hood controller shall modulate the exhaust air terminal unit to maintain the fume hood exhaust air volume at set point to maintain the required fume hood average face velocity at 100 FPM.
  2. Each fume hood controller shall transmit a 0-10V or 4-20mA signal to the BAS indicating the exhaust airflow.
  3. Each fume hood controller shall transmit a common alarm to the BAS via a set of dry contacts.
  4. In the event the sash is raised above 18" for setting up the fume hood, any low airflow alarms shall be suppressed for 2 minutes (adjustable).

E. Supply Terminal Unit:
  1. The BAS shall sum all return airflows and shall sum all supply airflows.
  2. The supply airflow set point shall be continually calculated as follows: (Supply airflow set point) = (TOTAL return airflow) - (Lab differential airflow offset).
  3. The supply air terminal shall modulate to maintain the supply airflow at set point. The supply air terminal shall respond to a change in set point to maintain laboratory pressurization.

F. Occupied/Unoccupied Control:
  1. The room shall be indexed to the occupied mode when ALL of the following conditions are met:
     a. The time-of-day (TOD) is between 6 am and 6 pm.
     b. The rest of the time, the room shall be indexed to the unoccupied mode.
  2. During the building occupied hours, room temperature control shall remain in the occupied mode regardless if the lights are on or off.
  3. The rest of the time, the BAS shall be indexed to the unoccupied mode. If system operator needs to the lab to remain in its occupied mode for an extended period of time, Lab operator shall call the BAS system operator, and request the room remain in the occupied mode for the extended time period.
  4. The final occupied schedule shall be coordinated with the Owner.

5. Any GSEL and SES GSEL labs shall operate 24/7 with no unoccupied mode. ASC controllers for these labs shall be fed from standby power.

G. Unoccupied Temperature Set Points: Between 6 pm and 6 am.
   1. In cooling, the room temperature set point shall be overridden, and the set point shall be reset to 80 DEGF. The reheat coil control valve shall remain closed.
   2. In heating, the room temperature set point shall be overridden, and the set point shall be reset to 65 DEGF.
   3. The space shall be indexed into and out of occupied mode based on the local occupancy sensor which shall be coordinated with the Owner. The zone shall remain in the occupied mode for 30 minutes after occupants were last sensed.

3.14 TYPICAL OFFICE SPACE

A. Refer to the Contract Drawings for a diagram of this system.

B. An office space is defined as one office or group of offices served by one air terminal unit.

C. The terminal units are controlled independent of system pressure fluctuations by application specific controllers (ASC) using electric actuation. The space served by the terminal units is controlled in occupied and unoccupied modes.

D. The BAS shall monitor the reheat coil discharge temperature.

E. Occupied Mode: The VAV terminal unit is controlled within the maximum and minimum supply airflows indicated on the mechanical schedules. The controller monitors the room temperature sensor and air velocity sensor and modulates the supply air damper in sequence with the reheat valve to maintain the room temperature at set point. The set point shall be dictated by the set point dial which is integral to the room temperature sensor. The dial shall be electronically limited between 68 and 76 DEGF. Supply air volume remains at minimum when HW reheat valve is modulated. Initial set points shall be 68 DEGF in the heating mode and 76 DEGF in the cooling mode.

F. Occupied/Unoccupied Mode:
   1. The room shall be indexed to the occupied mode when ALL of the following conditions are met:
      a. The time-of-day (TOD) is between 6 am and 6 pm.
   2. When the building is in the occupied mode, the room shall be indexed to the occupied mode when motion has been sensed in the room from the lighting system occupancy sensor. When room is occupied, system shall regulate the room’s temperature using the room’s thermostat setting. When building is in the occupied mode, and room is designated as unoccupied by the lighting system, rooms temperature setting shall be reduced two degrees lower or higher as determined if the building is in a heating or cooling condition.
   3. The rest of the time, the BAS shall be indexed to the unoccupied mode.
   4. The final occupied schedule shall be coordinated with the Owner.

G. Unoccupied Temperature Set Points: Between 6 pm and 6 am.
   1. In cooling, the room temperature set point shall be overridden, and the set point shall be reset to 80 DEGF. The reheat coil control valve shall remain closed.
   2. In heating, the room temperature set point shall be overridden, and the set point shall be reset to 65 DEGF. Reheat coil control valve shall be modulated to maintain the rooms unoccupied temperature setpoint.
   3. The space shall be indexed into and out of occupied mode based on the local occupancy sensor or from the unoccupied override button on the thermostat. The zone shall remain in the occupied mode for 30 minutes after occupants were last sensed.

3.15 TYPICAL DENSELY OCCUPIED ROOM

A. Refer to the Contract Drawings for a diagram of this system.

B. The terminal units are controlled independent of system pressure fluctuations by application specific controllers (ASC) using electric actuation. The space served by the terminal units is controlled in occupied and unoccupied modes.

C. The BAS shall monitor the reheat coil discharge temperature.

D. Occupied Mode: The VAV terminal unit is controlled within the maximum and minimum supply airflows indicated on the mechanical schedules. The controller monitors the room temperature sensor and air velocity sensor and modulates the supply air damper in sequence with the reheat valve to maintain the room temperature set point. Supply air volume remains at minimum when HW reheat valve is modulated.

E. Occupied/Unoccupied Mode:
   1. The room shall be indexed to the occupied mode when ALL of the following conditions are met:
      a. The time-of-day (TOD) is between 6 am and 6 pm.
   2. When the building is in the occupied mode the room shall be indexed to the occupied mode when motion has been sensed in the room from the lighting system occupancy sensor. When room is occupied, system shall regulate the room’s temperature using the room’s thermostat setting. When building is in the occupied mode, and room is designated as unoccupied by the lighting system, rooms temperature setting shall be reduced the unoccupied setting.
   3. The rest of the time, the BAS shall be indexed to the unoccupied mode.
   4. The final occupied schedule shall be coordinated with the Owner.

F. Unoccupied Temperature Set Points: Between 6 pm and 6 am.
   1. Coordinate the occupied and unoccupied schedules with the Owner.
   2. Unoccupied Temperature Set Points
      a. In cooling, the room temperature set point shall be overridden, and the set point shall be reset to 80 DEGF. The reheat coil control valve shall remain closed.
      b. In heating, the room temperature set point shall be overridden, and the set point shall be reset to 65 DEGF. Reheat coil control valve shall be modulated to maintain the rooms unoccupied temperature setpoint.
      c. The space shall be indexed into and out of occupied mode based on the local occupancy sensor which shall be coordinated with the Owner. The zone shall remain in the occupied mode for 30 minutes after occupants were last sensed.

G. Demand Control Ventilation: The CO2 shall be monitored on the BAS in rooms where CO2 sensors are shown on the contract drawings. In the event the CO2 sensor senses 700 ppm or greater, the VAV terminal unit air flow control shall be overridden and the air flow shall be reset upwards to the maximum scheduled value to maintain the CO2 below set point. Damper airflow control loop shall be disengaged until the CO2 is back to normal conditions.

3.16 ROOM CONTROL WITH CHILLED BEAMS (LABS AND OFFICES)

A. Refer to Detail on Contract Drawing for diagrams of these types of room controls.

B. The terminal units are controlled independent of system pressure fluctuations by a programmable system controller (PSC) using electric actuation. The space served by the terminal units is controlled in occupied and unoccupied modes. All the terminal units in a given laboratory shall operate in concert to maintain the laboratory pressure relative to the adjacent corridor at all times.

C. Supply Terminal Unit (Supplying the Chilled Beams):
   1. The supply terminal unit shall modulate to maintain the supply airflow at set point. The set point shall be reset based on the occupancy status of the room. The VAV terminal unit is controlled within its minimum and maximum supply air flow in sequence with the chilled beam heating and cooling control valves to maintain room temperature set point.

D. Temperature Control (4-Pipe):
   1. Upon a decrease in room temperature below set point, the VAV terminal unit shall modulate the air flow to its scheduled minimum set point. Upon a rise in temperature, the reverse shall occur.
   2. The chilled beam cooling control valve shall modulate in sequence with the heating coil control valve to maintain room's temperature set point. Upon a decrease in room temperature below set point, the chilled water valve shall modulate closed. Upon a further decrease in room temperature the final heating coil shall modulate open to maintain room temperature set point. Upon a rise in temperature, the reverse shall occur.
   3. The room temperature set point shall be dictated by a local set point adjustment which is integral to the temperature sensor. The set point adjustment shall be electronically limited between 70 to 75 DEGF. Initial set points shall be 68 DEGF in the heating mode and 76 DEGF in the cooling mode.
   4. Room temperature sensors shall have integral set point adjust knob (temperature adjustment limited by software). Unoccupied override pushbutton shall be integral with temperature sensors associated only with rooms incorporating the occupied/unoccupied mode. The override mode shall function for a period of 2 HRS (adjustable).

E. Temperature Control (2-Pipe):
   1. Upon a decrease in room temperature below set point, the VAV terminal unit shall modulate the air flow to its scheduled minimum set point. Upon a rise in temperature, the reverse shall occur.
   2. The chilled beam cooling control valve shall modulate to maintain room's temperature set point. Upon a rise in room temperature above set point, the chilled water valve shall modulate open. Upon a drop in temperature, the reverse shall occur.
   3. The room temperature set point shall be dictated by a local set point adjustment which is integral to the temperature sensor. The set point adjustment shall be electronically limited between 70 to 75 DEGF. Initial set points shall be 68 DEGF in the heating mode and 76 DEGF in the cooling mode.
   4. Room temperature sensors shall have integral set point adjust knob (temperature adjustment limited by software). Unoccupied override pushbutton shall be integral with temperature sensors associated only with rooms incorporating the occupied/unoccupied mode. The override mode shall function for a period of 2 HRS (adjustable).

F. Occupied/Unoccupied Control:
   1. Refer to the lab or office sequence for the occupied/unoccupied mode.

G. Condensation Control:
   1. The BAS shall monitor the space temperature and humidity and calculate the dewpoint. The calculated dewpoint shall be displayed on the BAS graphic screens. In the event the dewpoint in the space approaches the chilled water temperature to the chilled beams (60 DEGF), the chilled water temperature shall be reset upwards. Reset range shall be between 58 to 60 DEGF.
   2. The condensation switch shall be wired directly to the PSC controlling the laboratory. In the event the condensation switch senses condensation, the BAS shall annunciate an alarm on the BAS and shall command the chilled beam control valve closed.
   3. Once the condensation switch no longer senses condensation, the chilled water valve shall be released and allowed to ramp to the control set point over a 5 minute time period.

3.17 FUEL OIL SYSTEM CONTROL

A. Generators are operated on fuel oil.

B. BAS shall monitor the following points to/from the fuel oil system control panel. All other signals shall be through the use of a BACnet or Modbus interface.
   1. Storage tank DT level (analog input).
   2. Fuel oil system common alarm (digital input).
   3. Fuel oil pump #1 Hand-Off-Auto switch in the auto position (digital input).

4. Fuel oil pump #1 status.
5. Fuel oil pump #2 Hand-Off-Auto switch in the auto position (digital input).
6. Fuel oil pump #2 status.
7. Storage tank ST level (analog input).
8. Fuel oil system leak detected (digital input).

3.18 OXYGEN DEPLETION MONITORING SYSTEM CONTROL

A. Refer to detail on contract drawing for a diagram of this typical type of system. System shall be provided in the following areas: Powder Handling Room E058A, Cylinder Storage Room, GSEL Lab E187, EO/IR Concept Development Lab E067, RAD NUC Linear Accelerator Hall E048, Experimental Hall E046, AMDS AP1 Program Lab W189, REDD Additive Manufacturing Facility E058, SES ASO GSEL Cleanroom Lab E112, and MISR Large #1 W289 and MISR large #2 E287.

B. BAS shall provide an oxygen depletion monitoring system as referred to on contract drawings. Oxygen depletion monitoring system shall function as follows:
   1. A sensor shall be located in the room at five foot above the finished floor. Final location and quantity to be coordinated with equipment manufacturer and Owner EH&S personnel.
   2. Local sensor shall provide a signal to an oxygen depletion monitoring panel located outside of the room. BAS and FAS systems shall be alarmed upon detection that the room oxygen level is below a low oxygen limit set point of 19.5 percent. Monitoring panel shall also energize a horn/red strobe device above the doorway in the room and a red strobe to be located above the doorway in the corridor at each entrance to the room.
   3. Monitoring panel shall be provided with a horn silence pushbutton. Upon activation pushbutton shall silence the local horn alarm. Strobes and exhaust fan (if required) shall remain energized until oxygen levels return to their normal state.
   4. Mount strobe/horns centered above door frame and ceiling.
   5. Strobe/horn shall be clearly identified as to its function.

C. BAS shall monitor a fault alarm from the monitoring panel and alarm when activated.

3.19 CARBON DIOXIDE MONITORING SYSTEM CONTROL

A. Refer to detail on contract drawing for a diagram of this typical type of system. System shall be provided in the following areas: GSEL Lab E187, EO/IR Concept Development Lab E067, High Bay Sets W182, W188 and E188, KMT/KMR High Bay E183, AMDS AP1 Program LAB W189, and SES ASO GSEL Lab.

B. BAS shall provide a carbon dioxide monitoring system as referred to on contract drawings. Monitoring system shall function as follows:
   1. A sensor shall be located in the room at five foot above the finished floor. Final location and quantity to be coordinated with equipment manufacturer and Owner EH&S personnel.
   2. Local sensor shall provide a signal to a carbon dioxide monitoring panel located outside of the room. BAS and FAS systems shall be alarmed upon detection that the room carbon dioxide level is above a low alarm limit set point of 1000 ppm. Monitoring panel shall also energize a red horn/strobe device above the doorway in the room and a red strobe to be located above the doorway in the corridor at each entrance to the room. If the room also has an Oxygen depletion monitoring, a common strobe/horn can be used.
   3. Monitoring panel shall be provided with a horn silence pushbutton. Upon activation pushbutton shall silence the local horn alarm. Strobes shall remain energized until oxygen levels return to its normal state.
   4. Mount strobe/horns centered above door frame and ceiling.
   5. Strobe/horn shall be clearly identified as to its function.

C. BAS shall monitor a fault alarm from the monitoring panel and alarm when activated.

3.20 OZONE MONITORING SYSTEM CONTROL

A. Refer to detail on contract drawing for a diagram of this typical type of system. System shall be provided in the following areas: RAD NUC Linear Accelerator Hall E048, and Experimental Hall E046.

B. BAS shall provide an ozone monitoring system as referred to contract drawings. Monitoring system shall function as follows:
   1. A sensor shall be located in the room at five foot above the finished floor. Final location and quantity to be coordinated with equipment manufacturer and Owner EH&S personnel.
   2. Local sensor shall provide a signal to a monitoring panel located outside of the room. BAS and FAS systems shall be alarmed upon detection that the room level is above a low alarm limit set point of 0.1 ppm. Monitoring panel shall also energize a red horn/strobe device above the doorway in the room and a red strobe to be located above the doorway in the corridor at each entrance to the room. If the room also has an Oxygen depletion monitoring, a common strobe/horn can be used.
   3. Monitoring panel shall be provided with a horn silence pushbutton. Upon activation pushbutton shall silence the local horn alarm. Strobes shall remain energized until alarm levels return to its normal state.
   4. Mount strobe/horns centered above door frame and ceiling.
   5. Strobe/horn shall be clearly identified as to its function.

C. BAS shall monitor a fault alarm from the monitoring panel and alarm when activated.

3.21 CARBON MONOXIDE MONITORING SYSTEM CONTROL

A. Refer to detail on contract drawing for a diagram of this typical type of system. System shall be provided in the following areas: High Bay Labs.

B. Refer to Section 25 90 00 - 3.10 Mechanical Room Ventilation for Boiler Carbon Monoxide monitoring.

C. BAS shall provide a carbon monoxide monitoring system as referred to on contract drawings. Monitoring system shall function as follows:
   1. A sensor shall be located in the room at five foot above the finished floor. Final location and quantity to be coordinated with equipment manufacturer and Owner EH&S personnel.
   2. Local sensor shall provide a signal to a carbon monoxide monitoring panel located outside of the room. BAS and FAS systems shall be alarmed upon detection that the room carbon monoxide level is above a low alarm limit set point of 50 ppm. Monitoring panel shall also energize a red horn/strobe device above the doorway in the room and a red strobe to be located above the doorway in the corridor at each entrance to the room.
   3. Monitoring panel shall be provided with a horn silence pushbutton. Upon activation pushbutton shall silence the local horn alarm. Strobes shall remain energized until alarm levels return to its normal state.
   4. Mount strobe/horns centered above door frame and ceiling.
   5. Strobe/horn shall be clearly identified as to its function.
   6. Upon CO detection alarm being activated, BAS shall index associated exhaust fan into operation.
   7. Normal system operation shall commence upon CO alarm being cleared.

D. BAS shall monitor a fault alarm from the monitoring panel and alarm when activated.

3.22 POWER OUTAGE SEQUENCE

A. In response to a power outage, the following shall occur concurrently:
   1. All AHUs and exhaust fans shall be shut down.
   2. All hydronic systems shall be shutdown.

B. Once standby power is available the following shall occur concurrently:
   1. All AHUs and exhaust fans fed from standby power shall be restarted as indicated in their respective sequence of operations in this section.

2. Note: The emergency generators will operate for no less than 30 minutes.

C. Once normal power is restored, the following systems shall be restarted immediately:
1. The hydronic systems.
2. The AHU-6 system shall be restarted with its associated exhaust fans.
3. Critical terminal equipment serving spaces such as telecom closets and electrical rooms shall operate up to the power interruptions, and shall be restarted immediately after power is restored.

D. Once normal power is restored, the following systems shall be restarted in 5 second increments:
1. Exhaust fans.
2. All remaining AHUs associated EFs can be restarted in 5 second increments.

3.23 TYPICAL FAN COIL UNIT

A. Refer to Details on Contract Drawing M-808 for a diagrams of this typical type of room control.

B. Fan Coil Units shall condition the air twenty-four (24) hours per day, seven (7) days per week to satisfy the associated area temperature setpoints

C. All Fan Coil Unit functions shall be controlled by an Application Specific Controller (ASC)

D. The fan shall operate continuously. The cooling coil control valve shall modulate to maintain the room temperature at 2 DEGF above the space setpoint dictated by the wall mounted temperature sensor.

E. Section 25 10 00 shall provide power and control wiring as required.

F. Four pipe fan coil units are for heating and cooling and shall run continuously. Upon a rise in the space temperature, the controller shall modulate the cooling coil valve towards the closed position. Conversely in a drop in space temperature, the controller shall modulate the heating coil valve towards the open position. Provide a minimum deadband of 5 DEGF to prevent simultaneous control of heating and cooling.

G. Two pipe fan coil units are either for cooling or heating only and shall run continuously. Refer to contract drawings and schedules for unit requirements. For cooling only, upon a rise in the space temperature, the controller shall modulate the cooling coil valve open from its normally closed position. For heating only, upon a drop in space temperature, controller shall modulate heating valve open from its normally closed position. Reverse sequence shall take place as required.

H. Fan coil unit to be furnished with a drain pan and high level switch. BAS shall install and wire switch to controller and shutdown FCU and close chilled/hot water valves upon a high water level condition in drain pan condition.

I. Fan coil unit shall be provided with a condensate pump with a drain pan and float switch in the drain pan. BAS shall install and wire switch to controller and shutdown FCU upon a high water condition.

J. FCU units over 2000 cfm shall be provided with a smoke detector on the return. The BAS shall monitor the fire alarm system (FAS) via a fire alarm relay. In the event the FAS senses smoke and changes the state of the relay, an alarm shall be annunciated on the BAS and the associated FCU fan shall be de-energized through a hardwired interlock in the FAS relay.

K. Set points:
1. Labs: 75 DEGF (summer), 70 DEGF (winter).
2. Lab Support Areas: 75 DEGF (summer), 70 DEGF (winter).
3. Electrical Spaces: 80 DEGF.
4. Communication Rooms: 75 DEGF.
5. Mechanical Spaces: 80 DEGF.

3.24 UNDER FLOOR LEAK DETECTION

A. Refer to Details on Contract Drawing M-808 for a typical arrangement.

B. BAS shall monitor underfloor leak detection and an alarm shall be annunciated on the BAS in the event water is sensed.

3.25 MISCELLANEOUS MONITORING

A. Monitor the following points on the BAS. Provide all wiring, terminations, and field coordination necessary to successfully monitor the points listed below. For analog points, coordinate the signal type with the 3rd party equipment providers to ensure the proper scaling factors are applied to the signals to ensure the correct value is displayed on the BAS.

B. Review construction documents at the time of bid to confirm the quantities of each type of 3rd party equipment being monitored.

C. Coordinate the alarming requirements with Owner, setup the alarms and commission the operation of all the alarms prior to turnover.

D. For digital points, open contacts shall indicate an "alarm" condition; closed contacts shall indicate a "normal" condition. The de-energized state of the contacts shall be open.

E. All points shall be displayed on the BAS graphic screens.

F. The location field in the table below is for information only. It is the contractor's responsibility to locate all equipment on the contract drawings.

G. Hot water recirculation pump CP-1 shall operate when the building is in its occupied mode. BAS shall monitor the pump status and alarm if pump is not in operation during the buildings occupied cycle.

EQUIPMENT DESCRIPTION	LOCATION	POINT DESCRIPTION	I/O TYPE	QUANT.	TREND	ALARM
Elevator Sump Pump	Elevator Pit	High Level Alarm On/Off Status	DI DI	1 1	N N	Y Y
Sump Pump		High Level Alarm On/Off Status Oil Present	DI DI DI	1 1 1	N N N	Y Y Y
Domestic Water Meter		Instantaneous Flow	AI	1	Y	Y
Domestic Water Meter		Totalized Flow	DI	1	Y	Y
Domestic Water Booster System		Pump Status Low Suction Cutout Pump Failure Alarm	DI DI DI	1 1 1	N N N	Y Y Y
Main Switchgear		Building Loads	BACnet	1	Y	N
Switchgear Feeder Breaker		Activated	BACnet	8	Y	Y
ATS switch		Normal Power		3	Y	Y
ATS switch		Standby Power		3	Y	Y
Chillers			BACnet	2	Y	Y
Boilers			BACnet	2	Y	Y
Standby Generator			BACnet	1	Y	Y

EQUIPMENT DESCRIPTION	LOCATION	POINT DESCRIPTION	I/O TYPE	QUANT.	TREND	ALARM
Laboratory Air System		Start Permissive Trouble Alarm Air Dryer Alarm	DO DI DI	1 1 1	N Y N	N Y Y
UPS Alarms			DI	1	Y	Y
Ultraviolet Sterilizer		Trouble Alarm	DI	1	Y	Y
Cooling Tower Water Treatment		Trouble Alarm	DI	1	Y	Y
Standby Generator Belly Tank		Low Fuel Oil Alarm	DI	1	Y	Y
Hot Water Recirculating Pump CP-1		Operating Status	DI	1	Y	Y

3.26 TYPICAL GENERATOR ROOM CONTROL

A. Refer to the Contract Drawings for a diagram of this system.

B. Generator Interlock
1. When the generator is enabled, the following sequence shall occur: The associated room intake and exhaust dampers shall be hardwire-interlocked with the generator. When the generator is enabled the dampers shall open, once the dampers prove open with the associated limit switches, the generator shall start. If at any point during operation, the limit switch indicates the damper is closing an alarm shall be annunciated on the BAS.
2. The dampers shall be provided with fast acting actuators (full open within 6 seconds).
3. Dampers shall fail to their open position and normally held closed by the generator panel.
4. BAS shall monitor the dampers open and closed positions, and alarm if the damper is closed and it should be open or open and it should be closed.

3.27 AIR CURTAIN/UNIT HEATER CONTROL (HOT WATER)

A. General: Air curtain/unit heaters are furnished with space thermostat for field mounting by Section 25 10 00. Two-position control valve shall be provided with unit. Coordinate with Section 23 82 39.

B. Air Curtain Temperature Control: Once door has been opened, fan shall be started by a switch provided with unit and upon a decrease in space temperature below set point, remote-mounted electric thermostat shall open control valve. Reverse shall occur on an increase in temperature above setpoint or when door closes.

C. Unit Heater Temperature Control: Thermostat provided with unit heater shall start the fan and open the hot water control valve when required to maintain a room temperature setpoint.

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DIVISION 26

ELECTRICAL

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SECTION 26 00 10
ELECTRICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Electrical General Requirements, as indicated, in accordance with provisions of Contract Documents.
   1. Drawings are diagrammatic and indicate general arrangement of systems and equipment, except:
      a. Specific installation details.
      b. When specific dimensions are indicated for electrical equipment it is intended that these be limiting dimensions. When proposed equipment exceeds these limiting dimensions, advise Architect. Features and functions of specified equipment shall not be superseded by these limiting dimensions.
   2. For exact locations of building elements, refer to dimensioned architectural/structural drawings.
   3. Field measurements take precedence over dimensioned drawings.
   4. Intention is to indicate size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement.

B. Completely coordinate with work of other trades.

C. Concrete Anchoring:
   1. Cracked concrete is the baseline condition for the design of cast-in-place and post-installed anchors in alignment with both ACI 318 and International Building Code.

D. Installation of all systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination drawings.

1.2 SYSTEM DESCRIPTION

A. Provide materials to provide systems in compliance with performance requirements specified.

B. Provide modifications required by reviewed shop drawings and field coordinated drawings.

1.3 QUALITY ASSURANCE

A. Perform work in accordance with but not limited to:
   1. Federal, state and local codes, regulations and ordinances.
   2. Underwriters Laboratories, Inc. (UL) requirements.
   3. NFPA-70 National Electrical Code (NEC).
   4. Occupational Safety and Health Act (OSHA).
   5. All authorities having jurisdiction.
   6. Factory Mutual System (FM) requirements.
   7. International Building Code (IBC).
   8. ACI 318: Building Code Requirements for Reinforced Concrete.

B. Prototype room: Perform electrical work required in Section 01 43 41.

1.4 SUBMITTALS

A. Product Data:
   1. Concrete Anchors:
      a. Document Manufacturer Approval or Listing for cracked concrete application
         1) Drop-in anchors are not cracked concrete rated.

B. Contract Closeout Information:
   1. Final performance test reports.

1.5 PROTECTION

A. Provide covering and shielding for equipment to protect from damage.

B. Protect nameplates on motors and similar equipment, to prevent defacing.

C. Repair, restore or replace damaged, corroded and rejected items.

1.6 JOB CONDITIONS

A. Examine Contract Documents to determine how other work will affect execution of electrical work.

B. Make arrangements for and pay for permits, licenses, and inspections.

C. Cause as little interference or interruption of existing utilities and services as possible.
   1. Schedule work which will cause interference or interruption in advance with Owner, Architect, authorities having jurisdiction and affected trades.

D. Determine and verify locations of existing utilities on or near site.

E. Temporary construction power and communications (See Division 01)

F. Record drawings:
   1. Keep a complete set of electrical drawings in job site office for indicating actual installation of electrical systems and equipment.
   2. Use this set of drawings for no other purpose.
   3. Where any material, equipment, or system components are installed differently from that indicated, indicate differences clearly and neatly using ink.
   4. At project completion, submit record set of drawings. Refer to Section 01 78 39 for specific requirements.

1.7 ENVIRONMENTAL CONDITIONS

A. General:
   1. Provide NEMA 1 enclosures for electrical equipment unless otherwise indicated.

B. Conduit: See Section 26 05 33.

C. Cable: See Section 26 05 19.

D. Boxes and Fittings: See Section 26 05 34.

E. Damp and Wet Locations:
   1. Exterior applications:
      a. Provide NEMA 3R enclosures for electrical equipment.

1.8 CLEANROOM PROTOCOL

A. All work within the clean zone shall be installed in accordance with 13 60 13 Special Clean Zone Requirements and 13 60 16 Cleanroom Protocol.

1.9 LAB ROOM PROTOCOL

A. Conduits and conductors with a lab shall only serve that lab. Conduits and conductors shall not be allowed to feed through a lab to serve adjacent spaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Concrete Anchors:
   1. Hilti
   2. Simpson Strong-Tie
   3. Powers Fasteners

2.2 MATERIALS

A. Concrete Anchors:
   1. Cast-in-place or post installed anchor approved for cracked concrete applications.
      a. Note; Drop-In Anchors SHALL NOT be used.

B. Material and Equipment:
   1. Current and standard design of manufacturers regularly engaged in their production.

C. Use UL labeled electrical materials and fabricated assemblies.

D. Structural Steel for Supports:
   1. ASTM A36.
   2. Galvanize members installed in areas of high humidity or condensation.
   3. Furnish other members with shop coat of rust inhibiting primer.
   4. Shop fabricate for field assembly using bolts.
   5. Minimize field welding.
   6. Retouch primer and galvanizing after field welding.
   7. Unless support is otherwise indicated where weight of equipment exceeds 400 LBS, submit engineering design and calculations signed and sealed by a registered Engineer licensed to practice Structural Engineering in the state in which the project is located.

E. Concrete Anchors:
   1. Cast-in-place or post installed anchor approved for cracked concrete applications.
      a. Note; Drop-In Anchors SHALL NOT be used.

F. Access doors, panels and frames: See Section 08 31 16.
   1. Provide where indicated on Drawings.
   2. Where not indicated on Drawings, provide access panels and/or doors at walls, and inaccessible ceilings as required to permit access to equipment, devices and piping requiring service, adjustment, or inspection.
   3. Size:
      a. As required to allow access, inspection, service, and removal of items served.
      b. Minimum 18 x 18 IN.

G. Rain hoods and counter flashings not exposed to view:
   1. Stainless steel: Minimum 20 GA.
   2. Sheet copper: Minimum 24 OZ.

H. Rain hoods and counter flashings exposed to view: As specified in Section 07 62 00.

2.3 FIRESTOPPING

A. Maintain fire and smoke ratings where electrical items penetrate fire and fire/smoke rated building elements.

B. Use materials and methods as specified in Section 07 84 00.

PART 3 - EXECUTION

3.1 GENERAL

A. When changes in location of any work are required, obtain approval of Architect before making change.

B. Do not change indicated sizes without written approval of Architect.

C. Provide offsets and crossovers in conduits, raceways, cable trays and ducts.

D. Where electrical items penetrate fire and/or smoke rated walls, ceilings and floors, comply with Section 07 84 00.

3.2 CUTTING AND PATCHING

A. Provide cutting, fitting, repairing, patching and finishing of installed work.
   1. Include installed work of other sections where it is to disturb such work to permit installation of electrical work.
   2. Repair or replace existing or new work disturbed.

B. Avoid cutting, where possible, by setting sleeves or frames, and by requesting openings in advance.

C. Before cutting, obtain approval of Structural Engineer.
   1. Use only approved methods.
   2. Cut holes approved by Engineer neatly to admit work.
   3. Do not weaken walls or floors; locate holes in concrete to avoid structural members.

D. Locate openings and sleeves to permit neat installation of conduits and equipment.

E. Do not remove or damage fireproofing materials.
   1. Install hangers, inserts, supports, and anchors prior to installation of fireproofing.
   2. Repair or replace fireproofing removed or damaged, at no extra cost.

F. See Section 01 73 29.

3.3 EXCAVATING AND BACKFILLING

A. Excavating, trenching, and backfilling:
   1. See Section 31 23 00.
   2. See Section 26 05 43.

3.4 INSTALLATION OF EQUIPMENT

A. Install equipment in accordance with manufacturer's recommendations.

B. Anchoring Devices and Supports.
   1. Use anchoring devices and structural supports suitable for equipment and install in accordance with manufacturer's recommendations.
   2. Check loadings and dimensions of equipment with shop drawings.
   3. Do not cut, or weld to, building structural members.
   4. Provide equipment supports even though not detailed on architectural and structural drawings.

C. Verify equipment will fit support layouts indicated.

D. Provide boxes, sleeves and devices for installation.

E. Make penetrations through roofs prior to installation of roofing.

F. Install rain hoods and metal counter flashings as indicated and make penetrations of electrical work through walls and roofs water and weathertight.
   1. Furnish clamps, waterproofing material and labor.
   2. Where metal flashings are applied over concrete, paint concrete with 1/8 IN of mastic cement first.
   3. Set flashing in mastic cement, watertight.

G. Have repair and replacement of roof construction, damaged by this work, done in manner which will not nullify roof warranty.

H. Install equipment to permit easy access for normal maintenance.
   1. Maintain easy access to switches, motors, drives, pull boxes, receptacles, etc.
   2. Relocate items which interfere with access.

I. Provide concrete foundations (isolation pads) or housekeeping pads for floor mounted electrical equipment as follows unless otherwise indicated:
   1. Install nominal 4 IN high concrete housekeeping pads. Outside dimension of pad shall be at least 4 IN larger in all directions than base of equipment or 228 MM 9 IN from center of anchor, whichever is greater.
   2. Use 3,000 PSI concrete.
   3. Reinforce with No.4 12 IN OC each way, with short No.4 dowels into floor at 24 IN OC each way.
   4. Chamfer top edges 3/4 IN.
   5. Make faces smooth.
   6. Set anchor bolts for equipment.

3.5 PAINTING

A. See Section 09 91 13, and Section 09 91 23.

3.6 FIELD QUALITY CONTROL

A. Perform indicated tests to demonstrate workmanship, operation, and performance.
   1. Conduct tests in presence of Architect and, if required inspectors of agencies having jurisdiction.
   2. Arrange date of tests in advance with Architect, manufacturer and installer.
   3. Give minimum of 24 HRS notice to inspectors.
   4. Furnish or arrange for use of electrical energy, steam, water, diesel fuel, or gas required for tests.
   5. Furnish lubricating materials required for test.

B. Repair or replace equipment and systems found inoperative or defective and retest.
   1. If equipment or system fails retest, replace it with products conforming with Contract Documents.
   2. Continue remedial measures and retests until satisfactory results are obtained.

C. Test equipment and systems as indicated for each item, unless otherwise recommended by manufacturer.

3.7 FINAL PERFORMANCE TEST

A. Perform panel load balance, short circuit, and freedom from ground, and ground test (including ground fault protection where provided).
   1. As part of putting systems in operation, provide tabulated results of load balance and voltage at each switchboard, panelboard and motor control center. Use true RMS measuring metering devices.
   2. Provide written report that circuits have been energized and no short circuits exist.
   3. Provide neutral to ground resistance tests to prove neutral is grounded in only one location.
   4. Provide ground test at service entrance and provide report on resistance to earth of the grounding electrode system.

3.8 ADJUST AND CLEAN

A. Inspect equipment and put in good working order.

B. Clean exposed and concealed items.

C. Where new work occurs in existing areas where no other work has been done, clean area and restore to original condition.

3.9 PUTTING SYSTEMS IN OPERATION - START UP

A. Put systems into satisfactory operation prior to final acceptance, at time agreed to by Contractor, Owner and Architect.

B. Operate systems in good working order for period of 5 working days.

3.10 DEVICE MOUNTING

A. See symbol legend for devise mounting heights unless otherwise noted.

B. Dimensions are to center of device unless otherwise indicated.

C. Coordinate device locations with equipment/furnishings abutting walls such as, but not limited to, architectural millwork, casework, lockers, mirrors, and equipment. Refer to architectural and casework/equipment elevations to facilitate coordination of device placement. Devices shall be relocated at Contractor's expense if conflict exists after installation.

END OF SECTION

SECTION 26 00 11

WIRING EQUIPMENT FURNISHED BY OTHER DIVISIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish conduit, wiring, outlet boxes, receptacles, circuit breakers, fittings, switches, starters, (with overloads), to make final connections to equipment.

B. Connect:
1. Elevator equipment, (Division 14).
2. Heating, ventilation, cooling and plumbing system equipment, (Divisions 22, 23, 25).
3. Automatic door equipment, (Division 08).
4. Projection screens, (Division 11).
5. Parking control equipment, (Division 11).
6. Electric signs, (Division 10).
7. Fixed and/or movable equipment, (Division 11).
8. Panel folding doors, (Division 08).
9. Systems furniture (Division 12).
10. Motorized shades (Division 12).
11. Electronic security equipment, (Division 28).
12. Bridge cranes and hoist, (Division 41).

C. Completely coordinate with work of other trades.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Elevator:
1. Provide following for each elevator:
    a. Shunt Trip Breaker:
        1) Locate on wall or fabricated rack near door of machine room.
        2) Furnish conduit and wire from switch to controller.
    b. 30 A S/N, 120V disconnecting switch for 120V power supply for car lights.
        1) Locate adjacent to elevator disconnect.
    c. 120V GFCI duplex receptacle and vapor-tight fixture in each elevator pit, with switch and pilot light located outside of pit at 48 IN above floor. Pit light shall not be protected by GFCI.
    d. 120V GFCI duplex receptacle and vapor-tight fixture at top of each elevator hoistway, with switch and pilot light located adjacent to access door. Hoistway light shall not be protected by GFCI.
    e. 120V GFCI duplex receptacle in each elevator machine room.
    f. 120V single receptacle mounted in pit for sump pump.
    g. Provide NEMA 3R equipment in elevator machine room if room is sprinkled.
    h. Car telephone outlet J-box with empty 3/4 IN conduit to telephone cabinet.
        1) Locate at midpoint of each shaft or at elevator controller as directed by elevator installer.
2. See section 28 31 00 for connections to Fire Alarm System.
3. Coordinate controls connection to automatic transfer switches serving elevators. See specification 26 36 23.
4. The shunt trip breaker for each elevator shall be a UL listed device with shunt trip voltage isolation relay monitored by the fire alarm system in accordance with NFPA 72. Shunt trip disconnect for elevator shall be rated for use in wet location if elevator machine room is sprinkled.

B. Mechanical Specification Divisions Equipment:
   1. Furnish conduit, wire, and connect Mechanical Specification Divisions equipment.
   2. Furnish motor starters except in package or prewired units as indicated in Mechanical Equipment Schedule.
      a. Connect motors.
      b. Furnish starters with thermal overload protection for motors not having such protection, except as otherwise indicated.
      c. Starters: See Section 26 24 19.
   3. Furnish proper thermal overload heater elements in starters.
   4. Coordinate all equipment shutdown emergency power off (EPO) switch requirements with Mechanical/Controls Contractor.
   5. Provide connection to all air handling unit internal receptacle, lighting, and UV germicidal circuits. Coordinate interconnections within unit with Mechanical Contractor.
   6. Smoke and Fire/Smoke Dampers:
      a. Provide power connection to all smoke and fire/smoke dampers. The Contractor shall utilize the 120V Emergency circuits shown on the drawings for this purpose. Total load on each circuit shall not exceed 1200VA upon actuator operation.
      b. Each damper shall include a local disconnecting means.
   7. Locate or relocate disconnects to areas with proper clearances.

C. Automatic Door Equipment:
   1. Furnish conduit, wiring, outlet boxes to make final connections to motors, switches, safety mats, proximity detectors, remote control units, electric dead bolts.
   2. See Section 28 31 00 for connections to fire alarm system.
   3. Switches for control of automatic doors provided by door manufacturer, installed by electrical.

D. Panel Folding Doors:
   1. Furnish conduit, wiring, and outlet boxes, to make final connections to electrically operated panel folding doors and associated key activated switches, drive motor and limit switches.
      a. Install key switches and limit switches per manufacturer's requirements.
      b. Install wiring in conduit.
      c. Furnish local disconnect switch.

E. Projection Screens:
   1. Furnish conduit, wiring, outlet boxes to make final connections to power projection screens and associated UP/STOP/DOWN switches.
   2. UP/STOP/DOWN switches provided by door manufacturer, installed by electrical.

F. Division 11 Equipment:
   1. Furnish conduit, wiring, outlet boxes, receptacles, circuit breakers, fittings, switches, to make final connections to equipment.
   2. Where equipment items are to be connected using plug and receptacle, furnish receptacle compatible with plug.
   3. Where equipment is to be directly connected, use flexible conduit as indicated in Section 26 05 33.
   4. See Division 11 and electrical plans for equipment to be connected.

G. Parking Control Equipment:
   1. Furnish conduit, wiring, outlet boxes, to make final connections to parking gates, magnetic loops, ticket spitters, attendant booths, as indicated.

H. Electric Signs:
   1. Furnish conduit, wiring, and outlet boxes, to make final connections to exterior electric signs. Sign(s) shall be controlled by exterior lighting master controls.

I. Systems Furniture:
   1. Provide power connection to pre-wired systems furniture. Coordinate final connection requirements.

2. Coordinate circuit breaker for circuits feeding systems furniture with systems furniture internal wiring. If a shared neutral is provided within the systems furniture, a multi-pole circuit breaker of appropriate ampacity shall be provided.

J. Motorized Shades:
   1. Provide all conduit, wiring, outlet boxes, etc. to make final connections to motorized shades, associated controllers, and local switches.
   2. Coordinate additional controls with patient room nurse call system. Provide additional contacts and/or relays as required.
   3. Controllers and switches shall be provided by the manufacturer, installed by electrical.

K. Division 28 Electronic Security Systems:
   1. Furnish complete raceway system, minimum size conduit 3/4 IN, from main head end equipment to the end device, including any necessary standard size backboxes, wireways, junction boxes, pullboxes and manholes.
   2. Furnish 120 volt AC power wiring and connections to electronics systems UPS equipment.
   3. Furnish heavy duty nylon pull string or wire suitable for use in pulling in wire in conduit.
   4. Division 28 installer: Furnish conduit requirements and special backboxes to the Electrical Specifications Divisions installer.
   5. Division 28 installer: Furnish additional conduits required (not shown on drawings) or increase in size of conduit to effect the installation of the Division 28 equipment.
   6. Refer to Division 28 and to electronic security drawings, Series EY.

2.2 BRIDGE CRANES AND HOIST

A. Provide all power and control conduit, wiring, disconnect switches, outlet boxes, etc., to make final connections to all motors, switches and control stations.

B. Install and connect to control stations furnished by Division 41 per manufacturer's instructions.

C. Provide control conductors in conduit, conductor type and quantity as recommended by supplier of equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Perform work in accordance with applicable Electrical Specifications Divisions.

B. Wire equipment complete, properly connected and energized.

C. Furnish conduit and wiring as required for directly-connected switches as indicated or required.

END OF SECTION

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SECTION 26 05 13
MEDIUM VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Medium Voltage Cables, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. EPR insulated cable shall comply with the following:
   1. NEMA Publication No. WC 74-2006, ICEA Publication S-93-639, 5-46 kV Shielded Power Cable for Use in the Transmission & Distribution of Electric Energy,
   2. AEIC (Association of Edison Illuminating Companies) Publication No.CS8-07, Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46 KV
   3. UL1072 Medium Voltage Power Cables.

B. Splices and terminations shall comply with the following:
   1. IEEE 404-2006 IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 to 500000 V
   2. IEEE 48- IEEE Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV.
   3. IEEE 386-2006 IEEE Standard for Separable Insulated Connector System for Power Distribution Systems above 600 V.

C. Factory Tests:
   1. Each reel of cable shall be tested in accordance with requirements of:
      a. ICEA-S-93-639 including but not limited to following tests:
         1) Electrical resistance.
         2) Insulation resistance.
         3) High voltage a.c. and d.c potential.
      b. AEIC-CS8-07 including but not limited to following test:
         1) Corona.
   2. Factory test data and certification of compliance shall be submitted.

D. High potential testing shall comply with the following:
   1. IEEE 400-2001 IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
   2. InterNational Electrical Testing Association (NETA)- Acceptance Testing Specifications For Electrical Power Distribution Equipment and Systems.

E. Qualifications:
   1. Cable technician:
      a. Three years experience in handling, terminating and splicing medium voltage cables.
      b. Specifically trained by factory representative on terminations and splices to be used on project. If not trained on products to be used, on-site training by factory representative shall be preformed before any terminations or splices are made.
   2. Cable testing :
      a. Independent testing organization shall have been engaged in full practice in final inspection, testing, calibration, and adjusting of electrical distribution systems, for minimum of five years.

b. Testing shall be performed by individual who has had at least 5 years experience in testing of medium voltage cables of this type with specified testing procedure.
c. Independent testing organization shall have calibration program with accuracy traceable every six months in unbroken chain, to National Institute of Standards and Technology (NIST).
d. Independent testing organization shall have designated safety representative on project. Standards followed shall include OSHA, NFPA 70E and IEEE 510.
e. Inspection, testing, and calibration shall be performed by engineering technician, certified by national organization, such as InterNational Electrical Testing Association or National Institute for Certification in Engineering Technologies, with minimum of five years experience inspecting, testing, and calibrating electrical equipment, systems and devices. Information on certified engineering technician shall be submitted to Engineer for approval prior to start of work.
f. Qualifications of independent testing organization shall be submitted to Engineer for approval prior to start of testing. Full membership to InterNational Electrical Testing Association constitutes proof of meeting all above requirements.

1.3 SUBMITTALS

A. Product Data:
  1. Technical data on each type of cable, splice and termination.

B. Samples:
  1. Cable sample:
    a. Length submitted to include all stamped on information including:
      1) Manufacturers name.
      2) Plant number or designation.
      3) Conductor size.
      4) Copper.
      5) Voltage rating.
      6) Insulation type and level.
      7) Insulation thickness.
      8) UL designation.
      9) Type MV-105.

C. Project Information:
  1. Factory test reports.
  2. Cable Technician qualifications.
  3. Independent testing organization qualifications.
  4. Engineering Technician qualifications.
  5. Cable pulling tension record from pulling rig dynamometer.
  6. Cable test reports signed by the engineering technician including the following information:
    a. Summary of Project.
    b. Description of equipment/components tested.
    c. Visual inspection report.
    d. Description of tests.
    e. Test results including appropriate test forms.
    f. Conclusions and recommendations.
    g. Identification of test equipment used.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Medium voltage cable:
  1. Base:
    a. Okonite.
    b. Kerite.

c. Southwire.
d. General Cable.

B. Splices and terminations:
1. Base:
a. 3M.
b. Raychem.
c. Elastimold.
d. Joslyn.
e. Cooper Power Systems.

C. High dielectric, arc proof and insulating tape:
1. Base:
a. 3M.
b. Okonite.

2.2 MATERIALS

A. Medium Voltage Power Cable:
1. Medium voltage cable: Single conductor, copper, rated 105 DEGC wet or dry, EPR, 133 PCT insulation level, Type MV-105.
a. 15 kVrated, 220 MIL average thickness.
b. Minimum spot thickness 90 PCT of average thickness.
2. Cable shall be no more than 12 months old and each reel shall have label indicating name of manufacturer and date of manufacture.
3. Conductor: Compressed concentric round, Class B, stranded, annealed base copper.
4. Conductor shield: Free stripping layer of extruded semi-conducting EPR firmly bonded to the insulation.
5. Insulation: Ethylene Propylene Rubber (EPR).
6. Insulation shield: Free stripping layer of extruded semi-conducting EPR.
7. Shield: Helically applied 5 MIL uncoated copper tape overlapped a minimum of 12.5 PCT.
8. Outer jacket: Oil and sunlight resistant PVC.
9. Armor: None.
10. Armor Jacket: None.

B. Splices And Terminations:
1. Splicing and terminating materials:
a. Acceptable to and as recommended by cable manufacturer.
b. Equal to or exceed rating of cable.
2. Splices: Cold shrink molded rubber or hot shrink manufactured kit type in accordance with IEEE 404 and suitable for water immersion.
a. Conductor splices: Compression type.
b. Insulation, shield and jacket splices:
1) In-line splices:
a) Cold shrink molded rubber: 3M 5500 series.
b) Hot shrink, 5 kV: Raychem HVS 820S Series.
c) Hot shrink, 15 kV: Raychem HVS 1520S Series.
2) Wye splices:
a) Hot shrink: Raychem HVSY 1520S Series.
c. Splices: Deadfront, modular, separable insulated connectors in accordance with IEEE 386 and suitable for water immersion.
d. 200A loadbreak elbows and 2-way, 3-way and/or 4-way loadbreak junctions mounted on a stainless steel bracket.
1) Cooper Power Systems 500 Series.
e. 600A deadbreak T-Body connectors with grounding eye and test point, connecting plugs, insulating plug with cap and stub, and insulating plug with cap.
1) Cooper Power Systems 600 Series.

3. Terminations:
   a. Indoor: Cold shrink or hot shrink manufactured kit type in accordance with IEEE 48 Class 1 terminations utilizing high dielectric constant stress control tube:
      1) Conductor termination: Compression type lug.
      2) Insulation, shield, and jacket terminations:
      3) Cold shrink: 3M 5620K Series.
      4) Hot shrink, 5 kV: Raychem HVT-80-SG Series.
      5) Hot shrink, 15 kV: Raychem HVT-150-SG Series.
   b. Outdoor or within exterior enclosures: Porcelain, cold shrink or hot shrink manufactured kit type in accordance with IEEE 48 Class 1 terminations utilizing high dielectric constant stress control tube:
      1) Conductor termination: Compression type lug.
      2) Insulation, shield, and jacket terminations:
      3) Porcelain: 3M 5900 Series.
      4) Cold shrink: 3M 5630K Series.
      5) Hot shrink, 5 kV: Raychem HVT-80-SG Series.
      6) Hot shrink, 15 kV: Raychem HVT-150-SG Series.
   c. Within exterior enclosures: Deadfront, modular, separable insulated connectors in accordance with IEEE 386.
      1) 200A loadbreak elbows with hook stick pulling eye, grounding eye, and test point.
         a) Elbows shall be compatible with other manufacturers of loadbreak bushing inserts.
         b) Refer to Sections Low Profile Pad Mounted Switchgear and/or Pad Mounted Transformer for loadbreak bushing inserts and bushing wells.
         c) Cooper Power Systems 500 Series.
      2) 600A deadbreak elbows with pulling eye, grounding eye and test point.
         a) Elbows shall be compatible with other manufacturers of deadbreak bushings.
         b) Refer to Sections Low Profile Pad Mounted Switchgear and/or Pad Mounted Transformer for deadbreak bushings.
         c) Cooper Power Systems 600 Series.

2.3 ARC PROOF TAPE

A. Flexible, conformable, organic fabric coated one side with flame-retarded flexible elastomer; self-extinguishing; and shall not support combustion.

B. 3M Scotch 77.or Plymouth “Plyarc”

2.4 INSULATING TAPE FOR USE WITH ARC PROOF TAPE

A. Woven glass fabric with pressure-sensitive thermosetting adhesive.

B. 3M Scotch 69.

2.5 PULLING LUBRICANT

A. Pulling lubricant: Approved by cable manufacturer.

PART 3 - EXECUTION

3.1 CABLE PULLING

A. Do not install cable during wet conditions.
   1. Prior to pulling cables, drain or pump out manholes and other low points if standing water is present.
   2. Blow out conduits with dried compressed air if moisture is present in conduits.
   3. Install end caps immediately on all cut ends of cable prior to pulling, and maintain end caps while pulling in cable.
      a. If end caps are damaged, remove and install new end caps.
      b. Do not remove end caps until ready to terminate or splice cable.

B. Do not install conductors when ambient temperature is near minimum as recommended by manufacturer for installation of the type of conductor insulation.

C. Set up reels as close to duct entrance as possible.

D. Do not bend cable permanently or temporarily to radius less than 12 times cable diameter.

E. Provide cable protector at duct entrance.

F. Pull all cables occupying same conduit together.

G. Make attachment to cable to be pulled by woven basket grips or directly to conductor.

H. Use swivel connector.

I. Seal cable ends.

J. Use no pulling lubricant on first or last 5 FT of cable.

K. Pull cables slowly and steadily:
   1. Do not exceed 50 FPM.
   2. Stop only if absolutely necessary.

L. Maximum pulling tension on conductor not greater than smaller of following:
   1. Manufacturer's allowable tension.

M. Provide pulling rig with pulling tension indicating and recording dynamometer.
   1. Submit record of the actual pulling tension of each cable pull. Submittal shall indicating compliance with allowable pulling tension.
   2. Replace cables when actual pulling tensions exceeds the allowable pulling tension.

3.2 SPLICING AND TERMINATING

A. Install splices and terminations acceptable to the cable manufacturer and in accordance with the splice and termination kit manufacturer's instructions.

B. Splices and terminations shall be performed by qualified individual(s) with a minimum of 5 years of experience in splicing and terminating the same or similar types of cable, splices and terminations approved for installation.

C. Ground shield at each termination and splice.

3.3 FIREPROOFING (ARC-PROOFING)

A. All cables in pull boxes, junction boxes, cable tray and manholes shall be arc-proofed. Irregularities of cable at splice shall be evened out with arc-proof tape. Each circuit shall be individually fireproofed.

B. Strips of fireproofing tape approximately 1/16 IN thick by 3 IN wide shall be wrapped tightly around each circuit spirally in one half-lapped wrapping, or in two butt-joint wrappings with second wrapping covering joints in first wrapping
   1. Tape shall be applied with coated side toward cables and shall extend one inch into ducts.
   2. To prevent unraveling, fireproofing tape shall be random spiral wrapped with pressure sensitive glass cloth tape.
   3. Fireproofing tape shall consist of a flexible, conformable fabric having one side coated with flame retardant, flexible, polymetric coating and/or chlorinated elastomer.
   4. Tape shall not be less than 0.050 in. thick and shall weigh not less than 2.5 LBS per square yard.
   5. Tape shall be non-corrosive to cable sheaths, shall be self-extinguishing, and shall not support combustion.
   6. Tape shall not deteriorate when subjected to oil, water, gases, salt water, sewage or fungus.

3.4 TESTING OF CABLES

A. Factory test: See quality assurance paragraphs at beginning of this specification.

B. Field tests: Comply with following requirements:
   1. After all terminations and splices have been made, and prior to connections to equipment, provide following acceptance tests:
      a. Shield continuity test.
      b. DC high potential tests.
   2. New Cable:
      a. Tests shall be performed and submitted on new cable.
      b. Test new cable after installation, splices and terminations have been made but before connection to equipment and existing cables.
   3. Existing Cables:
      a. Test shall be performed and submitted on existing cable interconnected to new cable.
      b. After testing new cable and connection to existing cable has been completed, test interconnected cable. Disconnect cable from all equipment that might be damaged by test voltages.
   4. High Potential Test:
      a. Leakage current test shall be high potential D.C. step voltage method.
      b. Prior to high potential test, test cable and shields for continuity, shorts, and grounds.
      c. High potential test shall measure leakage current from each conductor to insulation shield. Use corona shields, guard rings, taping, mason jars, or plastic bags to prevent corona current from influencing readings. Unprepared cable shield ends shall be trimmed back one inch or more for each 10kV of test voltage.
   5. Safety Precautions:
      a. Exercise suitable and adequate safety measures prior to, during, and after high potential tests, including but not limited to placing warning signs and preventing people and equipment from being exposed to test voltages.
   6. Test Voltages:
      a. New shielded cable D.C. test voltages shall be as follows:

		Test Voltage kV	
Rated Circuit Voltage Phase-to Phase Volts	Wire Size AWG or MCM	100 Percent Insulation Level	133 Percent Insulation Level
8001-15000	2-1000	55	65

      b. Existing cable of all types interconnected to new cable shall be tested at 1.7 times existing cable rated voltage.
   7. High Potential Test Method:
      a. Apply voltage in approximately 8-10 equal steps.
      b. Raise voltage slowly between steps.
      c. At end of each step, allow charging currents to decay, and monitor time interval of decay.
      d. Read leakage current and plot curve of leakage versus test voltage on graph paper as test progresses. Read leakage current at same time interval for each voltage step.
      e. Stop test if leakage currents increase excessively or “knee” appears in curve before maximum test voltage is reached.
         1) For new cable, replace cable and repeat test.
         2) For existing cable interconnected to new cable, notify owner for further instructions.
      f. Upon reaching maximum test voltage, hold voltage for five minutes. Read leakage current at 30- second intervals and plot curve of leakage current versus time on same graph paper as step voltage curve.

1) Stop test if leakage current starts to rise, or decreases and again starts to rise. Leakage current should decrease and stabilize for acceptable cable.

g. Terminate test and allow sufficient discharge time before testing next conductor.

8. Replace all cable that fails testing.
   a. Any cable which has terminations and/or splices which are suspected to have caused failure may be re-terminated and/or re-spliced and retested.
   b. Second failure shall be cause for replacement.
   c. In all cases where cable is questionable due to testing results, Architect/Engineer will determine replacement requirements.
9. Retest all replaced cable.
10. Submit complete test results.

END OF SECTION

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SECTION 26 05 19

LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Low Voltage Electrical Power Conductors and Cables, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 SUBMITTALS

A. Project information:
   1. Type MC Metal Clad cable.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Splices and taps for smaller than No.6 AWG wire:
   1. Base:
      a. 3M.
      b. Ideal Electric.
      c. Heyco Molded Products.
      d. Elastimold.
      e. Buchanan Construction Products.
   2. Type MC Metal Clad cable:
      a. Base:
         1) AFC Cable Systems.
         2) Southwire.
         3) Belden.

2.2 MATERIALS

A. Wire for 600 volts and below: Single conductor, soft drawn, copper wire with 600 volt insulation, UL listed.
   1. For feeders and branch circuits: Type THWN/THHN or XHHW.
   2. For exterior feeder and branch circuits: Type XHHW.
   3. Use no wire smaller than No.12 AWG, except as follows:
      a. Smaller size wire may be used only where specifically indicated.
      b. No.14 AWG may be used for pilot control and signal circuits.
   4. Size conductors to match over current protective device unless larger conductors are indicated.
   5. No.10 and smaller wire: Solid conductor.
   6. No. 10 AWG conductor to be used for 20 ampere, 120V circuits exceeding 100 FT.
   7. No. 10 AWG conductor to be used for 20 ampere, 277V circuits exceeding 200 FT

B. Splices and taps for smaller than No.6 AWG wire:
   1. 3M, "Scotchlok" or "Hyflex".
   2. Ideal "Wingnut" or "Wirenut".
   3. Heyco.
   4. Elastimold insulated conical spring-type connectors.

C. Splices and taps for No.6 AWG wire and larger: Use compression connectors with prestretched insulation to equal insulation of wire being spliced.

D. Splices and taps - General: Do not make splices and taps with crimp or indenter-type connectors.

E. Pulling lubricant: Do not use cable pulling lubrication compound containing petroleum or other products which may deteriorate insulation.

F. Color coding: Color code all conductors in accordance with NEC as follows:
  1. Color code all wiring.
  2. Use following colors in lighting and power wiring:

	120/208 VOLT	277/480 VOLT
Phase 1	Black	Brown
Phase 2	Red	Orange
Phase 3	Blue	Yellow
Neutrals	White	Gray
Ground	Green	Green

  3. Isolated equipment grounding conductor: Green with one or more yellow stripe(s).
  4. Color coding of ends only will be acceptable for feeder phase conductors.
  5. Color coding of ends only will be acceptable for neutral and grounding conductors number 4 AWG and larger.

G. Type MC Metal Clad cable: Multi-conductor type THHN 600 volt 90 degC insulated solid copper conductors with a polypropylene assembly tape over all conductors and all within an interlocking galvanized steel armor.
  1. Listed per UL 1569 Metal Clad cable.
  2. Suitable for use in environmental air handling spaces, cable tray, and up to 3 hole through-penetration fire rated walls.
  3. Maximum of three phase conductors per cable.
  4. Provide insulated equipment grounding conductor.
  5. Provide isolated equipment ground conductor in cables serving isolated ground receptacles.
  6. Conductor size, number and/or size of neutral(s) and insulation color code shall be as specified elsewhere in this section.
  7. Fittings shall be steel clamp type with insulating throat and UL listed for use with type MC cable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting and receptacle home runs indicated are for identification purposes only.

B. Install all line voltage wiring in conduit unless otherwise indicated.

C. Install no more than 3 phase conductors in one conduit. This excludes ground wire. The neutral conductor shall be considered as a current carrying conductor.

D. Two or three non-receptacle, non-appliance (i.e. lighting) branch circuits may be carried on one neutral leg as permitted by NEC. Provide a separate neutral conductor for each phase conductor in all receptacle and appliance branch circuits.

E. Run panelboard and motor feeders in individual conduits.

F. Provide secondary feeders from K-rated transformers with neutral conductors sized at 200 PCT of the phase conductor size.

3.2 TYPE MC METAL CLAD CABLE

A. Install cable in accordance with manufacturer’s written instruction.

B. Cable shall be concealed above accessible ceilings and within drywall partitions.

C. Cable shall be routed parallel or perpendicular to structure.

D. Cables shall be independently supported.

E. Damaged cable shall be replaced.

F. Cable shall only be used for lighting fixture whips and receptacle branch circuit wiring concealed within drywall partition. Homeruns from first device to the panelbaord shall be in conduit.

END OF SECTION

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SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Grounding and Bonding for Electrical Systems, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 SUBMITTALS

A. Product Data:
   1. Technical data on connectors.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Exothermic weld kits:
   1. Base:
      a. Cadweld.

B. Compression fittings:
   1. Base:
      a. Burndy.

2.2 MATERIALS

A. Wire and Cable:
   1. See Section 26 05 19.
   2. Main ground: Copper conductor, sized as required by appropriate service grounding conductor table of NEC.
   3. Grounding copper conductor for non-metallic conduit and ducts: Copper bar or insulated conductor, sized in accordance with NEC or as indicated.

B. Conduit:
   1. See Section 26 05 33.

C. Grounding Clamp Connections:
   1. Clean contact surfaces, tinned and sweated during bolting.

D. Grounding Type Insulated Bushings:
   1. See Section 26 05 33.

PART 3 - EXECUTION

3.1 GENERAL

A. Ground neutral conductors, conduit systems, cabinets, equipment, motor frames, etc., in accordance with NEC and applicable codes.

B. Locate neutral ground disconnecting link or links in main switchboard so that low-voltage neutral bar with all interior secondary neutrals can be isolated from common equipment grounding bus.

3.2 INSTALLATION

A. Main Ground:
   1. Install main grounding conductor in steel conduit and connect to grounding electrode system using an exothermic weld or UL listed compression fitting.
      a. Unless otherwise indicated, install main ground unspliced in exposed conduit.
      b. Make connections easily accessible for inspection, not underground or concealed in floors or walls.
      c. Provide grounding electrode system in accordance with NEC.
      d. Resistance to earth of the grounding electrode system shall not exceed 5 ohms.
   2. Bond grounding conductor to conduit at entrance and exit, of same type and quality as other conductors in building.
   3. Install grounding jumper of same size around water meter using ground clamps.

B. Wall Mount Busbars:
   1. Mount busbars plumb and anchor to securely to substrate in accordance with manufacturer’s instructions.
   2. Complete conductor connections with 2-hole bolt-on compression lugs.
      a. Size to fit busbar and conditions.

C. Distribution:
   1. Make metallic raceway fittings and grounding clamps tight to insure that equipment grounding system operates continuously at ground potential.
      a. Provide low impedance current path to insure proper operation of overcurrent devices during potential ground fault currents.
   2. Do not solder grounding circuit connections.
   3. Where metallic conduits terminate without mechanical connection to metallic housing (switchboards, motor control centers, etc.), provide each conduit with grounding type insulated bushing.
      a. Connect each bushing to grounding bus in equipment with bare copper conductor.
   4. In nonmetallic conduits or ducts maintain continuity of equipment grounding system by bar or conductor installed and connected by approved method to conductive noncurrent-carrying equipment at both ends.
   5. Ground conduit, panel boards, receptacles, accessible fixtures, switchgear, transformers, motors and motor equipment.
   6. Make ground continuity positive throughout entire project.

3.3 TESTING AND FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

B. Perform testing in accordance with test instrument manufacturer’s recommendations.

C. Utilize approved Earth Ground Clamp Meter to test grounding and bonding system.
   1. Record results and provide to Owner prior to Project Closeout.

D. Test communication systems grounding and bonding with building systems in operation.

E. Measure effectiveness of bonding jumpers with clamp on meter to metal being tested to ground, or perform two point testing method (busbar to metal being grounded).
   1. If resistance is less than 0.1 Ohms between two test points, bonding is adequate.
   2. If resistance is greater than 0.1 Ohms between two test points, check connections and retest.
   3. Provide report of test to Owner.

END OF SECTION

SECTION 26 05 33
CONDUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Conduits, as indicated, in accordance with provisions of Contract Documents.

B. Conduit runs are diagrammatic. Verify and coordinate locations in field.

C. Completely coordinate with work of other trades.

1.2 SECTION INCLUDES

A. Rigid Metal Conduit (RMC).

B. Intermediate Metal Conduit (IMC).

C. Electrical Metallic Tubing (EMT).

D. Liquidtight Flexible Metal Conduit (LFMC).

E. Rigid Nonmetallic Conduit (RNC).

F. Conduit fittings.

G. Expansion fittings.

H. Inserts and attachments.

I. Supports, sleeves and seals.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Electrical Components, Devices, and Accessories shall be listed and labeled in accordance with NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Certifications:
   1. Conduit: Stamp each length with name or trade mark of manufacturer and affix UL label.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Coordinated drawings showing final layout of all conduits greater than 2 IN coordinated with all other trades.

B. Product Data:
   1. Manufacturer’s data for each product specified.
   2. IBC Certificates of Compliance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. As noted for each type listed below.

2.2 MATERIALS

A. Rigid Metal Conduit (RMC):
1. Acceptable Manufacturers:
a. Base:
1) Allied Tube and Conduit Corp.
2) Republic Conduit
3) Wheatland Tube
2. Materials
a. Hot dipped galvanized, or sherardized, including threads.
b. Standard pipe thread with coupling; deliver with thread protector and end caps.
c. Standards:
1) NEMA/ANSI C80.1 – Electrical Rigid Steel Conduit – Zinc Coated (ERSC).
2) UL 6 - Electrical Rigid Metal Conduit – Steel.

B. Electrical Metal Tubing (EMT):
1. Acceptable Manufacturers:
a. Base:
1) Allied Tube and Conduit Corp.
b. Optional:
1) Republic Conduit.
2) Wheatland Tube.
2. Materials
a. Electrical Metal Tubing (EMT): Galvanized steel of thin wall thickness.
b. Provide factory colored EMT for all conduits 1 IN and below. Follow electrical identification spec section.
c. Standards:
1) Nema/ANSI C80.3 –Steel Electrical Metal Tubing (EMT).
2) UL 797 - Electrical Metallic Tubing – Steel.

C. Liquid Tight Flexible Metal Conduit (LFMC):
1. Manufacturers based on specification compliance:
a. Base:
1) Anamet Electrical
2) Electri-Flex.
3) AFC.
2. Materials
a. Liquidtight Flexible Metal Conduit (LFMC): Steel, hot dipped galvanized with PVC jacket.
b. Standards:
1) UL 1660 – Standard for Liquid-Tight Flexible Nonmetallic Conduit.

D. Rigid Non-Metallic Conduit (RNC):
1. Acceptable Manufacturers:
a. Base:
1) Carlon.
2) Queen City Plastics.
3) Cantex
2. Materials
a. Rigid Nonmetallic Conduit (RNC): Polyvinyl chloride (PVC), Schedule 40 or 80, meeting minimum requirements of NEC.
b. Standards:
1) UL 651 - Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
2) NEMA TC-2 – Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.

E. Conduit Fittings:
   1. Acceptable Manufacturers:
      a. Base:
         1) Appleton Electric.
         2) Thomas & Betts.
         3) O-Z/Gedney.
   2. Materials
      a. Standards:
         1) ANSI/NEMA FB-1 – Fittings, Cast metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
         2) UL 514B - Conduit, Tubing, and Cable Fittings.
      b. RMC Fittings
         1) Threaded cast ferrous alloy with corrosion resistant finish. Cast body with gasketed corrosion resistant screw cover and threaded hubs.
         2) Not Approved: Zinc alloy and similar soft metal die castings.
      c. EMT Fittings:
         1) Steel compression-ring type.
         2) Set screw type fitting with steel body and cup type screws.
      d. LFMC Fittings:
         1) Squeeze type, cadmium plated, straight and angle connectors for all sizes except twist-in connectors for 3/4 IN and below. Connectors shall be liquid-tight.
      e. PVC Conduit Fittings:
         1) PVC plastic solvent weld type, with threaded adapters as required.
      f. Bushings:
         1) Threaded, galvanized, malleable iron.
         2) Bushings for conductors No.4 and larger: Separate insulated bushings.
            a) Do not use insulated throat connectors.
         3) Grounding bushings: With screw termination for green grounding wire.

F. Expansion Fittings:
   1. Acceptable Manufacturers:
      a. Base:
         1) Cooper Crouse – Hinds
         2) O-Z/Gedney
         3) Appleton Electric.
   2. Materials
      a. Description:
         1) Watertight deflection type cast slip joint fitting for conduit, with flexible bonding conductor for continuity of ground through metallic conduit.
      b. Design Standards:
         1) O-Z/Gedney: Type DX.
         2) Cooper Crouse – Hinds: Type XJG.

G. Inserts and Attachments:
   1. Select inserts and attachments to suit loading conditions.
      a. See Section 01 31 11 for load limitations where more than one trade may be applying loads to device.
   2. Inserts For Placement in Concrete Formwork:
      a. Malleable iron, wedge with nut, galvanized finish.
      b. Size inserts to suit threaded hanger rods.
   3. Use plastic toggles where securing directly to drywall.

H. Supports, Sleeves and Seals:
   1. Conduit supports:
      a. Standards:
         1) UL 2239 - Hardware for the Support of Conduit, Tubing, and Cable.
         2) Listed and in compliance with other applicable standards.

b. Designed specifically for electrical installations.
c. Hangers:
    1) Steel cadmium plated threaded rods with straps or clamp conduit holder.
d. Straps:
    1) Two-hole steel, cadmium or zinc plated.
e. Beam Clamps:
    1) Steel cadmium plated.
f. Channels and Fittings:
    1) Channels: Hot-dipped galvanized.
    2) Fittings: Galvanized.
g. Trapeze assemblies:
    1) Constructed from channels and supported by at least two (2) threaded rods attached to building structure.
h. Do not use following to support conduit:
    1) Wire including ceiling support wires.
    2) Perforated strap hangers.
    3) Plastic or nylon tie wraps.

2. Sleeves:
    a. Black iron pipe, RMC sized to accommodate work passing through.
3. Sealer for sleeves and openings around conduit:
    a. UL listed for assembly.
    b. See Section 07 84 00.
4. Sealer for use inside conduits:
    a. Acceptable Manufacturers:
        1) Base:
            a) Arnco.
            b) Polywater.
    b. Materials
        1) Description:
            a) Watertight / Air tight foam sealant for electrical conduit.
            b) Listed for application with electrical wiring and conduit.
        2) Design Standards:
            a) Arnco: Hydra-Seal.
            b) Polywater: FST Duct Sealant.

I. Ductbank Accessories:
    1. Acceptable Manufacturers:
        a. Base:
            1) Cantex.
            2) Carlon.
            3) Thomas & Betts.
    2. Conduit supports:
        a. Shall be designed specifically for electrical installations.

PART 3 - EXECUTION

3.1 SCHEDULE OF CONDUIT UTILIZATION

A. Use no conduit smaller than 3/4 IN.

B. Size conduit in accordance with NEC unless indicated larger.

C. Rigid Steel Conduit (RMC) shall be used in following locations unless otherwise noted:
    1. Outdoors Exposed.
    2. In exterior masonry walls.
    3. In wet locations.
    4. For exposed interior runs below 10 FT above finished floor unless otherwise indicated.

5. For feeders over 600 volts.
6. In explosion-proof areas.

D. EMT shall be used for other 600 volt and below dry applications as follows:
   1. Concealed in walls or above finished ceilings.
   2. Exposed EMT may be used below 10 FT level in following locations:
      a. From floor to ceiling in electrical equipment rooms.
      b. Directly above motor control centers in locations other than electrical equipment rooms.
      c. Directly above junction boxes or control panels associated with elevators or mechanical equipment with conduit termination point of 6 FT or more above floor.

E. Liquid-tight flexible steel conduit:
   1. For connection to equipment subject to vibration.
   2. Use liquid-tight flexible conduit for applications, including but not limited to:
      a. All damp and wet locations.
      b. Dietary production and dishwashing areas.
      c. Mechanical pumps.
      d. Laboratory casework.
   3. Liquid-tight flexible steel conduit shall be limited to a maximum of 6 FT with no bends greater than 90 degrees.

F. Flexible steel conduit shall not be used.

G. PVC conduit may be used subject to following:
   1. Do not use exposed PVC conduit unless otherwise noted.
   2. Provide a 600 volt, insulated, green grounding conductor in each PVC conduit.
      a. Power circuits: Proper ampacity per NEC.
      b. Communications circuits: No.12 AWG minimum.
   3. 45 DEG and greater bends in PVC conduit runs shall be made with rigid steel conduit.
   4. Schedule 80 PVC conduit may be used for grounding electrode system and telecommunications ground backbone runs below and above grade and stubs through concrete slabs on grade.
   5. Direct burial Schedule 40 PVC or concrete encased Type EB may be used as follows:
      a. Underground Ducts and Raceways for Electrical Systems: See Section 26 05 43.
      b. Voice and data systems where underground and in or under concrete slabs on grade.
      c. Underground and concrete encased conduits over 600 volts.

3.2 INSTALLATION

A. Unless otherwise noted install all conduits concealed within walls and above finished ceilings.

B. Do not run horizontally in CMU.

C. Apply Appleton TLC or T and B Kopr-Shield joint compound to conduit threads where installed underground or exposed to weather.

D. Provide separate conduit systems for telephone, exit signs, fire alarm, emergency lighting, and other communications systems, unless otherwise indicated.
   1. Separate systems of different voltage classes into different conduit systems unless otherwise noted.
   2. Provide dedicated junction boxes and pull boxes to separate wiring systems.
   3. Do not combine 208/120 and 480/277V wiring in common wireways or pull boxes.
   4. Keep communications systems separated.

E. Where practical, group homeruns to same panelboard.
   1. Do not enclose more than three single phase circuits or one three phase circuit in one raceway unless noted otherwise.
   2. Exposed overhead conduit may be used in mechanical, electrical and other equipment rooms except conduit drops to following:

3. Where finished walls are provided, conduit drops to wiring devices, fire alarm devices, telecommunications outlets and other flush mounted devices shall be concealed within finished walls.

F. Run non-buried conduit in straight lines at right angles to or parallel with walls, beams or columns.

G. Keep conduit away from uninsulated hot water and steam pipes.
   1. Where crossings are unavoidable, leave minimum 6 IN clearance.

H. Avoid running conduits underneath water lines except for crossings.

I. Do not cross conduit in front of access door in HVAC duct.

J. Only nylon or polyethylene rope shall be used to pull wire and cable in conduit systems.

K. Provide conduit support designed for building structural conditions to carry load imposed.

L. Provide inserts or fasteners to attach hangers to structure.
   1. Do not use drilled or explosive driven inserts in precast-prestressed concrete construction.
   2. Drilled or explosive driven inserts may not extend more than 1 IN into post-tensioned concrete construction.
   3. Attachment to metal roof deck may be by means of prepunched tabs, prepunched holes, or with screws in sides of ribs or toggle bolts in bottom of ribs.
   4. Space hangers in joints between precast units minimum 4 IN from walls.

M. Protect inside of conduit from dirt and debris during construction by capping openings with tapered plugs or plastic caps.
   1. If moisture or debris gets into conduit remove before wire is drawn into place.

N. Make conduit field cuts square and ream to full size.
   1. Shoulder conduit in couplings.

O. Use trapeze assemblies to support multiple conduits.
   1. Coordinate layout to provide adequate access to cable tray assemblies if applicable.

P. Installation of conduit or rack of conduits shall not interfere with placement of specified luminaire.

Q. Hangers in roof deck:
   1. Do not extend above tops of ribs, or otherwise interfere with vapor retarder, insulation or roofing.

R. Independently support conduit systems from building structure or walls with approved hangers.
   1. Do not support from piping, ducts or support systems for piping or ducts.
   2. Do not support from ceiling or ceiling support systems.
   3. Do not install to prevent ready removal of equipment, piping, ducts or ceiling tiles.
   4. Do not support from drywall.

S. Do not install conduit under pads for fans, pumps, boilers, or other machinery.

T. Seal and waterproof penetrations of floor slab at mechanical rooms above grade.
   1. Where required, provide firestop systems in accordance with Section 07 84 00.

U. Conduit shall not be installed in structural elements, i.e. concrete columns, beams, decks, or slabs unless otherwise noted.

V. Sum of angles in any conduit run shall not exceed 360 DEG.
   1. Install conduit body, junction box or pull box where additional bends are necessary.
   2. Install pull boxes every 100 FT in long conduit runs.
   3. Conduit body, junction box and pull box covers shall be accessible.
   4. Conduit bodies may be used as follows:
      a. On exposed runs at junctions, bends or offsets where splices are not required.
      b. Around outside corners of walls and equipment or around beams.

5. Conduit bends:
    a. Make field bends with tools designed for conduit bending.
        1) Heating of metallic conduit to facilitate bending is not permitted.
    b. Hand conduit bender may be used on 3/4 IN RMC, IMC or EMT conduit and 1 IN EMT conduit.
        1) Use conduit bending machine for larger sizes.
    c. Make no bends with radius less than 12 times diameter of associated cable.
    d. No conduit bends shall exceed 90 DEG.

W. Support suspended conduits within 12 IN of any change of direction of 45 DEG or greater.

X. Make joints in threaded conduit watertight with white nonleaded compound applied to male threads only.
    1. Cut square, ream smooth, and properly thread field joints to receive couplings.
    2. Do not use running threads.

Y. Neatly seal openings around conduits, etc., where they pass through fire rated construction or exterior walls or roof. Provide proper rated seal for fire-rated penetrations.

Z. Conduit passing through concrete wall or slab penetrations:
    1. All core drilling, sleeves, block-outs or other penetrations must be approved by Structural Engineer prior to installation.
    2. Space sleeves and core drills to insure minimum of three (3) times nominal trade diameter of largest adjacent conduit between sleeves or core drills.
    3. Use block-outs for concentrations of conduits in confined area.

AA. No exterior horizontal roof supported conduit runs are permitted in lengths exceeding 6 FT unless indicated otherwise.

BB. Empty conduits:
    1. Install 3/16 IN minimum diameter polypropylene or nylon pull-line from end to end with tag at each end designating opposite terminus.
    2. Cap conduits indicated to be stubbed out underground with glued-on PVC caps.

CC. Conduit stub-outs:
    1. Extend conduit stub-out to cable tray system and attach to edge of tray with cable tray manufacturer recommended coupling.
    2. Terminate conduit with insulating bushing.

DD. Conduits stubbed into manholes:
    1. Terminate metal conduit with insulating bushing.
    2. Terminate non-metallic conduit with bell ends.

EE. All conduit stub-outs on site shall be identified in one of following ways and noted on as-built drawings provided to Owner:
    1. Permanently marked.
    2. Dimension from landmark on site or building.
    3. Using a Global Positioning System (GPS) device accurate to within 6 IN.

3.3 INSTALLATION - BELOW GRADE NON-CONCRETE ENCASED CONDUIT

A. Maintain depth of conduit at least 30 IN below finished grade.
    1. Remove materials from trench that could damage conduit.
    2. Use sand or selected material for bedding and first layer of backfill.

B. Use long radius bends and deflection couplings for changes in direction.
    1. Maintain a minimum radius of 36 IN.

C. Tighten taper-fit joints with light blows of a sledge hammer.
    1. Dope threaded joints and tighten with tool.
    2. Seal plastic joints around entire perimeter with chemical bonding agent.

D. Cap empty conduit.
    1. Seal ends with approved waterproofing compound after conductors have been installed.

E. Provide rigid steel conduit elbows where non-metallic conduit emerges from underground, with threaded adapters for change of material.
    1. Provide 36IN minimum radius or larger elbows as required by local utility company.

F. Do not place backfill until work is inspected and approved.

3.4 INSTALLATION - CONCRETE ENCASED CONDUIT

A. Conduit design is based upon field assembly of raceways and spacers with concrete cast in place.

B. Unless shown otherwise, use Schedule 40 rigid nonmetallic conduit in concrete encasement.
    1. Keep top of concrete envelope a minimum of 30 IN below finished grade.
    2. Route conduit lines to clear interferences, but make linear wherever possible.
    3. Use long radius bends and deflection couplings for changes in direction, maintaining a minimum radius of 36 IN.
    4. Pitch conduit at 3 IN/100 FT (1:400) away from buildings and toward manholes for drainage.

C. Anchor conduit in place with plastic interlocking spacers 48 IN OC to prevent dislocation during concrete placement.
    1. Stagger joints horizontally and vertically.
    2. Tighten taper fit joints with light blows of sledge hammer.
    3. Dope threaded joints and tool tighten.
    4. Seal joints with a chemical bonding agent.

D. Use rigid steel conduit elbows where conduit emerges from underground.
    1. Provide threaded adapters for change of material.
    2. Provide 36IN minimum radius elbows or as required by local utility company.

3.5 INSTALLATION - DUCTLINE IDENTIFICATION

A. Provide identification for conduits not encased in concrete.
    1. Use warning tape for direct buried conduits.
    2. Use concrete colorant for concrete encased conduit.
    3. For warning tape, backfill trench to within 12 IN of finished grade.
    4. Install tape continuously along entire length of trench, and complete backfill operation.

B. See Section 26 05 53 for concrete colorant and warning tape.

3.6 INSTALLATION - EMPTY CONDUITS

A. Arrange empty conduits for easy installation of future cables.
    1. Cap conduits in accessible locations.

B. Provide a draw line in each empty conduit, tagged at each end with identification and location of other end.
    1. For draw line, use manufactured fish tape, 200 LB test nylon line, or other approved means.

3.7 INSTALLATION - CONNECTIONS AND FITTINGS

A. Install rigid conduits squarely into boxes.
    1. Rigidly clamp to box with locknut on outside and inside and provide bushing on inside.

B. Fit all conduit ends at switch and outlet boxes with approved lock nuts and bushing forming approved tight bond with box when screwed tightly in place.

C. Above lay-in tile ceilings, make connections to lay-in type luminaires with flexible steel conduit no longer than 6 FT.
    1. Arrange conduit and box systems for easy removal of lay-in ceiling.

D. Make motor and equipment connections with liquid-tight steel conduit not exceeding 24 IN length.

E. Provide expansion joint fittings as follows:
   1. On conduit at all building expansion or control joints where conduit is rigidly attached to structure.
   2. Where necessary to compensate for thermal expansion and contraction.
   3. Liquid-tight flexible metal conduit may be used for expansion fittings on runs smaller than 1 IN where exposed, or concealed above suspended ceilings.
      a. Leave slack in conduit for movement.
      b. Fasten on each side of joint.

F. Provide junction box with ductseal on raceways subject to different temperatures including but not limited to:
   1. Conduits passing from interior to exterior of structure.
   2. Conduits serving cold storage rooms, freezers and refrigeration equipment.

G. Provide sealing fittings on rigid galvanized conduit in hazardous areas and install in accordance with NEC.

H. When roof exhaust fans are equipped with housing conduit entries and integral disconnects, install conduit to roof exhaust fans through fan housing with no conduit exposed.

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SECTION 26 05 34
BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Boxes, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. UL 514A – Metallic Outlet Boxes.
   2. ANSI/NEMA FB-1 – Fittings, Cast metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
   3. ANSI/SCTE 77 Specification for Underground Enclosure Integrity.

B. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Dimensioned drawings indicating locations of all floor boxes.
   2. Dimensioned drawings indicating locations of all poke-thru assemblies.

B. Product Data
   1. Describe configurations, finishes, colors, and dimensions for all of following:
      a. Ingrade splice boxes.
      b. Special mounting boxes and covers.
      c. Floor boxes.
      d. Poke-thru assemblies.
         1) Provide IBC Certificates of Compliance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Galvanized Outlet Boxes and Fittings:
   1. Base:
      a. Emerson Industrial – Appleton Electric
   2. Optional:
      a. Hoffman.
      b. Hubbell Electrical Products - RACO
      c. Thomas & Betts –Steel City

B. Corrosion Resistant and Wet Location Boxes and Fittings:
   1. Base:
      a. Thomas & Betts
   2. Optional:
      a. Robroy

C. Box Supporting Brackets:
   1. Base:
      a. Erico/Caddy
      b. Hubbell/RACO

D. Ingrade Splice and Pull Boxes:
   1. Base:
      a. Hubbell Quazite.

E. Wet Location Boxes/Covers and Interior Pedestal Boxes:
   1. Base:
      a. Hubbell.

F. Exterior pedestal boxes.
   1. Base:
      a. Legrand Wiremold Outdoor Ground Box.

G. Television Multi-Service Wall Boxes:
   1. Base:
      a. Hubbell.
      b. Wiremold.

H. Flush Floor Boxes:
   1. Base:
      a. Hubbell
      b. Wiremold.

I. Through Floor Service Fittings Poke Thru:
   1. Base:
      a. Wiremold.
      b. Hubbell.
      c. Thomas and Betts.

2.2 MATERIALS

A. Outlet Boxes:
   1. Minimum Size:
      a. 4 IN square or octagon.
      b. Depth as required.
   2. Lighting outlet boxes:
      a. Galvanized.
      b. Use extension and plaster rings as required.
      c. Verify proper depth with partition thickness.
      d. Provide with proper fittings to support and attach luminaires.
      e. Support outlet boxes for luminaires and other ceiling-mounting devices in lay-in acoustical tile ceilings by bar hangers anchored to ceiling construction members which do not interfere with tile removal.
   3. Switch and receptacle boxes for concealed wiring:
      a. Galvanized.
   4. Exposed switch and receptacle boxes:
      a. Corrosion resistant, cast, malleable iron, with threaded hubs
      b. Design Basis: Crouse-Hinds Type FS.
   5. Narrow switch boxes (for hollow metal jambs):
      a. Design Basis: Hubbell-Raco 426.
   6. Weatherproof receptacle boxes:
      a. Corrosion resistant cast malleable iron type, with threaded hubs and neoprene gasket.
      b. Design Basis: Crouse-Hinds Type FS.
   7. Concealed gang-switch and junction boxes not dimensioned:
      a. Galvanized.

8. Boxes for 277 volt switches on opposite phases:
    a. Where multi-ganging boxes, provide barriers per NEC.
9. Extension Rings:
    a. To suit conditions.
10. Hardware:
    a. Grounding screw and connectors as required by wiring method.
11. PVC coated steel boxes:
    a. Provide NEMA RN-1 compliant coating of PVC.

B. Supports:
1. Box supporting brackets:
    a. Caddy MEB1 and SGB Series.
2. Far side box support:
    a. Hubbell/RACO Catalog No. 978.

C. Pull and Junction Boxes:
1. Minimum Size:
    a. 4 IN square.
    b. Depth as required.
2. Galvanized steel, code gauge.
3. Cover:
    a. Same material as box, screw-on type.

D. Ingrade Splice and Pull Boxes:
1. Underground Enclosures:
2. Polymer concrete, PC Style gasketed boxes, green color; provide ANSI/SCTE 77 tier load rating for application with open base in a gravel bed.
3. Cover Logo: ELEC.
4. Stainless steel inserts and bolts.

E. Special Receptacle Mounting Boxes/Covers:
1. Weatherproof covers:
    a. Receptacle type as indicated on drawings.
    b. Mount on "FS" cast metal box.
2. Suitable for wet location when receptacle is in use.
    a. Die-cast aluminum construction, meets extra-duty rating in UL 514D.
    b. Padlockable, gasketed NEMA 3R cover.
        1) Single outlets: Hubbell WP700E.
        2) Duplex outlets: Hubbell WP8E.
        3) Duplex GFCI receptacles: Hubbell WP26E.

F. Television/Monitor Multi-Service Wall Box:
1. Shall provide interface between power, communication and audio/video cabling by providing a common recessed wall box for all device outlets.
2. Shall be manufactured from stamped steel and shall have a polyester baked white enamel interior finish.
3. Box shall have independent wiring compartments that accommodate standard size wall plates and shall have removable and relocatable dividers.
4. Box shall be provided with device and storage compartments removable from the top of the box.
5. Box shall be provided with mounting brackets allowing box to be secured to wall studs.
6. Box shall be provided with a trim ring flange and decorative cover with white finish.
7. Refer to Drawings for devices specified within box.
8. Multi-service wall box: Arlington Steel A/V Box TVBS505.

G. Flush Floor Boxes:
1. General:
    a. See Section 26 27 26 and electrical symbol legend for receptacle requirements.

b. Provide combination power and communication boxes.
c. Floor boxes do not provide any fire separation or fire rating.
    1) Floor boxes shall rely upon floor assembly components, physical dimensions, structural materials, etc., to provide fire separation and rating.
    2) Coordinate all floor box installations with other trades to ensure that installation will provide required floor rating.
        a) Submit installation details to Architect for approval prior to installation.
    3) Refer to telecom and electrical drawings for number of telecom and electrical outlets required in each floor box.

2. Floor boxes in laboratory and lab support areas:
    a. Comply with UL 514-A and C scrub water requirements to prohibit entrance of water into box when covers are closed.
3. Recessed Activation Multi-Service Metal Concrete Floor Boxes:
    a. Capable of supplying Power, Data, Voice, and AV services.
    b. Base product: System One by Hubbell Incorporated: Legrand Wiremold
    c. Floor box material:
        1) 16 GA galvanized sheet metal.
4. Finish shall be by Architect.
5. Eleven (11) gang flush in-floor box for power and communications:
    a. Wiremold RFB11.
6. Nine (9) gang flush in-floor box for power and communications:
    a. Wiremold RFB9.
    b. Concrete-tight stamped steel construction with 14 gauge sides and bottom and 10 GA steel top.
    c. Nominal box dimensions, plus/minus 2 PCT:
        1) Length: 14.75 IN.
        2) Width: 12.63 IN
        3) Height: 6.13 IN.
        4) Wiring volume: 156 cubic inches.
        5) Height: 4.13 IN.
        6) Wiring volume: 132 cubic inches.
    d. Access to each end of floor box shall be provided by concentric 1 IN and 1.25 IN knockouts.
    e. Access from behind and below each multi-gang compartment shall be provided by concentric 1 IN and 1.25 IN knockouts.
    f. Access from behind and below each single gang compartment shall be provided by concentric .75 IN and 1 IN or 1 IN and 1.25 knockouts.
    g. External pre-pour adjustment shall be provided by at least 2 IN leveling screws.
    h. Cover:
        1) Cast aluminum.
        2) Lid to be offered with solid, flush surface for tile, wood or terrazzo and an insert option for carpet inlay.
        3) Egress to be provided by two 15/16 IN by 6-3/8 IN access doors.
        4) Access door to fold under lid during cable exit for unobtrusive appearance and mechanical protection.
7. Four (4) compartment flush in-floor box for power and communications:
    a. Wiremold RFB4 CI-1 Cast Iron
    b. Cast iron floor box for use on grade and elevated slabs.
    c. Nominal box dimensions (plus/minus 2 PCT):
        1) Length: 14.5 IN.
        2) Width: 11.88 IN
        3) Height: 3.44 IN.
        4) Wiring volume: Two compartments at 36 cubic inches and two at 27 cubic inches.
    d. Provide four independent wiring compartments that allow capacity for up to four duplex receptacles and/or communication services.
    e. Box shall permit tunneling from adjacent compartments

f. Provide four 1 IN and four 1.25 IN conduit hubs.
g. Box shall be fully adjustable, providing maximum of 1.88 IN pre-pour adjustment, and a maximum of 0.75 IN after-pour adjustment.
h. Cover:
   1) Activation covers shall be manufactured of die-cast aluminum or die-cast zinc.
      a) Provide powder coated paint finish to be selected by Architect.
   2) Activation covers shall be available as follows:
      a) Flanged (7.75 IN long by 6.56 IN wide) and flangeless (6.75 IN long by 5.56 IN wide) versions.
      b) With tile or carpet inserts.
      c) Flush covers.
      d) Covers with one 1 IN trade size screw plug opening and one combination 1.25 IN and 2 IN trade size screw plug openings for furniture feeds.
      e) Coordinate cover with floor finish.

H. Through Floor Service Fittings Poke Thru:
1. Poke-Thru Assemblies with Devices:
   a. Provide combination power and communication poke-thru devices flush floor mounted.
   b. Assembly consists of an insert and an activation cover.
   c. Overall poke-thru assembly nominal length shall be 16 IN plus or minus 3 PCT.
   d. Insert body shall have necessary channels to provide complete separation of power and communication services.
   e. Provide one 3/4 IN trade size channel for power and two 1/2 IN trade size channels for communication cabling.
   f. Channels shall be arranged such that communication cables can be conduit protected and connected to insert body using die-cast zinc conduit connector with two 1/2 IN trade size threaded openings to accept both rigid and flexible conduit connections.
   g. Body will consist of an intumescent fire stop material to maintain fire rating of floor slab.
      1) Intumescent material will be held securely in place in insert body and shall not have to be adjusted to maintain fire rating of unit and floor slab.
   h. Insert shall have spring steel-retaining ring that will hold poke-thru device in floor slab without additional fasteners.
   i. Poke-thru insert shall also consist of 3/4 IN conduit stub that is connected to insert body and 402 CM3 24.5 cubic inch stamped steel junction box for wire splices and connections.
   j. Stamped steel junction box shall also contain necessary means to electrically ground poke-thru device to system ground.
   k. Provide gasket attached to underside of trim flange to maintain scrub water tightness.
   l. Finish to be selected by Architect.
   m. The overall trim flange shall be nominal 7.5 IN diameter plus or minus 2 PCT.
   n. The overall trim flange shall be nominal 8.25 IN diameter plus or minus 2 PCT.
   o. Provide two 20 amp duplex receptacle prewired with three No. 12 AWG THHN conductors for power applications.
   p. Power receptacles shall be capable of being wired as standard receptacle or for isolated ground.
   q. Finish shall be selected by Architect.
   r. Provide black poke-thru activation cover manufactured from textured Polycarbonate or PVC.
   s. Provide gray poke-thru activation cover manufactured from textured Polycarbonate or PVC.
   t. Provide ivory poke-thru activation cover manufactured from textured Polycarbonate or PVC.
   u. Slide holder assembly shall be flush with floor and provide Dead-front protection that allows receptacle covers to snap back into place when receptacle is not in use.

v. Provide gasket attached to underside of cover assembly to maintain scrub water tightness by preventing water, dirt, and debris from entering power and communication compartments.
w. Device shall also have accommodations for up to four communication connectors.
x. Cover shall have individual slides to allow access to communication connectors and will close over connectors when not in use.
y. Each activation cover shall also provide locations to adhere labels to identify both power and communication circuits.
z. Communication Modules Mounting Accessories:
    1) Poke-thru device manufacturer shall provide complete line of bezels to facilitate mounting of UTP, STP, 150 ohm, fiber optic, coaxial, and communication devices.
    2) Communication connectors shall be capable of being installed either flush or recessed. For communications, the unit will contain accommodations for up to four connectors for UTP, fiber optic, coaxial, audio, and video solutions.
    3) Poke-thru device shall accommodate Ortronics workstation connectivity outlets and modular inserts or Pass and Seymour Network Wiring System.
    4) To accommodate communication solutions, device shall accept discrete keystone type connectivity devices from various manufacturers.
    5) All communication inserts shall be nonmetallic.
    6) System shall provide for connection of other modular inserts for additional communication options.
    7) Unit shall also be supplied with two dual Category 5e T568-B modular inserts coordinated with Owner's requirements.
    8) Unit shall accommodate mechanism to permit protection of communication cabling. This mechanism shall be zinc die-cast with two openings to accept both flexible and rigid conduit. Openings shall accept 0.50 IN trade size conduit.
aa. Wiremold Series Evolution 6ATCP Series 6 IN core.

2. Poke-Thru Assemblies for Furniture Connections:
    a. Provide poke-thru device to interface between systems furniture and power and communication cabling in ceiling space below.
    b. Assembly consists of an insert and an activation cover.
    c. Overall poke-thru assembly nominal length shall be 16.94 IN plus or minus 3 PCT.
    d. The insert body shall have necessary channels to provide complete separation of power and communication services.
    e. Provide one 3/4 IN trade size channel for power, and one 1 1/4 IN trade size channel for communication cabling.
    f. Body will consist of intumescent fire stop material to maintain fire rating of floor slab. Intumescent material will be held securely in place in insert body and shall not have to be adjusted to maintain fire rating of unit and floor slab.
    g. Insert shall have spring steel retaining ring that will hold poke-thru device in floor slab without additional fasteners.
    h. Poke-thru insert shall also consist of one 3/4 IN trade size conduit stub and one 1 1/4 IN trade size conduit stub that are connected to insert body and 402 CM3 24.5 cubic inch stamped steel junction box for wire splices and connections.
    i. Stamped steel junction box shall also contain necessary means to electrically ground poke-thru assembly to system ground.
    j. Provide activation cover with two conduit openings to feed modular furniture applications and provide flush appearance.
    k. Finish shall be selected by Architect.
    l. Provide gasket attached to underside of trim flange to maintain scrub water tightness.
    m. The overall trim flange shall be nominal 7.5 IN diameter plus or minus 2 PCT.
    n. Activation cover insert shall provide one 3/4 IN NPSM threaded opening for power and one 1 1/4 IN NPSM threaded opening for communication to feed systems furniture workstations. Each activation cover shall also be supplied with one 3/4 IN trade size and one 1 1/4 IN trade size threaded conduit connectors and one 3/4 IN trade size and one 1 1/4 IN trade size conduit closure plugs.

o. Wiremold Series 4FFATC.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mounting Outlet Boxes for Concealed Wiring:
   1. Boxes mounted adjacent to studs shall be attached directly to stud with a minimum of 4 metal screws.
      a. Provide far-side box support on all boxes.
      b. Box side support shall be secured to box with drywall screws.
   2. Boxes that are not attached directly to studs shall be attached to box support bracket spanning studs.
      a. Bracket shall be attached to studs with 2 screws at each end.
      b. Attach box to bracket with 2 screws minimum.
   3. For outlets mounted above or below counters, benches, or furniture, coordinate location and mounting heights with casework, millwork and furniture.
      a. Adjust outlet mounting height to agree with required location for equipment served.
   4. Position outlet boxes to locate luminaires as shown on reflected ceiling plans.

B. When a metallic junction box for electrical receptacles or switches is contained within a 1 or 2-HR rated fire or smoke wall of gypsum wall board construction and an opening is provided for box in surface of wall, area of opening shall not exceed 16 SQIN, unless junction box is protected by approved UL listed firestop.
   1. Aggregate area of such junction boxes in a rated wall not protected by an approved firestop shall not exceed 100 SQIN in 100 SQ FT of wall area as measured from floor to structural deck or rated membrane.
   2. Junction boxes with openings on opposite faces of rated walls shall have a horizontal separation of 24 IN as a minimum, regardless of box size, unless protected by an approved method.
   3. Locations of studs do not have any bearing on the above requirements, nor does the use of mineral wool fire-safing alter these requirements.

C. Back to back boxes shall not be installed within same stud cavity.
   1. Where installation within the same stud cavity is required based on device layout, unfaced glass or mineral fiber sound batting shall be installed to prevent sound transfer between rooms.

D. Fill unused punched-out openings in boxes with closures.

E. Use outlet boxes sized to accommodate quantity of conductors enclosed.

F. Provide pull boxes or junction boxes in conduit runs where indicated or as required to facilitate pulling of wires or making of connections.
   1. Make box covers accessible.

G. Paint inside of boxes and box cover per Section 26 00 10.

H. Identify circuit numbers on inside of box and cover plate.
   1. Identification shall be post painting of boxes.

I. Coordinate floor boxes with slab depth to assure that concrete depth is adequate for specified box.
   1. Set boxes level based on slab depth.
   2. Maintain fire rating.

J. Poke-thru assemblies shall permit wiring to be completed at floor level.
   1. Core drill holes to accommodate assemblies as required.
      a. Coordinate requirements with manufacturer.

2. Locate poke-thru devices a minimum of two (2) foot on center and so no more than one assembly is provided per 6 m2 65 SQFT of floor area in each span.
3. Complete installation by pushing unit down into cored hole.
    a. Prior to and during installation, refer to system layout and/or approval drawings.
4. Installer shall comply with detailed manufacturer’s instruction sheet included with each device.
5. Each assembly shall contain retainer for securing device in slab, as well as necessary intumescent material to seal cored-hole under fire conditions.

K. When an outlet box is located in a sound attenuated wall rate STC 45 and greater, provide sealant between outside of box and edge of opening in wall.

L. When an outlet box is located in a sound attenuated wall rated STC 51 and greater, provide putty pad on all four sides and back of box and provide sealant in each conduit entering the box.

END OF SECTION

SECTION 26 05 35

SURFACE METAL RACEWAYS AND WIREWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Pre-wired surface metal raceways shall be provided for branch circuit wiring. Low voltage wiring shall be field wired.

B. Wireways shall be provided to consolidate or splice conductors where indicated.

1.2 QUALITY ASSURANCE

A. System standards:
   1. UL 5 – Standard for Surface Metal Raceways and Fittings.
   2. UL 870 – Wireways, Auxiliary Gutters and Associated Fittings
   3. NEMA WD 6 – Wiring Device Configurations.

1.3 SUBMITTALS

A. Shop drawings:
   1. Pre-wired surface metal raceways.
      a. Provide drawings that indicate complete layout of all products that make up each complete system prior to installation with raceway lengths, device type (power and data), locations and circuits identified.

B. Product data:
   1. Pre-wired surface metal raceways.
   2. Wireways.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Surface metal raceways:
      a. Base:
         1) Wiremold.
         2) Post Glover/Versa-duct.
   2. Wireways:
      a. Base:
         1) Eaton Electrical.
         2) Schneider Electric/Square D.
         3) Siemens.
         4) General Electric.
   3. Other manufacturers desiring approval comply with Section 01 25 13.
   4. Wiremold and Schneider Electric/Square D types listed for quality and performance reference

B. Prewired surface metal raceways: Factory prewired multi-outlet two piece aluminum raceway with base and snap-on cover(s) for mounting power and/or communication devices.
   1. Wiremold Series ALA3800 Isoduct:
      a. Nominal dimensions: 2.25 IN by 3 IN single compartment raceway with 5.93 SQ IN cross sectional area.

b. Raceways shall be capable of flush mounting following NEMA configuration receptacles without an adaptor box:
    1) Straight blade devices: 5-20R, 5-30R, 5-50R, 6-20R, 6-30R, 6-50R, 7-30R, 10-20R, 10-30R, 10-50R, 14-20R, 15-20R, 18-20R, 5-20R GFCI and 5-20R with surge protection.
    2) Twist-lock type receptacles: Any 15, 20 or 30 amp receptacle with NEMA configurations L5 thru L23.

c. Allow for a minimum of 115 NO.12 AWG THHN conductors with any receptacle capable of being mounted.

2. Wiremold Series ALA4800 Isoduct:
    a. Nominal dimensions: 2.25 IN by 6 IN two compartment raceway with 3830 5.93 SQ IN cross sectional area for each compartment. Provide separate cover for each compartment.
    b. Raceways shall be capable of flush mounting following NEMA configuration receptacles without an adaptor box:
        1) Straight blade devices: 5-20R, 5-30R, 5-50R, 6-20R, 6-30R, 6-50R, 7-30R, 7-50R, 10-20R, 10-30R, 10-50R, 14-20R, 15-20R, 18-20R, 5-20R GFCI and 5-20R with surge protection.
        2) Twist-lock type receptacles: Any 15, 20 or 30 amp receptacle with NEMA configurations L5 thru L23.
    c. Allow for a minimum of 115 NO.12 AWG THHN conductors in either compartment with any receptacle capable of being mounted.
3. Where receptacles cannot be mounted flush in cover, provide cast aluminum adapter box surface mounted and centered on cover with concealed fasteners capable of mounting receptacle.
4. Provide base, cover(s), devices, circuiting, connectors, labeling, accessories and fittings for a complete installation including but not limited to elbows (90 degree, internal and external), slide couplings for joining raceway sections, blank end caps for closing open ends of raceway, and flat tees.
5. Manufactured of extruded NO.6063-T5 aluminum with a minimum wall thickness of 0.078 IN.
6. Verify length of raceway in field and cut in factory. Field cutting is unacceptable.
7. Covers shall be 12 IN in length and shall be removable without fasteners.
8. Securely mount devices flush in cover and locate horizontally in center of cover.
9. Raceway shall be electrically continuous and listed as an equipment grounding conductor.
10. Provide clear anodized finish with minimum thickness of 0.004 IN.
11. Provide receptacles and circuiting as indicated on drawings. Receptacles shall be:
    a. In accordance with Section 26 27 26.
    b. Factory installed and wired.
    c. Identified as follows:
        1) Panel mark number and circuit number from which it is fed. Refer to building plans.
        2) Voltage, phase and amperage for receptacles rated higher than NEMA 5-20R configuration
        3) By one of two methods:
            a) Engraved on cover with black lettering, or,
            b) Engraved on phenolic nameplates with adhesive backing or attached to cover with screws.
12. Conductors shall be in accordance with Section 26 05 19.
13. Provide 6 IN pigtails at receptacles. Feed through connection of receptacles is not acceptable.
14. Provide 12 IN pigtails at feed location. Tag circuit(s) with panel mark and circuit number.
15. Refer to Section 27 15 43 for communication devices.
16. Wiring connections of these devices shall be completed at jobsite by contractor.
17. At elbows in communication compartments, provide radius control fittings.

C. Wireway: NEMA I lay-in wire-way.
   1. Provide fittings as required.
   2. Provide solid cover where passing through partitions.
   3. Design for continuous grounding.
   4. Provide general purpose, oil-tight, rain-tight and/or dust-tight type wireway as required.
   5. Knockouts shall be manufacturer's standard or as required.
   6. Size as indicated on the drawings.
   7. Hinged cover.
   8. Finish: Electro-coated gray epoxy paint over phosphate primer.
   9. Schneider Electric/Square D Class 5110.

PART 3 - EXECUTION

3.1 SURFACE RACEWAY AND WIREWAY INSTALLATION

A. Prior to and during installation, refer to system layout drawing containing all elements of system. Installer shall comply with detailed manufacturer's instruction sheets, which accompany system components, as well as complete system instruction sheets, whichever is applicable.

B. All raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.

C. All metal raceway shall be electrically continuous and bonded in accordance with National Electrical Code for proper grounding.

D. Mount surface raceway and wireways on walls or support channels as indicated in manufacturer's instruction sheets. Raceway shall be securely supported at intervals not exceeding 1.5 m 5 FT.

E. All raceway systems shall be installed complete, including insulating bushings and inserts where required by manufacturer's installation sheets. All unused raceway openings shall be closed.

F. Install wiring devices in raceway of type, quantity and location indicated on drawings.

G. Observe following guidelines for conductor fill in raceways and wireways:
   1. Install no more than 30 current carrying conductors.
   2. Cross-sectional area of conductors shall not exceed 20 percent of raceway or wireway.

H. If more than 3 conductors are installed in raceway of cross-sectional area less than 4 SQIN, derating factors of NEC shall be observed.

I. Install wireways with manufacturer's name or trademark visible after installation.

J. Close ends of wireway and any unused conduit openings.

END OF SECTION

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SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Underground Ducts and Raceways for Electrical Systems, as indicated, in accordance with provisions of Contract Documents.

B. Definitions:
   1. Unsuitable material: Debris and/or soil material judged unsuitable by Engineer for support of slabs or other site improvements.
   2. Engineer: Soils Engineer employed by Owner, empowered to conduct inspections and make approvals.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Compaction density test:
   1. Standard Proctor, ASTM D698.

B. Comply with Safety Rules & Regulations for Excavation for local jurisdiction.

C. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Manholes and hand holes.
   2. Duct bank layouts, sections and elevations indicating existing and final grade elevation, duct bank elevation and elevation and crossing utilities.

B. Product Data:
   1. Duct bank conduit separation.

C. Project Information:
   1. Test reports.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Store conduit to avoid warping or deterioration.

B. Store plastic conduit on flat surface protected from direct rays of sun.

1.5 JOB CONDITIONS

A. Protect existing utilities and structures as indicated in Section 26 00 10.

B. Avoid overloading. Keep surcharge sufficient distance back from edge of excavation to prevent slides or caving. Maintain and trim excavated materials in such a manner to be as little inconvenience as possible to public and adjoining property owners.

C. Provide full access to public and private premises, to fire hydrants, sidewalks and other points to prevent serious interruption of travel.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Handholes:
   1. Base:
      a. Hubbell Power Systems, Inc.
   2. Optional:
      a. Armorcast Products Company.
      b. Synertech.

2.2 MATERIALS

A. Duct System:
   1. Duct system: Single or multiple, round bore PVC conduits direct buried or completely encased in concrete as indicated.
      a. Rigid PVC conduit: As specified in Section 26 05 33.
      b. Separators: Concrete, plastic or other non-metallic, non-decaying material.
      c. Concrete: 3000 PSI. Conform to Division 03 requirements.
      d. Reinforcing steel: ASTM A615 Grade 60. Conform to Division 03 requirements.
   2. Pull wire: Heavy nylon cord, free of kinks and splices.
   3. Marker tape: 3 IN wide, .005 IN thick brightly colored plastic tape with continuous metallic backing and a .001 IN corrosion resistant metallic foil core. Tape shall be labeled ELECTRIC, TELEPHONE or SIGNAL at intervals not exceeding 10 FT.

B. Manholes:
   1. Electric and telephone manholes: Types as indicated.
      a. Concrete: 4,000 PSI. Conform to Division 03 requirements.
      b. Precast or poured-in-place manholes acceptable.
      c. Cover and frame: 36 IN diameter, gray cast iron, with machine finished seat for perfect joint between cover and frame.
      d. Embossed identification on cover: ELECTRIC, COMMUNICATIONS, or TELEPHONE
      e. Provide floor drain with grate.
      f. Provide cable racks, ladder rungs, 2 ground rods, cable pulling iron.
   2. Cable racks: Non-metallic, mounted on wall.
      a. Equip with minimum of 8 adjustable hooks; minimum 2 spare hooks on each rack.
      b. Insulators: Best quality, high-glazed porcelain; provide for each hook.
      c. Space racks so each end of splices are supported horizontally.
   3. Ladder rungs: Galvanized, 12 x 12 IN x 3/4 IN diameter.
      a. Set with 7 IN clearance from rung to wall.
   4. Ground rods: 3/4 IN x 10 FT long, copper weld.

C. Handholes:
   1. Base Product: Quazite by Hubbell Power Systems, Inc.
      a. Construction: Polymer concrete.
      b. Suitable for heavy vehicular traffic (8000 LB over 10 x 10 IN area).
      c. Designed and tested to temperatures of -50 DEGF.
      d. Meet the requirements ANSI/SCTE 77 Specification for Underground Enclosure Integrity
      e. Secure cover with minimum 2 hex head fastener nuts.
      f. Open bottom.
      g. Embossed identification on cover: ELECTRIC
      h. Dimensions: Nominal 18 IN long x 11 IN wide x 12 IN deep.
      i. Provide 2 IN cover.

D. Backfill material:
   1. As approved by Engineer.
   2. Free of rock, cobbles, roots, sod, organic matter, and frozen material.

3. Moisture content at time of placement:
   a. 3 PCT plus/minus of optimum moisture content.
   b. Add water to dry material, or dry wet material as required, or furnish off site material at no additional cost to Owner.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove and dispose of materials determined by Engineer to be unsuitable.

B. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with other utilities, site grading, and surface features as determined in the field. Notify Engineer if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

C. Coordinate elevations of duct and duct bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features.
   1. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Engineer.
   2. Lay duct lines to minimum grade of 4 IN in 100 FT.
   3. Grade may be from one manhole to next, or both ways from high point between manholes, depending on contour of finished grade.
   4. Install duct lines so that top of concrete is not less than 30 IN below finished grade or finished paving at any point.

3.2 INSTALLATION

A. Excavate trenches by open cut method to depth indicated and necessary to accommodate the work.
   1. Do not excavate below indicated grades unless required to remove unsuitable material.
   2. Backfill over-excavations in firmly compacted 6 IN lifts.
   3. Keep trenches free of water.
   4. Brace and sheet trenches as soil conditions dictate. Do not remove until backfilling has progressed to a stage that no damage to conduit will result from removal.
   5. Permission may be granted for tunnel work for crossing under crosswalks, driveways or existing utility lines.
   6. Such tunnels are limited to 10 FT in length.

B. Where underground conduits run parallel with pipelines, a 1 FT minimum clearance shall be maintained, and at crossings, a 1 IN minimum clearance shall be maintained below the bottom of the pipes. Conduits should cross under existing pipes when practical and reasonable.

C. Open no more than 300 LF of trench at one time, or less, as required by Engineer.

D. Lay all duct lines to minimum grade of 4 IN in 100 FT.
   1. Grade may be from one manhole to next, or both ways from high point between manholes, depending on contour of finished grade.

E. Install duct lines so that top of concrete is not less than 30 IN below finished grade or finished paving at any point.

F. Provide minimum 12 IN separation between electric and communication ducts.

G. Clean conduit before using or laying.

H. Lay no conduit in water or in unsuitable weather or trench conditions.

I. Conduit spacers shall be sized to allow for the full separation of conduits as indicated on the drawings and spaced a maximum of 8 FT on centers.

J. Accomplish changes in direction of runs exceeding total of 15 DEG, either vertical or horizontal, by long sweep bends with minimum radius of 25 FT.
   1. Sweep bends may be made up of one or more curved or straight sections or combinations thereof.
   2. Provide rigid steel elbows at turn-ups to electrical equipment.
   3. Manufactured bends: Minimum radius of 48 IN for ducts of 3 IN in diameter and larger.
   4. Long sweep bends may be made up of one or more curved or straight sections and/or combinations thereof.

K. Furnish manufactured bends at end of runs.
   1. Minimum radius of 18 IN for conduits less than 3 IN trade size and 36 IN for ducts of 3 IN trade size and larger.

L. Make conduit joints in accordance with manufacturer's recommendations for conduit and coupling selected.
   1. Make conduit joints watertight.
   2. Make plastic conduit joints by brushing plastic solvent cement on inside of plastic coupling fitting and outside of conduit ends.
   3. Slip conduit and fitting together with quick one-quarter-turn twist to set joint tightly.

M. During construction and after duct line is completed, plug ends of conduits to prevent water washing into conduit or manholes.
   1. Keep conduits clear of concrete, dirt, and any other substance during course of construction.

N. Where it is necessary to cut tapered end on a piece of conduit at site, make cut with tool or lathe designed to cut taper to match taper of particular conduit being used.

O. Terminate conduits in end bells where duct lines enter pull boxes or manholes.

P. After duct line has been completed, pull standard flexible mandrel not less than 12 IN long, with diameter approximately 1/4 IN less than inside diameter of conduit, through each conduit. Then pull brush with stiff bristles through each conduit to make certain that no particles of earth, sand, or gravel have been left in line.

Q. Pneumatic rodding may be used.

R. Install pull wire in unused new ducts.
   1. Extend minimum of 3 FT into each manhole or above pads beyond ends of ducts.

S. Encase each conduit in concrete not less that 3 IN beyond any surface of conduit.
   1. Stagger conduit joints a minimum of 12 IN in concrete encased duct banks.
   2. Mix, place and cure concrete in accordance with Division 03 requirements.

T. Provide uniform spacing between conduits: Not less that 2 IN.
   1. Place separators on maximum 4 FT centers.
   2. Anchor ducts to prevent movement during placement of concrete.

U. Make conduit joints in accordance with manufacturer's recommendations for conduit and coupling selected.
   1. Make conduit joints watertight.
   2. Brush plastic solvent cement on inside of plastic coupling fitting and outside of conduit ends.

V. Place marker tape above service lines, electrical feeders and communication ducts outside building footprint. Locate tape 12 IN below finished grade.

W. After cleaning of conduit, install a 3/16 IN kevlar pull string with marked footage in each spare conduit.

3.3 INSTALLATION OF MANHOLES AND HANDHOLES

A. Determine exact location of each manhole and handhole after careful consideration has been given to location of other utilities, grading, and paving.
   1. Do not begin construction until location of each manhole and handhole has been approved by Engineer.

B. Construct manholes of type indicated in accordance with applicable details.
   1. Mix, place and cure concrete in accordance with Division 03 requirements.

C. Set manhole frames and covers.
   1. Paint with 2 coats asphaltic paint after inspection and approval and before setting.
   2. In paved areas, set top of manhole covers flush with finished surface of paving.
   3. In unpaved areas, set top of manhole covers approximately 1/2 IN above finished grade.
   4. Where existing grades are higher than finished grades, install sufficient number of courses of curved segmented concrete block between top of manhole and manhole frame to temporarily elevate manhole cover to existing grade level.

D. Install cable racks, ladder rungs and cable pulling iron.

E. Drive 2 ground rods into earth not less than 9 FT before manhole floor is placed.
   1. Extend ground rods approximately 4 IN above manhole floor.

F. Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days.

3.4 BACKFILLING

A. Backfilling: See Section 31 20 00.

3.5 COMPACTION

A. Compaction: See Section 31 20 00.

3.6 FIELD QUALITY CONTROL

A. Perform backfill density tests as directed by Engineer.
   1. Allow for one test per 100 FT of trench.

END OF SECTION

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SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Identification for Electrical Systems, as indicated, in accordance with provisions of Contract Documents.

B. Provide the following:
1. Identification for raceways.
2. Identification for conductors.
3. Underground-line warning tape.
4. Warning labels and signs.
5. Equipment identification labels.
6. Miscellaneous identification products.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.3 SUBMITTALS

A. Product Data:
1. Manufacturer literature for each electrical identification product indicated.

B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Project Information:
1. Identification Schedule:
   a. Index of electrical equipment and system components of identification signs and labels.

1.4 COORDINATION

A. Identification required in this section applies to equipment furnished in other Divisions.

B. Coordinate identification names and abbreviations with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, operation manuals, maintenance manuals, code requirements, standards, and 29 CFR 1910.145.
1. Use consistent designations throughout Project.
2. Equipment identification shall be Owner-furnished designation and not designation indicated on plans.

C. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

D. Coordinate installation of identifying devices with location of access panels and doors.

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

PART 2 - PRODUCTS

2.1 POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS

A. Colors for Raceways Carrying Circuits at 600 V or Less:
   1. As scheduled below.
   2. Legend: Indicate voltage and system or service type.

B. Colors for Raceways Carrying Circuits at More Than 600 V:
   1. Black letters on an orange field.
   2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING."

C. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 IN wide; compounded for outdoor use.

2.2 CONDUCTOR IDENTIFICATION MATERIALS

A. Conductor jacketing shall be color-coded as scheduled below.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Tape:
   1. Recommended by manufacturer for the method of installation and suitable to permanently identify and locate underground electrical and communications utility lines.
   2. Tape and ink:
      a. Chemically inert.
      b. Unaffected when exposed to acids, alkalis, and other destructive substances found in soil.

B. Color and Printing:
   1. Comply with ANSI Z535.1 through ANSI Z535.5.
   2. Inscriptions for Red-Colored Tapes with Black Lettering: ELECTRIC LINE, HIGH VOLTAGE.
   3. Inscriptions for Orange-Colored Tapes with Black Lettering: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Construction:
   1. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   2. Thickness: 4 mils.
   3. Weight: 18.5 LB/1000 SQ FT. .
   4. 3 IN Tensile According to ASTM D 882: 30 LBF, and 2500 PSI.

2.4 CONCRETE COLORANT

A. Color Pigment:
   1. Add red color pigment to concrete mixture according to manufacturer's written instructions.

2.5 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Baked-Enamel Warning Signs:
   1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
   2. 1/4 IN grommets in corners for mounting.
   3. Nominal size, 7 x 10 IN .

C. Warning label and sign shall include, but are not limited to, the following legends:
   1. Arc Flash Warning: “WARNING – ARC FLASH HAZARD.”
   2. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2.6 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting.
   1. Colors as indicated in Identification Schedule below.
   2. Letters:
      a. 1/4 IN high for equipment with cover plate less than 12 IN wide.
      b. 1/2 IN high for equipment with cover plate over 12 IN wide:

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 12 IN below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 IN overall.

G. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120V to ground: Identify with self-adhesive vinyl label applied in bands. Install labels at 30 FT maximum intervals.

B. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, manholes, and handholes, use color-coding conductor tape to identify the phase.

C. Boxes: Color code the covers of each junction and pull box.

D. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
   1. Install underground-line warning tape for both direct-buried conduit as well as conduits in ductbank.

E. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

F. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting:
   1. Comply with 29 CFR 1910.145.

2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
    a. Power transfer switches.
    b. Controls with external control power connections.

G. Nameplates: Provide engraved laminated nameplates for electrical equipment.
1. Colors:
    a. Normal Distribution Equipment: Gray with black letters.
    b. Emergency Distribution Equipment: Red with white letters.
    c. Optional Stand-By Distribution Equipment: Orange with white letters.
    d. UPS Distribution Equipment: White with black letters.
2. Letters:
    a. 1/4 IN high for equipment with cover plate under 12 IN wide.
    b. 1/2 IN high for equipment with cover plate over 12 IN wide:
3. Attach with stainless steel screws.
4. Switchgear, switchboard, distribution panel and motor control center nameplates:
    a. Center nameplate near top of first section. Label text to include:
        1) Equipment name and branch, i.e., "Panel XXXX - Life Safety Branch".
        2) Source, i.e., "Source - Switchboard XXXX".
    b. Provide similar nameplates for each main and feeder device. Mount label adjacent to or on cover of device. Label text to include:
        1) Description of load, i.e., "Load - Panelboard XXX".
5. Panelboard nameplates:
    a. Center nameplate near top of each section. Label text to include:
        1) Equipment name and branch, i.e., "Panel XXXX - Life Safety Branch".
        2) Source, i.e., "Source - Switchboard XXXX".
6. Disconnect switches, transformers, contactors, thermal element switches, starters, capacitors, etc. nameplates:
    a. Center nameplate near top of face plate or cover. Label text to include:
        1) Description of load, i.e., "Load - AHU-XXX".
        2) Source, i.e., "Source - MCC-XXXX".
7. Transfer switches:
    a. Center nameplate near top of cover. Label text to include:
        1) Description of load, i.e., "Distribution Board XXXX - Life Safety Branch".
        2) Normal source, i.e., "Normal Source - Switchboard XXXX".
        3) Emergency source, i.e., "Emergency Source - Switchboard XXXX".
8. Fire alarm, public address and other system control cabinet nameplates:
    a. Center nameplate near top of cover. Label text to include:
        1) Description of system, i.e., "Fire Alarm System Control Panel".
9. Relays and relay cabinet nameplates:
    a. Center nameplate near top of cover. Label text to include:
        1) Description of item controlled, applicable system or function and type of device, i.e., "AHU-XXX FA Shut Down Relay" or "Exterior Lighting Circuit XX-X Control Relay".
10. Lighting Control Panel nameplates:
    a. Center nameplate near top of cover. Label text to include:
        1) Equipment name and branch, i.e., "Lighting Control Panel XXXX - Normal Branch".
        2) Control Power Source, i.e., "Control Power – Panel XXXX".

H. Flash Hazard Warning Signs:
1. Provide for all switchboards, panelboards, and motor control centers per NEC Article 110.

I. Device Plates:
1. Color as scheduled in table below and label text as required under Section 26 27 26.

J. Paint outlet boxes, junction boxes and enclosures, except switchboard and panelboard enclosures, as scheduled in table below.

K. Paint emergency system conduits with 2 IN wide band 10 FT on center as scheduled in table below.
   1. Pressure-sensitive, color-impregnated tape will be acceptable.

L. High Voltage Signs:
   1. Distribution equipment rated over 600 volts and/or pull and junction boxes containing conductors rated over 600 volts shall have a sign posted on the front and rear as applicable:
      a. 1 to 1-1/2 IN high red letters stenciled on a 3 IN high white background.
      b. Sign shall read, "DANGER - HIGH VOLTAGE".

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SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Section 01 91 13 – Commissioning General Requirements

C. Section 22 08 00 – Commissioning of Plumbing Systems

D. Section 23 08 00 – Commissioning of HVAC Systems

E. Section 25 08 00 – Commissioning of Integrated Automation Control Systems

F. Section 27 08 00 – Commissioning of Communication Systems

G. Section 28 08 00 – Commissioning of Electronic Safety and Security Systems

H. Commissioning Plan

1.2 DESCRIPTION OF WORK

A. The purpose of this section is to specify the Division 26 responsibilities and participation in the commissioning process. All contractors responsible for Division 26 installation or other activities shall have commissioning responsibilities described herein.

B. Work under this contract shall conform to requirements of Division 1, General Requirements, Conditions of the Contract, and Supplementary Conditions. This specification covers Commissioning of Electrical Systems, which are a part of this project.

C. Commissioning shall be a team effort to ensure that all electrical equipment and systems have been completely and properly installed and function together correctly to meet the design intent. Additionally, system performance parameters shall be monitored and documented for fine tuning of control sequences and operational procedures. Commissioning shall coordinate and document equipment installation, equipment start-up, controls calibration, testing and balancing, and verification and performance testing.

D. The Commissioning Team is defined in Specification 01 91 13 Section 1.3 – Definitions. The electrical trades represented on the Commissioning Team shall include but not be limited to; electrical, lighting, fire alarm, telecommunications, security, and third party electrical testing agencies. The lead person for each trade who will actually perform or supervise the work is to be designated as the representative to the Commissioning Team. Responsibility for various steps of the commissioning process shall be divided among the members of the Commissioning Team, as described in this section.

E. Electrical Contractor(s) are responsible for electrical system installation, start-up, testing, preparation of O&M manuals, and operator training as defined in various Division 26 specification sections. Electrical Contractor(s) are responsible for coordination, observation, and verification of commissioning as defined in this section and Section 01 91 13. Neither Section 01 91 13 - Commissioning General Requirements nor Section 26 08 00 – Commissioning of Electrical Systems shall relieve the Electrical Contractor(s) from their obligations to complete all portions of work in a satisfactory and fully operational manner. Furthermore, Section 26 08 00 – Commissioning of Electrical Systems shall not relieve the Electrical Contractor(s) from any obligations set forth within Section 01 91 13 – Commissioning General Requirements.

1.3 DEFINITIONS

A. Electrical Contractor(s): The term Electrical Contractor(s) utilized herein refers to any and all subcontracting companies or venders whom are responsible for the construction or other provisions regarding any of the systems which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 26 of the specifications. Subcontracting parties outside of the scope of the systems being commissioned or outside of the scope of Division 26 are not included.

B. Equipment Manufacturer(s): The term Equipment Manufacturer(s) utilized herein refers to any and all subcontracting companies whom are responsible for the provision of equipment or components which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 26 of the specifications. Equipment Manufacturer(s) shall refer to the direct representative of the maker and/or distributor of the equipment or component being provided. This may include either the actual equipment manufacturer or the supplier thereof, under the provisions that the supplier has a thorough knowledge of the equipment or component and is recognized by the actual equipment manufacturer as being a proper representative.

1.4 SCOPE OF WORK

A. The Electrical Contractor(s) shall be required to Commission all equipment, components and accessories of each of the commissioned systems as outlined within Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning. In order to accomplish a complete commissioning process, the Electrical Contractor(s) shall be required to fulfill all requirements set forth within Specification 26 08 00 Section 1.5 – Roles and Responsibilities. Additionally, the Electrical Contractor(s) shall be required to fulfill all requirements set forth within Specification 01 91 13.

B. Through the Commissioning Process, the Electrical Contractor(s) shall accomplish thorough documentation, organized scheduling and coordination, detailed installation verification, and detailed system functional verification. For this, the Electrical Contractor(s) must cooperate and coordinate with the Commissioning Agent.

1.5 ROLES AND RESPONSIBILITIES

A. In addition to the Commissioning Agent, Owner and System Design Professional(s), the Commissioning Team is comprised of a minimum of one individual to represent each contracting company or vender whom is responsible for the construction or other provisions regarding any of the systems which are being commissioned, as outlined in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, and are defined within Division 26 of the specifications. See Specification 01 91 13 Section 1.3 – Definitions for the definition of the Commissioning Team.

B. Contracting companies providing members shall include but not be limited to; electrical contractor, lighting contractor, telecommunications contractor, security system contractor, fire alarm contractor, and third party electrical test agencies whose responsibilities are defined herein.

C. In addition to all roles and responsibilities defined herein, all Electrial Contractor(s) shall be required to fulfill all requirements described within Specification 01 91 13 Section 1.4 – Roles and Responsibilities.

D. Electrical Contractor(s)
   1. General Requirements:
      a. Include all cost to complete commissioning requirements for electrical systems in the contract price. Contractor costs shall be reflected within the Schedule of Values as specified within Specification 01 91 13 Section 2.2 – Schedule of Values.
      b. Ensure cooperation and participation of specialty Contractors and Sub-Contractors.

c. Ensure participation of major Equipment Manufacturers in appropriate start-up, testing and training activities.
d. Attend Commissioning Meetings for construction phase coordination as scheduled by the Commissioning Agent. Additionally, attend the Commissioning Kick-Off Meeting as scheduled by the Commissioning Agent.

2. Commissioning Schedule
   a. Prepare a Preliminary Schedule for electrical systems and equipment, including component installation, start-up and checkout, and system start-up. Integrate commissioning activities into this Preliminary Schedule including Pre-Functional Checklists and Functional Performance Tests. Coordination of the commissioning activities and their integration into the schedule shall be conducted within the Commissioning Meetings.
   b. Update the Preliminary Schedule and submit a Final Schedule which shall reflect all items within the Preliminary Schedule and shall also include but not be limited to: inspections, O&M manual submission, training sessions, feeder testing, ground system testing, equipment and component NETA testing, Coordination Study completion and implementation, equipment energizing, and task completion. All Contractor(s) shall integrate schedule activities into one complete Final Schedule which shall be reflected within the Construction Manager's/General Contractor's overall project schedule. The Final Schedule shall be continuously updated throughout the Construction Phase.
3. Submittal Requirements:
   a. Comply with all Submittal requirements as outlined within Specification 01 91 13 Section 2.3 – Submittals.
   b. Comply with all requirements as outlined within Specification 01 91 13 Section 2.5 – Start-Up and Test Reports.
   c. Provide a complete set of O&M manuals to the A/E and the Commissioning Agent.
   d. Provide the following documentation to the Commissioning Agent for the purpose of construction updates:
      1) General construction progress and status reports
      2) Updated Architect, Owner, System Design Professional, and Contractor deficiency logs
      3) Minutes from all construction and coordination meetings not otherwise conducted by the Commissioning Agent
      4) Pre Start-Up and Start-Up procedures
      5) Value Engineering Proposals and a list of all accepted VE items
      6) Coordination Studies, Manufacture Inspection Reports, Authority Having Jurisdiction Inspection Reports, etc.
      7) Construction document changes resulting from electrical Requests for Information
4. Pre-Functional Requirements:
   a. Detailed installation verification shall be performed on all installed equipment and systems to ensure that the installations conform to the contract documents, local and applicable codes, and standard practice. This shall be accomplished through the completion of Pre-Functional Checklists. The creation, distribution, completion and maintenance of Pre-Functional Checklists are detailed in Specification 01 91 13 Section 2.4 – Pre-Functional Checklists.
   b. Complete Pre-Functional Checklists on all electrical equipment and system components installed or provided by the Electrical Contractors(s).
   c. Notify the Commissioning Agent a minimum of two weeks (14 days) in advance, so that witnessing Equipment and System Start-Up can begin.
   d. Provide written notification to the Commissioning Agent for each system listed in Specification 01 91 13 Section 1.5 – Systems to be Included in Commissioning, that the system installation is complete in its entirety and that the system is fully operational, online, and ready for Functional Performance Testing.

5. Equipment and System Start-Up
    a. Perform all initial check-out and start-up procedures as outlined within the specifications and as per the Equipment Manufacturer's recommendations. Provide full documentation of all start-up and check-out procedures and results. Documentation is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist.
    b. Perform all feeder tests, ground system tests, infrared scanning and any other system component test required by the specifications requiring a 3rd party test agency. Provide full documentation of all tests procedures and results. Documentation is to be submitted to the Commissioning Agent in conjunction with the associated Pre-Functional Checklist. Some tests and inspections may be required to be witnessed and documented by the Commissioning Agent. For these tests and inspections, follow the procedures outlined in this Specification, Section 1.5-D-6 – Functional Performance Test Requirements.
    c. Perform all Testing requirements for electrical components. Submit copies of the Testing Report to all interested and reviewing parties as required by the specifications and to the Commissioning Agent. Also, submit a copy of the preliminary Testing documentation including the Testing Plan, Forms and Report format to the Commissioning Agent for review and approval.
6. Functional Performance Test Requirements:
    a. Detailed testing shall be performed on all installed equipment and systems to ensure that operation and performance conform to contract documents, local and applicable codes, and standard practice. This shall be accomplished through the completion of Functional Performance Tests. The creation, distribution and completion of Functional Performance Tests are detailed in Specification 01 91 13 Section 2.6 – Functional Performance Tests.
    b. Provide all appropriate equipment and materials as necessary to execute and complete all Functional Performance Tests. Comply with all requirements as outlined within Specification 01 91 13 Section 2.8 – Test Equipment.
    c. Provide appropriate technicians for participation during system verification and functional performance testing. Technicians shall demonstrate equipment as-installed condition and system performance to Commissioning Agent including all modes of system operation (e.g. normal, abnormal, emergency, etc.)
    d. Verify all functional performance tests prior to requesting test witness by the Commissioning Agent. Demonstrate all Functional Performance test tasks in the presence of the Commissioning Agent and assist the Commissioning Agent in all verification and functional performance tests.
    e. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Commissioning Agent for verification or diagnostic purposes. Typically, TAB Verification shall occur in conjunction with Functional Performance Testing. Electrical TAB requirements will include but not be limited to measuring and recording all electrical motor data; voltage, current, frequency, rotations per minute, power consumption, etc.
    f. Cancellation or delays of any electrical tests or Functional Performance Testing upon the day of that particular scheduled test, due to lack of preparation or status of installation shall be considered a failed test due to the additional time required by the Commissioning Agent to witness electrical testing. These additional tests shall be treated in accordance with Specification 01 91 13 Section 3.6-A.

7. Training Requirements:
   a. Comprehensive training of O&M personnel shall be performed by the Electrical Contractor(s) and Equipment Manufacturer(s) prior to turnover of the systems to the Owner. Training shall include but not be limited to classroom instruction and hands-on instruction of the installed equipment and systems. Training shall be coordinated by the Commissioning Agent via review and approval of the Contractor(s) Training Plan, Forms and Schedule. Alternately, the Commissioning Agent may provide a Training Plan including all forms for completion by the Electrical Contractor(s).
   b. The Training Schedule is to be coordinated and completed by the Electrical Contractor(s). The Training Schedule is to be updated and maintained as construction progresses. The Training Schedule and all updates shall be coordinated with and approved of by the Owner. A copy of the Training Schedule and all updates shall be provided to the Commissioning Agent.
   c. Contractor(s) responsible for the installation or provision of any piece of equipment or system shall attend, at minimum, the initial training session for that equipment or system.
   d. All Training Documentation shall be assembled and organized in a binder or set of binders. Coordinate with all other Contractor(s) to provide one complete bound Training Record. This requirement shall not be negated, unless other specific complete Project Training Record requirements, encompassing ALL project training documentation, is outlined elsewhere within the specifications.
   e. Contractor to make professional video recordings of all O&M staff training sessions.
8. Close-Out Requirements:
   a. Remedy all deficiencies identified during commissioning. Provide all materials, equipment, labor, etc. to accomplish these remedies.
   b. Provide a complete set of Record Documents (As-Built Drawings and Specifications) to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval by the Commissioning Agent.
   c. Provide a Project Training Record to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy of the Project Training Record for review and approval to the Commissioning Agent.
   d. Provide a complete copy of Equipment and System Warranties to the Architect and/or Design Professional as required by the project specifications. Provide an additional copy for review and approval by the Commissioning Agent.
   e. Provide to the Commissioning Agent, a complete record of Attic Stock as delivered to the Owner and as approved by the Owner.
   f. Contractor to provide CMMS data and MAXIMO documentation to Owner as required by project specifications.

E. Equipment Manufacturer(s):
   1. Comply with all requirements as outlined within Specification 26 08 00 Section 1.5 Sub-Section D – Electrical Contractor(s).
   2. Assist in scheduling of training sessions. Provide training of Owner’s Maintenance Personnel with adequacy required for full comprehension of equipment and maintenance procedures. Coordinate training with the Commissioning Agent. Training forms for Agenda and Training Record shall be provided by the Commissioning Agent. These forms are to be utilized for all Training Sessions. Manufacturer's standard training forms shall not be accepted as Training Records if Commissioning Forms are provided. Manufacturer standard training forms may be submitted as supplemental information, but the Commissioning Forms must be completed in their entirety.
   3. Review installation for manufacturer’s specific requirements. Verify safeties, limits, relays and all other equipment specific settings are correct. Verify these settings optimize equipment performance and efficiencies.

4. Perform, approve and document all start-up services as outlined within the specifications for each piece of equipment, component and accessory. Perform all standard manufacturer services as outlined on manufacturer supplied forms. Additionally, perform all other requirements specifically called for within the project specifications, not otherwise performed in a manufacturer standard startup service. Provide additional documentation for these services on forms with manufacturer's letterhead.
5. Demonstrate performance of equipment as required within Functional Performance Tests.

F. Third Party Electrical Test Agencies
1. Comply with all requirements as outlined within Specification 26 08 00 Section 1.5 Sub-Section D – Electrical Contractor(s).
2. Certified Third Party Test Agency shall perform all electrical tests as required by the specifications and as outlined within the Functional Performance Test procedures.
3. Testing Agency shall provide all equipment, components and accessories required for testing.
4. Functional Performance Tests for all power equipment, components and accessories shall follow NETA Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems. Electrical Contractor(s) shall notify the Commissioning Agent prior to any testing being performed by the Certified Third Party Test Agency with a minimum of two weeks (14 days) notice.
5. Testing Agency shall notify the Commissioning Team of all deficiencies and un-safe conditions existing within these systems. If predominant un-safe conditions exist it shall be the responsibility of the Third Party Testing Agency to terminate testing to be continued at a later date.

1.6 DOCUMENTATION

A. The Commissioning Agent shall oversee and maintain the development of commissioning documentation. The commissioning documentation shall be kept in three ring binders, and organized by system and sub-system when practical. All pages shall be numbered, and a table of contents page(s) shall be provided. The commissioning documentation shall include, but not be limited to, the following:
1. Start-Up and Check-Out Documentation: Organized and arranged with its associated Pre-Functional Checklist.
2. System and Component tests (i.e. Feeder Test Reports, Ground System Reports, etc.): Organized and arranged with its associated Pre-Functional Checklist.
3. Pre-Functional Checklist: Organized and arranged as per provided by the Commissioning Agent. Typically these forms are organized by System and Sub-System and according to the order of standard specifications as outlined by American Institute of Architects (AIA.)
4. Functional Performance Tests: All tests performed by the installing contractors for internal checkout and for witness by the Commissioning Agent shall be kept by the Contractor(s), organized and arranged by System and Sub-System, and turned over to the Commissioning Agent for inclusion into the Final Commissioning Report.
5. Project Training Record: The Training Record shall be provided with a Table of Contents followed by the updated Training Schedule and finally followed by each Training Session Agenda and Record. The Training Session Agenda and Record shall be organized by System and Sub-System.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The appropriate Contractor(s) shall furnish all special tools and equipment required during the commissioning process. A list of all tools and equipment to be used during commissioning shall be submitted to the Commissioning Agent for approval. The owner shall furnish necessary utilities for the commissioning process. Additional test equipment requirements are found in Specification 01 91 13 Section 2.8 – Test Equipment.

2.2 TEST EQUIPMENT - PROPRIETARY

A. 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.

PART 3 - EXECUTION

3.1 GENERAL

A. A pre-construction meeting of all Commissioning Team members shall be held at a time and place designated by the General Contractor. The purpose shall be to familiarize all parties with the commissioning process, and to ensure that the responsibilities of each party are clearly understood.

B. A Final Commissioning Plan shall be developed by the Commissioning Agent. The Electrical Contractor(s) shall assist the Commissioning Agent in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation in a timely manner. If contractor initiated system changes have been made that alter the commissioning process, the Commissioning Agent shall notify the Owner.

C. The Commissioning Process shall follow the schedule and procedures set forth within the Final Commissioning Plan.

D. The Electrical Contractor(s) shall complete all phases of work so the systems can be started, tested, balanced, and acceptance procedures undertaken. This includes the complete installation of all equipment, materials, feeders, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, and change orders.

E. The Electrical Contractor(s) shall coordinate all Commissioning Activities into the project as required herein and as outlined within the Commissioning Plan. The Electrical Contractor(s) shall complete all required Commissioning and Construction Activities correctly and on schedule.

3.2 PARTICIPATION IN ACCEPTANCE PROCEDURES

A. The Electrical Contractor(s) shall provide skilled technicians to start-up and debug all systems within Division 26. These same technicians shall be made available to assist the Commissioning Agent in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the Commissioning Agent and coordinated by the Electrical Contractor(s). Electrical Contractor(s) shall ensure that the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. System performance problems and discrepancies may require additional technician time, Commissioning Agent time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods, at no cost to the owner, until the required system performance is obtained.

C. The Commissioning Agent reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and willingness to work with the Commissioning Agent. The Electrical Contractor(s) shall provide adequate documentation and tools to start-up and test the equipment, system, and/or sub-system.

3.3 DEFICIENCY RESOLUTION

A. In some systems, miss-adjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the Owner, with input from the contractor and equipment supplier. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the Owner and/or Architect shall have final jurisdiction over any additional work done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Any and all schedule items affected by this work shall be reflected on the Commissioning and Overall Project Schedules.

3.4 ADDITIONAL COMMISSIONING

A. The Electrical Contractor, and associated sub-contractors, shall be responsible for any additional commissioning required as a result of failure of a pre-functional or a functional test. Incomplete or incorrect Pre-Functional Checklists reviewed by the Commissioning Agent shall require an additional inspection to verify the re-completed PFC is complete and accurate. Functional Performance Tests witnessed by the Commissioning Agent which fail, shall require retesting, again witnessed by the Commissioning Agent. These documents must be re-checked or re-witnessed in order for the system to be approved and accepted by the Commissioning Agent.

B. The Commissioning Agent will invoice the Owner for additional time, plus expenses, required to witness any retesting due to failed PFC's or FPT's and the Owner may deduct this cost at his discretion from the Construction Manager's Application for Payment. It is the Electrical Contractor's responsibility to properly de-bug systems and verify successful system performance prior to inviting the Commissioning Agent to witness the test.

3.5 SEASONAL COMMISSIONING

A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Initial commissioning shall be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. Heating equipment shall be tested during winter design extremes. Cooling equipment shall be tested during summer design extremes with a fully occupied building. Each contractor and supplier shall be responsible to participate in the initial and the alternate peak season tests of the systems as required to demonstrate performance.

3.6 PRE-FUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTS

A. The Commissioning Agent shall be responsible for preparing the Pre-Functional Checklist. The Electrical Contractor(s) shall be responsible for completing their applicable sections. Detailed descriptions of Pre-Functional Checklists are outlined in Section 01 91 13-2.4.

B. The Commissioning Agent shall be responsible for preparing the Functional Performance Tests. The Commissioning Agent and Contractor (s) shall schedule the tests and assemble the commissioning team members who shall be responsible for the tests. Participating contractors, manufacturers, suppliers, etc. shall include all costs to do the work involved in these tests in their proposals. Detailed descriptions of Functional Performance Tests are outlined in Section 01 91 13-2.6.

C. Following is a list of tasks and supporting information that shall be required:
   1. Electrical contractor - provide a foreman electrician familiar with the electrical interlocks, interfaces with emergency power supply, and interfaces with alarm and life-safety systems. Provide access to the contract plans, and all as-built schematics of sub-systems, interfaces, and interlocks.

D. Documentation and Reporting Requirements
   1. Any contractors with responsibilities related to the equipment to be installed, i.e. mechanical, electrical, TAB, controls, Construction Manager or General Contractor, shall be responsible for completing their related portion of the Pre-Functional Checklist and Functional Performance Test forms and shall sign off on its completion.
   2. If deficiencies are identified during verification, the construction manager must be notified, and action taken to remedy the deficiency. The final tabulated checklist data sheets shall be reviewed by the Design Professional and the Commissioning Agent, to determine if verification is complete, and the operating system is functioning in accordance with the contract documents.

END OF SECTION

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SECTION 26 09 13
POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Power Monitoring and Control, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 SYSTEM DESCRIPTION

A. Power monitoring system shall consist of electronic circuit monitors, display units and circuit breaker interface modules installed as required or indicated in the project drawings.
   1. The power monitoring system shall be connected to a Local Area Network (LAN) for remote monitoring from a personal computer workstation.

B. Power monitoring system shall utilize local system display units to display circuit monitor data.

C. The system shall interface with the existing campus Square D Power Logic Power Monitoring System.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Outline drawings of assembly.
   2. One line diagrams and wiring diagrams for assembly and components.
   3. Interconnection wiring diagrams.

B. Product Data:
   1. Technical data on each component.

C. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Power Monitoring and Control:
   1. Base (no substitutions):
      a. Schneider Electric/Square D: PM 8000 Series.

2.2 MATERIALS

A. Power Monitoring System Operation:
   1. The power monitoring system shall monitor points in power distribution system and provide local and remote readings as indicated.
   2. The power monitoring system shall, through software on a personal computer workstation, provide for:
      a. Monitoring multiple devices at one time.
   3. All equipment: UL listed.

B. Circuit Monitors:
   1. Description:

a. The electronic circuit monitors shall provide metering values such as frequency, temperature, current, voltage, power factor, power, demand current and real power, and accumulated real and reactive energy.
b. Each circuit monitor shall retain historical circuit data, time and date, setup and configuration values, and diagnostics data in the event of a control power failure, without the need for an internal battery.
c. Each circuit monitor shall capture voltage and current waveforms for export to a personal computer workstation for power quality analysis.

2. Installation:
   a. Electronic circuit monitors shall be installed by the switchgear manufacturer for all circuits as indicated by the project drawings.
   b. All control power, CT, PT, and communications wiring shall be factory installed and harnessed within the switchgear lineup.
   c. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements, including wire type, to be used.
3. Circuit monitor characteristics:
   a. The electronic circuit monitors shall accept inputs from industry standard instrument transformers (120VAC secondary PTs and 5A secondary CTs).
   b. Current and voltage signals shall be digitally sampled at a rate high enough to provide accurant RMS sensing and valid data for waveform analysis beyond the 30th harmonic of the fundamental power frequency.
   c. All setup parameters required by circuit monitor shall be stored in nonvolatile memory (no battery backup) and retained in the event of a control power interruption.
   d. Each circuit monitor shall also maintain, in nonvolatile memory, a maximum and minimum value for each of the Instantaneous Values reports, as well as the time and date of the highest peak for all of the peak demand readings.
   e. The following minimum instantaneous readings shall be reported by the circuit monitor:
      1) Frequency.
      2) Temperature.
      3) Current, per phase rms.
      4) Neutral current, rms.
      5) Current, 3-phase average rms.
      6) Current, apparent rms.
      7) Voltage, phase-to-phase & phase-to-neutral.
      8) Power factor, per phase.
      9) Power factor, 3-phase total.
      10) Real power, 3-phase total.
      11) Reactive power, 3-phase total.
      12) Apparent power, 3-phase total.
   f. The following minimum demand readings shall be reported by the circuit monitor:
      1) Average demand, real power.
      2) Peak demand, real power.
   g. The following energy readings shall be reported by the circuit monitor:
      1) Accumulated energy.
      2) Accumulated reactive energy.
4. The circuit monitor shall have the ability to monitor eight separate inputs from various devices and report the status of each input to a system display unit or personal computer workstation.
5. Waveform capture capability:
   a. All electronic circuit monitors shall include waveform capture capability.
   b. Upon a user-initiated command, the circuit monitor shall capture and store, in nonvolatile memory, 3-phase voltage and current samples consisting of 256 data points each.

c. These data points shall represent at least four cycles of each current or voltage waveform.
d. These samples shall be evenly gathered from three voltage and three current phases such that the original power signals with proper magnitude and phase relationships may be reconstructed.
e. It shall be possible to recreate the original power signal from the stored data with sufficient accuracy such that steady-state power harmonic analysis will provide valid information on harmonic content for up to the 30th harmonic of the fundamental power frequency.

6. Each circuit monitor shall display, on an integral LED display, the following electrical parameters (as a minimum):
   a. Current, per phase RMS.
   b. Voltage, phase-to-phase RMS.
   c. Voltage, phase-to-neutral RMS (per phase).
   d. Real power, 3-phase total.
   e. Reactive power, 3-phase total.
   f. Apparent power, 3-phase total.
   g. Power factor.
   h. Frequency.
   i. Peak demand, real power.
   j. Accumulated energy (MWH and MVARH).
7. Reset of the following parameters shall be allowed from the circuit monitor:
   a. Peak demand power.
   b. Energy (MWH).
   c. Reactive energy (MVARH).
8. Circuit monitor setup shall be allowed from the circuit monitor display. Setup parameters shall include:
   a. CT rating (XXXX:5).
   b. PT rating (XXXXX:120).
   c. System type (3-wire or 4-wire).
   d. Demand interval (5 to 60 minutes).
9. All reset and setup functions shall be keyswitch-protected to prevent unauthorized/accidental changes.
10. Provide CT's and PT's where not provided under other sections.
11. Connecting and networking circuit monitors:
    a. All data and calculated values stored in the circuit monitor shall be accessible to external devices via a double twisted pair cable (Belden #8723 or equal) by means of an RS485/RS422 serial communications port built into the circuit monitor.
    b. It shall be possible to connect from one communications port to another such that up to 32 electronic circuit monitors may be connected to form a continuous string extending up to 10,000 FT.
    c. These strings shall form individual data transfer networks that comply to the RS485 multi-drop communications standards.
    d. Communication rates on this network shall be adjustable up to 19.2 Kbaud to ensure acceptable throughput of data.
    e. It shall be possible to connect up to 100 of these networks together by means of network interface modules to form a high speed power monitoring and data acquisition network.

C. System Display Units (SDU):
1. Description:
   a. Each SDU shall provide real-time access to all metering and device data available for each monitored device.
2. Installation:
   a. Each SDU shall be installed by the switchgear manufacturer as indicated in the project drawings.

b. Each SDU shall be flush mounted in switchgear or large power panelboard door panels as indicated.

3. Characteristics:
   a. Each SDU shall access and display the data available from selected circuit monitors and circuit breaker interface modules connected to an individual data transfer network.
   b. Each SDU shall utilize a 4 line by 20 character, high contrast, backlit liquid crystal display (LCD) to provide high reliability and readability in all lighting conditions.
   c. Backlighting and contrast levels shall be adjustable.
4. Keypad:
   a. Each SDU shall allow for easy operation by providing a keypad with large keys for operator selections.
   b. Each key shall have a raised perimeter and tactile feedback to ensure a positive response even with gloved hand operation.
   c. The keys shall be clearly marked to indicate function and shall be separated into meaningful groups with display prompts to aid operator selections.
5. Configuration:
   a. Each SDU shall be configured by the manufacturer with all necessary data, such as CT ratios, PT ratios, device nameplates, demand alarm setpoints, etc., as required for proper operation.
   b. It shall be possible to modify the SDU configuration using the integral keypad. This capability shall be password-protected to prevent unauthorized modifications.
6. Data Viewing:
   a. All data, except the captured waveforms, shall be accessible from the SDU.
   b. Data shall be displayed in a logically organized form, complete with proper scalings and units.
   c. It shall be possible to sequentially view all available data from a selected circuit monitor or circuit breaker interface module by single keystroke advancing through the various display pages.
   d. It shall be possible to view the same data from multiple circuit monitors or circuit breaker interface modules by single keystroke advancing from monitor to monitor or module to module.
7. Display Reset:
   a. The SDU shall permit the reset of minimum-maximum values, accumulated energy values and time-and-date stamps stored in the circuit monitors. This capability shall be password-protected to prevent unauthorized access.

D. Circuit Breaker Interface Modules (CIM):
1. Description:
   a. Each CIM shall be capable of monitoring the following data, for local and remote display, without the need for additional instrument transformers or metering equipment:
      1) Current, per phase RMS.
      2) Historical trip data, including time-and-date stamps.
      3) Circuit breaker trip settings.
2. Characteristics:
   a. Each CIM shall provide removable terminal plugs for connection of up to eight solid-state trip circuit breakers.
   b. Each solid-state trip circuit breaker shall be wired to a communications adapter, which is then wired to the CIM.
   c. Each CIM shall contain a removable RS485 communications terminal plug shall permit a "daisy- chain" connection to other circuit monitoring devices.
   d. Each CIM shall be capable of reporting the following information (as a minimum):
      1) Real-time current:
         a) True RMS current for each phase.
         b) Ground-fault current, if circuit breaker is equipped with ground-fault protection.

2) Historical data:
   a) Time and date of last trip.
   b) Cause of trip.
   c) Phase currents at trip.
   d) Ground-fault current at trip, if circuit breaker is so equipped.
   e) Number of overload trips.
   f) Number of ground-fault trips.
3) Circuit breaker data:
   a) Circuit breaker type.
   b) Sensor rating.
   c) Plug rating.
   d) Long time settings: Pickup and delay.
   e) Short time settings: Pickup and delay.
   f) Instantaneous settings.
   g) Ground-fault settings: Pickup and delay.

3. Provide CIM capacity for all distribution devices in each switchboard.

E. Power Monitoring System Network:
1. Network description:
   a. A high speed (62.5 Kbaud minimum) local area network shall link each equipment lineup and personal computer workstation, such that an integrated data communications network is formed.
2. General network information:
   a. The PMCS shall be connected by means of a future high speed, industrially proven LAN.
   b. The future high-speed network shall consist of network interface modules that allow display units, computers, programmable controllers, and other high level or sub-networks to access the electrical data being gathered by the electronic circuit monitors.
   c. The network speed shall be adjustable up to 500 Kbaud.
3. Network interface module:
   a. The network interface modules shall be modular in design to allow for easy future expansion or modification of the system.
   b. Each network interface module shall allow for the connection of at least 32 circuit monitors and one local system display unit or other network compatible devices such as controllers, computers, etc.
   c. It shall be possible to connect at least 100 network interface modules together on a single twin axial conductor (Belden 9463 or equivalent) of up to 15,000 FT in length to form the high speed power monitoring communications network.
4. Interface to other systems:
   a. The high-speed network utilized by the power monitoring system shall permit easy interface with the Building Automation System (BAS).
   b. All circuit monitor data, status of monitored switches, and PLC registers shall be made available to the BAS vendor via circuit monitor and/or programmable controller register lists.
   c. Software required by the BAS to retrieve this data from the power monitoring system data highway, shall be the responsibility of the BAS vendor.

F. Software:
1. Metering software shall connect to and interface with the existing Schneider Powerlogic Campus Power monitoring system.
2. Software description:
   a. The power monitoring system shall be supplied with application software suitable for operation on a personal computer workstation without additional programming.
   b. The power monitoring system application software shall display all metering quantities provided by the circuit monitor as specified herein.

c. The power monitoring system application software shall be capable of logging circuit monitor data to a printer/hard disk, capturing/storing/retrieving waveform data, and reporting energy alarm levels.
d. The power monitoring system software shall be user friendly such that operators can easily become familiar with the implementation.
e. All data shall be presented in a well organized, clear manner.

3. System monitoring (multiple devices at a time):
   a. The power monitoring system software shall be compatible with Microsoft Windows 3.x operating system. The software shall be designed to utilize Windows' multi-tasking capabilities and state-of-the-art graphics to provide circuit data from multiple devices at the same time.
   b. Instantaneous readings, demand readings, energy readings, and other circuit information contained in the circuit monitors shall be displayed by the power monitoring system software using real time and historical tables, bar charts, analog meters, waveform plots, or time trend plots.
   c. The power monitoring system software shall log circuit data from multiple circuits including instrumentation data, demand and energy data.
   d. The power monitoring system software shall support alarms (visual, audible, required acknowledgement) in the background, thereby indicating selected conditions when the user is running other applications.
   e. Events shall be recorded in an event log with the number of stored events user selectable.
   f. Report status of circuit monitor inputs/outputs, trip units, PLC registers, etc.
   g. Capture, display, and store phase voltage and current waveforms and the residual (neutral) current waveform.
   h. Provide harmonic information for each circuit waveform including total harmonic distortion (THD), RMS magnitudes, peak values, crest factors (CF), magnitudes of the individual harmonics, telephone interference factor (TIF), etc.
   i. The power monitoring system shall provide standard reports to simplify routine printouts of various data formats.
   j. The power monitoring system software shall provide a means of resetting accumulated real and reactive energy, energy management alarms, minimum and maximums, and other circuit quantities.
   k. The power monitoring software shall provide for setup and diagnostic operations, with all setup and reset operations password-protected to avoid accidental or unauthorized operation.
4. Advances system monitoring:
   a. Provide for creating custom tables to display circuit information and the ability to easily modify them as the need arises.
   b. The user shall be able to develop custom reports from the power monitoring system software to simplify routine printouts of both standard and custom display formats.
   c. The power monitoring system software shall include a macro language with a timer for executing a specified (scheduled) macro, such as printing a report, on a scheduled basis.
   d. The power monitoring system software shall allow the user to control various system operations from the personal computer with valid password entry, including the operation of circuit monitor outputs, contacts, contents of PLC registers, and other compatible devices.
5. Interactive color graphics:
   a. An interactive color graphics interface shall be provided with the power monitoring system software which allows real-time circuit information to be displayed on power system drawings, elevation drawings, process drawings, etc.
   b. It shall be possible to display any of the circuit quantities monitored by the PMCS software on the drawing without restriction to the number or replacement of the values.
   c. The software shall allow the user to zoom, scale, and scroll the drawings to the desired degree of magnification.

d. The interactive color graphics software shall be capable of displaying status of circuit breakers (open/ closed/tripped), transformer fans (on/off), power factor capacitors (on/off), and other system information using colors selected by the user.
e. From within any drawing, the user shall have the ability to display other drawings through simple selections allowing hierarchical access to successive drawings.
f. The interactive color graphics software shall allow the user to control various system operations (e.g., circuit monitor output contacts).

6. Waveform analysis software:
   a. Waveform analysis software shall be provided which can be used to analyze, organize and achieve waveform information that will be acquired using the power monitoring system.
   b. The software shall include provisions for spectrum plots, power spectral densities, FFT's, and other operations which aid in analyzing power quality in the system.
7. Spreadsheet interface:
   a. The power monitoring system shall be provided with software which directly places monitored circuit information into a Lotus-compatible spreadsheet.
   b. The software shall be capable of scheduled sampling of the circuit quantities.
   c. Logging of all real-time instrumentation data including currents, voltages, power factors, real power, reactive power, apparent power, demand currents, watthours, varhours shall be possible.
8. Provide all programming required to implement software features.

G. Programmable Logic Controllers:
   1. Provide programmable logic controls of same manufacturer as power monitoring system which can communicate with circuit monitors to extract required data for control operations.
   2. Each PLC shall include ladder programs which will direct the automatic control operations as specified.
   3. Processor, input, output and network interface cards shall be provided as necessary to implement sensing and automatic control operations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install components as indicated and in accordance with manufacturer's instructions and recommendations.

B. Power monitoring system components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

C. Provide wiring required to externally connect equipment lineups.

D. Interconnection wiring requirements shall be clearly identified on the power monitoring system drawings.

E. Provide 120 volt power connections to equipment from nearest emergency panelboard.

3.2 TESTING

A. Provide a representative of manufacturer to supervise startup and testing of system.

B. Testing to include a complete working demonstration of the power monitoring system with simulation of possible operating conditions which may be encountered.

C. Provide manufacturer's representative for 5 days of start-up assistance.

3.3 OWNER PERSONNEL TRAINING

A. Provide up to 32 HRS of on-site training for power monitoring system.

B. Training to include documentation and hands on exercises necessary to enable operations personnel to assume full operating responsibility for the power monitoring system after completion of training.

END OF SECTION

SECTION 26 09 23
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Line Voltage Control Devices.

B. Lighting Control System with Low Voltage Control Devices.

C. Furnish labor, materials, tools, equipment, and services for Networked Lighting Control System, as indicated, in accordance with provisions of Contract Documents.

D. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Provide wiring devices conforming to the following standards:
   1. Underwriter's Laboratories (UL).
      a. UL 20 – Standard for Safety for General-Use Snap Switches.
      b. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
      c. UL 508 – Standard for Industrial Control Equipment.
      d. UL 514D – Cover Plates for Flush-Mounted Wiring Devices.
      e. UL 916 – Standards for energy Management Equipment and Optional Labeling System for Modular Energy Management Construction.
      f. UL 924 – Emergency Lighting and Power Equipment.
      g. UL 1472 – Solid State Dimming Controls.
   2. National Electric Manufacturers Association (NEMA).
      a. WD-1 – General Color Requirements for Wiring Devices.
      b. WD-6 – Wiring Devices – Dimensional Requirements.
      c. Enclosure Ratings.
   3. US Federal Specifications.
      a. Fed Spec switches (WS-896E).
      b. Fed Spec device plates (W-P-455).
      c. FCC Emissions Standards, and telephone override systems compliant with standards in Part 68.

B. Drawings are schematic based on the design standard products. Product substitutions may result in device changes but shall not result in performance changes. Lighting control devices and locations must be coordinated with all building and electrical components, including ballasts, drivers and interfaced control systems prior to submission of shop drawings

1.3 SYSTEM DESCRIPTION

A. This specification is intended to fully describe design, engineering, programming, hardware, software, ancillary devices and associated technical services required to provide a building-wide networked lighting control system.

B. Networked Lighting Control System is specified to perform scheduled and automated lighting control sequences.

C. Networked Lighting Control System includes but is not limited to the following components:
   1. Wallstations.
   2. LCD touch screen panel.
   3. Occupancy sensors.
   4. Photo sensors.
   5. Daylight compensating lighting controls.

6. Control modules.
7. Area lighting controllers.
8. Relay-based lighting control panels.
9. System server.
10. Lighting control system software – graphical user interface-based.
11. Communication wire.
12. Interface to BACnet.
13. Interface to Building Automation System.
14. Interface to audio-visual equipment.

D. The system shall perform, at a minimum, the following functions:
   1. Occupancy Sensing.
      a. The capability to affect the operation of lighting or other equipment based upon detecting the presence or absence of people in a space.
   2. Daylight Harvesting.
      a. The capability to automatically affect the operation of lighting or other equipment based on the amount of daylight and/or ambient light that is present in a space.
   3. High-End Trim (also known as Task-Tuning).
      a. The capability to set the maximum light output of an individual or group of luminaires at the time of installation and/or commissioning. The high-end trim feature must be field configurable.
   4. Zoning.
      a. The capability to group luminaires and form unique lighting control zones for a control strategy. Zoning is required for occupancy sensing, high-end trim, and daylight harvesting control strategies.
   5. Device Addressability.
   6. Continuous Dimming.
      a. The capability of the control system to provide control with sufficient resolution (100+ steps) to support light level changes perceived as smooth (as opposed to step dimming with a limited number of discrete levels).
   7. User interface.
      a. The interface used by the control system shall read and adjust settings during system start-up, commissioning, and/or ongoing operation.
   8. Localized Processing / Distributed Intelligence.
      a. The capability of sensors and luminaires to execute pre-programmed energy saving strategies in the absence of (resulting from either a loss of network connection or failure) a gateway or central processor.
   9. Scheduling.
      a. The ability to affect the operation of lighting and/or other equipment based on time of day or astronomical event.
   10. Personal Control.
      a. The capability for individual users to adjust the illuminated environment to their personal preferences within a space.
   11. Load Shedding (Demand Response).
      a. The ability to reduce the energy consumption of a lighting system, in a pre-defined way, on a temporary basis, in response to a demand response signal.
   12. Other Building Systems Integration.
      a. The ability to exchange data with other building systems such as Building or Energy Management Systems (BAS/EMS), Heating Ventilation and Air Conditioning (HVAC) Systems, or other lighting systems.
   13. Device Monitoring / Remote Diagnostics.
      a. The ability to monitor, diagnose, and report operational performance including system and/or component failures.
   14. System will provide end-of-life monitoring for LED luminaires.
      a. For each control relay, the system shall be programmed with the published L80 life of the LED luminaires connected.

b. Operating hours for each relay shall be logged. When operating hours reach programmed life, system shall generate an “End of Lamp Life” alarm.

c. For areas with Lumen Maintenance Controls:

1) Control system shall be programmed to dim lights to 80 percent of initial output.

2) Control system shall record the photocell reading at this level as the target maintained setpoint for the lumen maintenance system.

3) When system is unable to achieve the target setpoint, an “End of Lamp Life” alarm shall be generated.

E. Related Information:

1. Division 12 Section "Roller Shades" for shades controlled by network dimming control system.
2. Division 25 Section "Building Automation System (BAS)" for software and integration hardware for network lighting controls.
3. Division 26 Section "Electrical General Requirements".
4. Division 26 Section "Wiring Devices".
5. Division 26 Section "Building Lighting" for luminaires controlled by lighting control systems.
6. Division 26 Section “Site Lighting” for luminaires controlled by lighting control system.
7. Division 27 Section "Communications Horizontal Cabling" for communications cabling requirements for network power switching systems.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualification:

1. Manufacturer of network lighting controls and lighting management software with minimum five (5) years satisfactory manufacturing and support of components comparable to basis of design system.

B. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code

C. Underwriters Laboratories (UL):

1. UL 20 Plug Load Controls
2. UL 508 Industrial Control Equipment
3. UL 916 Energy Management Equipment
4. UL 924 Emergency Lighting

D. Project Conditions:

1. Environmental Conditions Range.

a. Temperature: 32 – 104 DEGF.

b. Relative Humidity: 10 – 90 PCT, noncondensing.

E. LEED Requirements:

1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

F. ABBREVIATIONS

1.
2. AV: Audio Video.

1.5 SUBMITTALS

A. Shop Drawings:

1. Make all lighting control submittals at one time following light fixture, lamp / module and ballast / driver approvals. Partial submittals will not be accepted.
2. Control devices must be coordinated with approved dimming ballasts and LED drivers prior to submission. Control devices cannot receive final approval without approved dimming ballasts and LED drivers.
3. Include an itemized list of any deviations from contract documents.

4. Prior to submittal of Shop Drawings, manufacturer shall arrange teleconference call with Lighting Designer to ensure intent of Designer will be met by system being proposed by manufacturer.
5. Composite wiring, schematic diagram, or both, of each control circuit as proposed for installation.
6. Show location of digital devices, including at minimum sensors, load controllers, and switches for each area on lighting plans.
   a. Properly identify every system component with exact nomenclature indicated for that device on Drawings, and every component shall be labelled with corresponding room number.
   b. Provide a schedule of every control station indicating correct pushbutton engraving.
   c. Manufacturer shall confirm locations for all occupancy sensors shown on lighting plans. It is the responsibility of the manufacturer to assure complete coverage for each area and adjust location and quantity of sensors as required. Alterations and/or additions to plan documents must be submitted with shop drawings.
   d. Manufacturer shall confirm locations for all photocells shown on lighting and reflected ceiling plans. It is the responsibility of the manufacturer to assure proper placement based on the sensing technology utilized and adjust location and quantity of sensors as required.
7. Lighting Control System Schedules:
   a. Include actual connect load, load type, voltage, panelboard and circuit identification, sequence of operation, and control device identifications.
   b. Identify any deviations from contract documents.
   c. For photocell activated operation, indicate the location and illumination level that will trigger operation. Where photocells are used for daylight harvesting or lumen maintenance, indicate the location and illumination level that will be maintained.
   d. Describe how each control module will be controlled upon initial start-up.
   e. Describe how each pre-set scene will be programmed.
8. Provide details including products and sequence of operation for each room or area and illustrate typical acceptable room or area connection topologies.
9. Network riser diagram including building levels indicated. Include network cable specification and end-of-line termination details, if required. Illustrate points of connection to integrated systems.
10. Circuits and emergency circuits with capacity and phase, control zones, load type and voltage per circuit.

B. Product Data:
   1. Manufacturers literature demonstrating compliance with requirements for each type of product required for complete distributed lighting control system.

C. Contract Closeout Information:
   1. Operating and Maintenance Data.

D. See Section 01 78 23.
   1. Load Measurement Report:
      a. Submit field test report of completed installation.
   2. Project Record Documents.
      a. See Section 01 78 39.
   3. Warranty.
      a. See Section 01 78 36.

1.6 WARRANTY

A. Manufacturer's warranty agreeing to repair or replace components of lighting controls system that fail in materials or workmanship within specified warranty period following substantial completion.
   1. Warranty Period: Five (5) years.
   2. Software and firmware updates and onsite software and firmware support: Five (5) years.

3. Technical hotline support: Unlimited.
4. Response time for on-site system maintenance: 24 HRS.

B. Manufacturer's Extended Support and Maintenance Program:
1. Provide proposal for manufacturer's renewable extended support and maintenance program to consist of the following:
   a. Parts and labor required for system maintenance.
   b. Remote diagnostics and programming support.
   c. On-site maintenance visit to provide preventive maintenance, staff training, and limited re-programming.
   d. Software and firmware updates.

PART 2 - PRODUCTS

2.1 LINE VOLTAGE CONTROL DEVICES

A. Toggle Switches:
1. Base Design Standard Manufacturer:
   a. Single-pole: Leviton 1221-2.
   b. Double-pole: Leviton 1222-2.
   c. Three-way: Leviton 1223-2.
   d. Four-way: Leviton 1224-2.
   e. Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
2. Acceptable Alternate Manufacturers:
   a. Hubbell.
   b. Cooper.
   c. Pass & Seymour.
3. Description: Specification grade, quiet-operating toggle-type with back and side wiring, 120-277 volts, AC only, 20 amp.
   a. Switches shall be listed per UL 20 and certified by UL to Federal Specification WS-896E, and shall be visibly marked "Fed Spec WS-896".
   b. All switches shall be equipped with a green grounding terminal.
4. Use white devices for "normal" circuits.
5. Use red devices for "emergency" and "critical" circuits.
6. Provide brushed stainless steel cover plates. Gang devices wherever possible; provide wall box wiring barriers between different voltages or emergency wiring.
7. Refer to symbol legend for modifications.

B. Wall-box Dimming Switches:
1. Performance:
   a. Dimmers shall provide full-range, continuously variable control of light intensity of incandescent, electronic low voltage, magnetic low voltage, 0-10V fluorescent and LED loads.
   b. Slider shall be captured behind an approximately 1 IN wide faceplate opening with a vertical linear-slide. Controls shall be thin profile with no exposed heat sink/yoke.
   c. "Slide-to-OFF" controllers shall use the vertical slider to dim light and switch off.
   d. “Preset Dimming” controllers shall use the vertical slider to dim and a push button on the dimming switch shall provide the on/off function independent of the dimmer slider position.
   e. Control ON / OFF function must be accomplished utilizing a mechanical air-gap switch to totally disconnect power from the load during OFF condition, and no leakage current shall be present at the fixture(s). Controls shall meet the applicable requirements of UL 20 and UL 1472 referring to the inclusion of a visible, accessible air-gap off switch and the limited short circuit test.

f. Operation at rated capacity shall be possible across the full ambient temperature range (0°C (32°F) to 40°C (104°F)), without shortening design lifetime. This includes modified capacities for ganging configurations which require the removal of fins.
g. Dimmer shall provide smooth and continuous Square Law dimming curve, for the full slider travel, on their rated load.
h. Controls shall meet ANSI/IEEE Std. C62.41-1980, tested to withstand voltage surges of up to 6000V and current surges of up to 200A without damage.
i. Dimmer shall include voltage compensation to compensate light output for variation in the AC line-voltage.
j. 3-way controls shall be connected using conventional 3-way and 4-way wire runs and toggle switches.
k. Provide five year product warranty.
l. Provide gray finish.
m. Provide stainless steel faceplate as required. Gang switches wherever possible; consult manufacturer's recommendations for removal of fins and derating required when ganging.

2. Incandescent Dimmers:
   a. Base, design standard: Leviton "IllumaTech Slide Dimmers"
      1) IPI06-1LZ– 600 watt capacity
      2) IPI10-1LX– 1000 watt capacity
      3) Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
      4) Optional acceptable alternate manufacturers: Hubbell, Cooper, Pass & Seymour.
      5) Use to control incandescent and 120V halogen loads.
   b. Dimmers shall have an adjustable high-end trim set to 90% of line voltage, unless otherwise noted.

C. Wall Box Vacancy Sensors:
1. Passive Infrared Vacancy Sensors:
   a. Base, design standard: Watt Stopper PW-101; PW-103 (multi-way). Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
   b. Optional acceptable alternate manufacturers:
      1) Hubbell Building Automation
      2) Acuity Sensor Switch
   c. Rating: 800W at 120V, 1200W at 277V, 50/60Hz.
   d. Infrared coverage: 525 SQFT Minor motion range shall extend 20 FT perpendicular and 7 FT parallel to device.
   e. Manual operation switches on and off; occupancy sensor switches off after adjustable time delay.
   f. Time delay shall be factory set at 20 minutes. Optional adjustments shall include 5 minute intervals from 5 minutes to 30 minutes as well as a test mode setting.
   g. Device shall include adjustable sensitivity settings, with factory default to "high".
   h. Device shall have audible alert prior to sensing off. Audible alert setting shall be able to be turned off in field.
   i. Provide gray finish.
2. Double Switch PIR Vacancy Sensors:
   a. Base, design standard: Watt Stopper PW-200; PW-203 (Multi-way). Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
   b. Optional acceptable alternate manufacturers:
      1) Leviton
      2) Hubbell Building Automation
      3) Acuity Sensor Switch
   c. Rating: 800W at 120V, 1200W at 277V, 50/60Hz.

d. Infrared coverage: 525 SQFT Minor motion range shall extend 20 ft perpendicular and 7 ft parallel to device.
e. Manual operation switches on and off; occupancy sensor switches off after adjustable time delay.
f. Time delay shall be factory set at 20 minutes. Optional adjustments shall include 5 minute intervals from 5 minutes to 30 minutes as well as a test mode setting.
g. Device shall include adjustable sensitivity settings, with factory default to “high”.
h. Device shall have audible alert prior to sensing off. Audible alert setting shall be able to be turned off in field.
i. Provide gray finish

3. Ultrasonic Vacancy Sensors:
   a. Base, design standard: Watt Stopper UW-100. Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
   b. Optional acceptable alternate manufacturers:
      1) Hubbell
      2) Acuity Sensor Switch
   c. Rating: 800W at 120V, 1200W at 277V, 50/60Hz.
   d. Infrared coverage: 225 SQFT Minor motion range shall extend 15 ft perpendicular and 7 ft parallel to device.
   e. Manual operation switches on and off; occupancy sensor switches off after adjustable time delay.
   f. Time delay shall be factory set at 20 minutes. Optional adjustments shall include 5 minute intervals from 5 minutes to 30 minutes as well as a test mode setting.
   g. Device shall have audible alert prior to sensing off. Audible alert setting shall be able to be turned off in field.
   h. Provide gray finish.
4. Vacancy Sensing 0-10V Dimming Switch:
   a. Base, design standard: Leviton Building Automation LHD-IRS-3-N-GY-M. Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
   b. Rating: 800W at 120V, 1800W at 277V, 50/60Hz.
   c. Infrared coverage: 1,000 SQFT.
   d. Manual operation button switches on and off; Raise and Lower buttons control dimming; occupancy sensor switches off after adjustable time delay.
   e. Time delay shall be factory set at 15 minutes. Optional adjustments shall include 4, 8 and 30 minute intervals.
   f. Device shall include integral daylight harvesting photocell. Range of photocell is 10-500 footcandles. Factory set light level override to 75 footcandles.

D. Ceiling Mounted Occupancy Sensors:
1. Ultrasonic Occupancy Sensor:
   a. Base, design standard:
      1) Wattstopper UT-355-1 (500 sq ft)
      2) Wattstopper UT-355-2 (1000 sq ft)
      3) Wattstopper UT-355-3 (2000 sq ft)
      4) Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
   b. Optional acceptable alternate manufacturers:
      1) Hubbell Building Automation
      2) Acuity Sensor Switch
   c. Rating: 800W at 120V, 1200W at 277V, 50/60Hz.
   d. Device utilizes ultrasonic technology to detect occupancy.
   e. Device cannot be mounted greater than 10 ft above finished floor.
   f. Time delay shall be set to 20 minutes. Optional adjustments shall include 5 minute intervals from 5 minutes to 30 minutes as well as 30 seconds.
   g. Provide white finish.

2. Passive Infrared Occupancy Sensor:
    a. Base, design standard:
        1) Wattstopper CI-355-1 (500 sq ft)
        2) Wattstopper CI-355 (1200 sq ft)
        3) Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
    b. Optional acceptable alternate manufacturers:
        1) Hubbell Building Automation
        2) Acuity Sensor Switch
    c. Rating: 800W at 120V, 1200W at 277V, 50/60Hz.
    d. Device utilizes passive infrared technology. Sensitivity shall be maximized.
    e. Time delay shall be set to 20 minutes. Optional adjustments shall include 5 minute intervals from 5 minutes to 30 minutes as well as 30 seconds.
    f. Provide white finish.
3. Dual Technology Occupancy Sensor:
    a. Base, design standard:
        1) Wattstopper DT-355 (1000 sq ft)
        2) Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
    b. Optional acceptable alternate manufacturers:
        1) Hubbell Building Automation
        2) Acuity Sensor Switch
    c. Rating: 800W at 120V, 1200W at 277V, 50/60Hz.
    d. Device utilizes both ultrasonic and passive infrared technology. PIR sensitivity shall be maximized.
    e. Either technology can trigger activation. Both technologies must fail to detect occupancy before lights turn off.
    f. Time delay shall be set to 20 minutes. Optional adjustments shall include 5 minute intervals from 5 minutes to 30 minutes as well as 30 seconds.
    g. Provide white finish.

E. Daylight Sensing Switching System:
1. Base Design Standard:
    a. Daylight Control Module: Wattstopper LCO-203
    b. Photocell: Wattstopper LS-290C
    c. Power Pack: Wattstopper BT-203
    d. Wall Switch: Wattstopper LS-3C
    e. All components must be provided by the same manufacturer.
    f. Use catalog numbers as a guide only. Follow descriptions, modifications and other requirements shown or specified.
    g. Optional acceptable alternate manufacturers are: Acuity Sensor Switch and Hubbell Building Automation
2. The daylighting control system shall be an open loop system. It shall consist of a control module, a power pack, and an external photocell
3. The daylighting control module shall provide ON/OFF switching of interior lighting.
4. The daylighting control module shall be capable of switching lighting for up to three control channels utilizing a single photocell.
5. The system shall utilize a line voltage power pack. Power pack shall be universal voltage. It shall connect to the control module via a quick connect cable. It shall contain three individual relays to correspond to the three control channels in the control module
6. The photocell shall measure incoming daylight and shall be a round, low-profile sensor suitable for ceiling mounting. The photocell shall read from 3 footcandles to 60,000 footcandles. Wiring for photocells shall be low voltage.
7. In order to ensure that lighting levels in each zone are balanced, the control module shall provide separately adjustable settings for each control channel. Each channel shall have its own adjustable setpoint, deadband, ON delay, OFF delay, and load shed setpoint.

8. The daylighting control module and power pack shall be suitable for panel mounting on a DIN rail. All necessary adjustments and calibrations shall be made to the control module only; none shall be necessary at the photocell location.
9. The daylighting control module shall include an auxiliary override that responds to a control interlock signal from an occupancy sensor, time clock, or energy management system. When a control interlock signal is received, the module shall turn off all outputs, overriding any ON signal based on ambient light levels.
10. The daylighting control system shall include an optional low voltage wall switch. When activated by a user, the wall switch shall hold lighting at the user-designated level until the control module is returned to automatic control. The switch shall provide a push button that enables the resumption of automatic control.

2.2 LIGHTING CONTROL SYSTEM WITH LOW VOLTAGE CONTROL DEVICES

A. Networked lighting control system basis of design
   1. Legrand WattStopper.

B. Acceptable alternates:
   1. Acuity nLight.
   2. Hubbell Building Automation.

2.3 DIGITAL LIGHTING MANAGEMENT LOCAL NETWORK

A. The Digital Lighting Management (DLM) local network is a free topology lighting control physical connection and communication protocol.

B. DLM Local Network:
   1. Plug n' Go: Automatic configuration and binding of occupancy sensors, switches and lighting loads to most energy-efficient sequence of operation based upon device attached.
   2. Replacement of any device in local DLM network with standard off-the-shelf unit without requiring significant commissioning, configuration or setup.
   3. Push n' Learn: Configuration to change automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.

C. Digital Room Devices:
   1. Connect to local network using pre-terminated Cat 5e cables with RJ-45 connectors, to provide data and power to room devices.
      a. Systems utilizing RJ-45 patch cords but do not provide serial communication data from individual end devices are not acceptable.

D. If manufacturer's pre-terminated Cat5e cables are not used for the installation, the contractor is responsible for testing each cable following installation and supplying manufacturer with test results.

E. WattStopper Product Number: LMRJ-Series.

2.4 DIGITAL ROOM CONTROLLERS

A. Digital controllers for lighting loads automatically bind room loads to connected devices in the space without commissioning or use of tools. Provide room controllers to match room lighting control requirements. The controllers will not have dip switches or potentiometers, or require special configuration for standard Plug n' Go applications.

B. Control units will include following features:
   1. Automatic room configuration to most energy-efficient sequence of operation based upon the devices in the room.
   2. Simple replacement – Using default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf.

3. Multiple room controllers connected together in a local network must automatically arbitrate with each other, without requiring any configuration or setup, so that individual load numbers are sequentially assigned using each controller's device ID's from highest to lowest.
4. Device Status LEDs to indicate:
   a. Data transmission.
   b. Device has power.
   c. Status for each load.
   d. Configuration status.
5. Quick installation features:
   a. Standard junction box mounting.
   b. Quick low voltage connections using standard RJ-45 patch cable.
6. Based on individual configuration, each load shall be capable of following behavior on power up following the loss of normal power:
   a. Turn on to 100 PCT.
   b. Turn off.
   c. Turn on to last level.
7. Each load shall at a minimum be configurable to operate in following sequences based on occupancy:
   a. Auto-ON/Auto-OFF (Follow ON and OFF).
   b. Manual-ON/Auto-OFF (Follow OFF only).
8. The polarity of each load output shall be reversible, via digital configuration, so that on is off and off is on.
9. BACnet object information shall be available for following objects:
   a. Load status.
   b. Electrical current (when available).
   c. Total watts per controller.
   d. Schedule state – normal or after-hours.
   e. Demand response enable and disable.
   f. Room occupancy status.
   g. Total room lighting and plug loads watts.
   h. Total room watts/SQFT.
   i. Force on/off all loads.
10. UL 2043 plenum rated.
11. Manual override and LED indication for each load.
12. Dual voltage 120/277 VAC, 60 Hz, or 347 VAC, 60 Hz. 120/277 volt models rated for 20A total load, de-rating to 16A required for dimmed loads,
13. Zero cross circuitry for each load.
14. All digital parameter data programmed into an individual room controller or plug load controller shall be retained in non-volatile FLASH memory within the controller itself. Memory shall have an expected life of no less than 10 years.

C. ON/OFF Room Controllers:
   1. One or two relay configuration.
   2. Efficient 150 mA switching power supply.
   3. Three RJ-45 DLM local network ports with integral strain relief and dust cover.
   4. WattStopper product numbers: LMRC-101, LMRC-102.

D. ON/OFF/Dimming enhanced Room Controllers:
   1. Real time current monitoring.
   2. Multiple relay configurations.
      a. One, two or three relays, LMRC-21x series.
      b. One or two relays, LMRC-22x series.
   3. 250 mA switching power supply.
   4. Four RJ-45 DLM local network ports with integral strain relief and dust cover.

5. One dimming output per relay.
   a. 0-10V Dimming:
      1) Where indicated, one 0-10 volt analog output per relay for control of compatible ballasts and LED drivers.
      2) 0-10 volt output shall automatically open upon loss of power to Room Controller to assure full light output from controlled lighting.
      3) LMRC-21x series.
   b. Dimming output channel:
      1) Independently configurable minimum and maximum calibration trim level to set dimming range to match true dynamic range of connected ballast or driver.
   c. LED level indicators on bound dimming switches shall utilize maximum and minimum trim.
   d. Dimming output channel:
      1) Independently configurable minimum and maximum trim level to set dynamic range of output within 0-100 PCT dimming range defined by minimum and maximum calibration trim.
   e. Set calibration and trim levels per output channel.
      1) Devices that set calibration or trim levels per controller are not acceptable.
   f. Configuration:
      1) Digital.
      2) Devices that set calibration or trim levels per output channel via trim pots or dip-switches are not acceptable.
6. Each load shall have independently configurable preset on level for Normal Hours and After Hours events to allow different dimmed levels established at start of both Normal Hours and After Hours events.
7. Fade rates for dimming loads shall be specific to bound switch buttons, and load shall maintain default value for bound buttons that do not specify a unique value.
8. Following dimming attributes may be changed or selected using wireless configuration tool:
   a. Establish preset level for each load from 0-100 PCT.
   b. Set high and low trim for each load.
   c. Set lamp burn in time for each load up to 100 HRS.
9. Override button for each load provides following functions:
   a. Press and release for ON/OFF control.
   b. Press and hold for dimming control.
10. WattStopper product numbers: LMRC-211, LRMC-212, LRMC-213, LMRC-221, LMRC-222.

2.5 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR

A. Wall or ceiling mounted (to suit installation) passive infrared (PIR), ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor.

B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:
   1. Digital calibration and pushbutton configuration for the following variables:
      a. Sensitivity – 0-100 PCT in 10 PCT increments.
      b. Time delay – 1-30 minutes in 1 minute increments.
      c. Test mode – Five second time delay.
      d. Detection technology – Dual Technology activation and/or re-activation.
      e. Walk-through mode.
   2. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
   3. Programmable control functionality including:
      a. Each sensor may be programmed to control specific loads within a local network.
      b. Sensor shall be capable of activating one of 16 user-definable lighting scenes.

c. Adjustable retrigger time period for manual-on loads. Load will retrigger (turn ON) automatically within a configurable period of time (default 10 seconds) after turning OFF.
d. On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
1) Ultrasonic and Passive Infrared.
2) Ultrasonic or Passive Infrared.
3) Ultrasonic only.
4) Passive Infrared only.
e. Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.
4. One or two RJ-45 port(s) for connection to DLM local network.
5. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.
6. Device Status LEDs, which may be disabled for selected applications, including:
a. PIR detection.
b. Ultrasonic detection.
c. Configuration mode.
d. Load binding.
7. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.
8. Manual override of controlled loads.
9. All digital parameter data programmed into an individual occupancy sensor shall be retained in non-volatile FLASH memory within the sensor itself. Memory shall have an expected life of no less than 10 years.

C. BACnet object information shall be available for the following objects:
1. Detection state.
2. Occupancy sensor time delay.
3. Occupancy sensor sensitivity, PIR and Ultrasonic.

D. Units shall not have any dip switches or potentiometers for field settings.

E. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.

F. WattStopper product numbers: LMPX, LMDX, LMPC, LMUC, LMDC.

2.6 DIGITAL WALL SWITCH OCCUPANCY SENSORS

A. Wallbox mounted passive infrared PIR or dual technology (passive infrared and ultrasonic) digital occupancy sensor with 1 or 2 switch buttons.

B. Digital Occupancy Sensors shall provide scrolling LCD display for digital calibration and electronic documentation. Features include the following:
1. Digital calibration and pushbutton configuration for the following variables:
a. Sensitivity – 0-100 PCT in 10 PCT increments.
b. Time delay – 1-30 minutes in 1 minute increments.
c. Test mode – Five second time delay.
d. Detection technology – PIR, Dual Technology activation and/or re-activation.
e. Walk-through mode.
f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
2. Programmable control functionality including:
a. Each sensor may be programmed to control specific loads within a local network.
b. Sensor shall be capable of activating one of 16 user-definable lighting scenes.

c. Adjustable retrigger time period for manual-on loads. Load will retrigger (turn ON) automatically during the configurable period of time (default 10 seconds) after turning OFF.
d. On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
   1) Ultrasonic and Passive Infrared.
   2) Ultrasonic or Passive Infrared.
   3) Ultrasonic only.
   4) Passive Infrared only.

3. Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.
4. Two RJ-45 ports for connection to DLM local network.
5. Two-way infrared (IR) transceiver to allow remote programming through handheld configuration tool and control by remote personal controls.
6. Device Status LEDs including
   a. PIR detection.
   b. Ultrasonic detection.
   c. Configuration mode.
   d. Load binding.
7. Assignment of any occupancy sensor to a specific load within the room without wiring or special tools.
8. Assignment of local buttons to specific loads within the room without wiring or special tools.
9. Manual override of controlled loads.
10. All digital parameter data programmed into an individual wall switch sensor shall be retained in non-volatile FLASH memory within the wall switch sensor itself. Memory shall have an expected life of no less than 10 years.

C. BACnet object information shall be available for the following objects:
   1. Detection state.
   2. Occupancy sensor time delay.
   3. Occupancy sensor sensitivity, PIR and Ultrasonic.
   4. Button state.
   5. Switch lock control.
   6. Switch lock status.

D. Units shall not have any dip switches or potentiometers for field settings.

E. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.

F. Two-button wall switch occupancy sensors, when connected to a single relay dimming room or fixture controller, shall operate in the following sequence as a factory default:
   1. Left button:
      a. Press and release - Turn load ON.
      b. Press and hold - Raise dimming load.
   2. Right button:
      a. Press and release - Turn load OFF.
      b. Press and hold - Lower dimming load.

G. Low voltage momentary pushbuttons shall include the following features:
   1. Load/Scene Status LED on each switch button with the following characteristics:
      a. Bi-level LED.
      b. Dim locator level indicates power to switch.
      c. Bright status level indicates that load or scene is active.

2. The following button attributes may be changed or selected using a wireless configuration tool:
   a. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
   b. Individual button function may be configured to Toggle, ON only or OFF only.
   c. Individual scenes may be locked to prevent unauthorized change.
   d. Fade UP and Fade DOWN times for individual scenes may be adjusted from 0 seconds to 18 HRS.
   e. Ramp rate may be adjusted for each dimmer switch.
   f. Switch buttons may be bound to any load on any load controller or relay panel and are not load type dependent; each button may be bound to multiple loads.
   g. WattStopper part numbers: LMPW, LMDW.

2.7 DIGITAL WALL SWITCHES

A. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration. Wall switches shall include the following features:
   1. Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
   2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
   3. Configuration LED on each switch that blinks to indicate data transmission.
   4. Load/Scene Status LED on each switch button with the following characteristics:
      a. Bi-level LED.
      b. Dim locator level indicates power to switch.
      c. Bright status level indicates that load or scene is active.
      d. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.
   5. Programmable control functionality including:
      a. Button priority may be configured to any BACnet priority level, from 1-16, corresponding to networked operation allowing local actions to utilize life safety priority.
      b. Scene patterns may be saved to any button other than dimming rockers. Once set, buttons may be digitally locked to prevent overwriting of the preset levels.
   6. All digital parameter data programmed into an individual wall switch shall be retained in non-volatile FLASH memory within the wall switch itself. Memory shall have an expected life of no less than 10 years.

B. BACnet object information shall be available for the following objects:
   1. Button state.
   2. Switch lock control.
   3. Switch lock status.

C. Two RJ-45 ports for connection to DLM local network.

D. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration shall be required to achieve multi-way switching.

E. The following switch attributes may be changed or selected using a wireless configuration tool:
   1. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
      a. Individual button function may be configured to Toggle, ON only or OFF only.
      b. Individual scenes may be locked to prevent unauthorized change.
      c. Fade UP and Fade DOWN times for individual scenes may be adjusted from 0 seconds to 18 HRS.
      d. Ramp rate may be adjusted for each dimmer switch.
      e. Switch buttons may be bound to any load on any load controller or relay panel and are not load type dependent; each button may be bound to multiple loads.

F. WattStopper product numbers: LMSW-101, LMSW-102, LMSW-103, LMSW-104, LMSW-105, LMSW-108 and LMDM-101, all compatible with wall plates with decorator opening.

2.8 DIGITAL DAYLIGHTING SENSORS

A. Digital daylighting sensors shall work with load controllers and relay panels to provide automatic switching capabilities for any load type connected to the controller or panel. Daylighting sensors shall be interchangeable without the need for rewiring.
   1. Closed loop sensors measure the ambient light in the space and control a single lighting zone.

B. Digital daylighting sensors shall include the following features:
   1. The sensor's internal photodiode shall only measure lightwaves within the visible spectrum. The photodiode's spectral response curve shall closely match the entire photopic curve. The photodiode shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5 PCT for any wavelengths less than 400 nanometers or greater than 700 nanometers.
   2. Sensor light level range shall be from 1-6,553 FTcandles (fc).
   3. The capability of ON/OFF for each controlled zone, depending on the selection of load controller(s) and load binding to controller(s).
   4. For switching daylight harvesting, the photosensor shall provide a field-selectable deadband, or a separation, between the "ON Setpoint" and the "OFF Setpoint" that will prevent the lights from cycling excessively after they turn off.
   5. For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights OFF or dimming lights to a field-selectable minimum level.
   6. Photosensors shall have a digital, independently configurable fade rate for both increasing and decreasing light level in units of percent per second.
   7. Photosensors shall provide adjustable cut-off time. Cut-off time is defined by the number of selected minutes the load is at the minimum output before the load turns OFF. Selectable range between 0-240 minutes including option to never cut-off.
   8. The digital wall switch in the space shall allow occupants to override the photosensor by reducing the lighting level to increase energy savings or, if desired, by raising lighting levels for a selectable period of time or cycle of occupancy.
   9. Integral infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool, and for communication with personal remote controls.
   10. Configuration LED status light on device that blinks to indicate data transmission.
   11. Status LED indicates test mode, override mode and load binding.
   12. Recessed switch on device to turn controlled load(s) ON and OFF.
   13. BACnet object information shall be available for the following daylighting sensor objects, based on the specific photocell's settings:
       a. Light level.
       b. Day and night setpoints.
       c. OFF time delay.
       d. ON and OFF setpoints.
       e. Up to three zone setpoints.
       f. ON/OFF operating mode.
   14. One RJ-45 port for connection to DLM local network.
   15. A choice of accessories to accommodate multiple mounting methods and building materials. The photosensors may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox. Standard tube photosensors accommodate mounting materials from 0-0.62 IN thickness (LMLS-500). Extended tube photosensors accommodate mounting materials from 0.62 IN-1.25 IN thickness (LMLS-500-L). Mounting brackets are compatible with J boxes (LMLS-MB1) and wall mounting (LMLS-MB2).
   16. Any load or group of loads in the room can be assigned to a daylighting zone.

17. Each load within a daylighting zone can be individually enabled or disabled for discrete control (load independence).
18. All digital parameter data programmed into a photosensor shall be retained in non-volatile FLASH memory within the photosensor itself. Memory shall have an expected life of no less than 10 years.

C. Open loop digital photosensors shall include the following additional features:
   a. An internal photodiode that measures light in a 60-degree angle (cutting off the unwanted light from the interior of the room).
   b. Automatically establishes application-specific setpoints following manual calibration using a wireless configuration tool or a PC with appropriate software. For switching operation, an adequate deadband between the ON and OFF setpoints for each zone shall prevent the lights from cycling; for dimming operation, a proportional control algorithm shall maintain the design lighting level in each zone.
   c. Each of the three discrete daylight zones can include any non overlapping group of loads in the room.
   d. WattStopper Product Number: LMLS-500.

D. Closed loop digital photosensors shall include the following additional features:
   1. An internal photodiode that measures light in a 100-degree angle, cutting off the unwanted light from bright sources outside of this cone.
   2. Automatic self-calibration, initiated from the photosensor, a wireless configuration tool or a PC with appropriate software.
   3. Automatically establishes application-specific setpoints following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of loads.
   4. WattStopper Product Number: LMLS-400, LMLS-400-L.

E. Dual loop digital photosensors shall include the following additional features:
   1. Close loop portion of dual loop device must have an internal photodiode that measures light in a 100 degree angle, cutting off the unwanted light from sources outside of this con
   2. Open loop portion of dual loop device must have an internal photodiode that can measure light in a 60 degree angle, cutting off the unwanted light from the interior of the room.
   3. Automatically establishes application-specific set-points following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of load.
   4. Device must reference closed loop photosensor information as a base line reference. The device must be able to analyze the open loop photosensor information to determine if an adjustment in light levels is required.
   5. Device must be able to automatically commission setpoints each night to provide adjustments to electrical lighting based on changes in overall lighting in the space due to changes in reflectance within the space or changes to daylight contribution based on seasonal changes.
   6. Device must include extendable mounting arm to properly position sensor within a skylight well.
   7. WattStopper product number LMLS-600.

2.9 DIGITAL LIGHTING MANAGEMENT SEGMENT NETWORK

A. The segment network shall be a linear topology, BACnet-based MS/TP subnet to connect DLM local networks (rooms) and LMCP relay panels for centralized control.
   1. Each connected DLM local network shall include a single network bridge (LMBC-300), and the network bridge is the only room-based device that is connected to the segment network.
   2. Network bridges, relay panels and segment managers shall include terminal blocks, with provisions for separate “in” and “out” terminations, for segment network connections.

3. The segment network shall utilize 1.5 twisted pair, shielded, cable supplied by the lighting control manufacturer. The maximum cable run for each segment is 4,000 FT. Conductor-to-conductor capacitance of the twisted pair shall be less than 30 pf/FT and have a characteristic impedance of 120 Ohms.
4. Network signal integrity requires that each conductor and ground wire be correctly terminated at every connected device.
5. Substitution of manufacturer-supplied cable must be pre-approved: Manufacturer will not certify network reliability, and reserves the right to void warranty, if non-approved cable is installed, and if terminations are not completed according to manufacturer's specific requirements.
6. Segment networks shall be capable of connecting to BACnet-compliant BAS (provided by others) either directly, via MS/TP, or through NB-ROUTERs, via BACnet/IP or BACnet/Ethernet. Systems whose room-connected network infrastructure require gateway devices to provide BACnet data to a BAS are unacceptable.

B. WattStopper Product Number: LM-MSTP, LM-MSTP-DB.

2.10 NETWORK BRIDGE

A. The network bridge module connects a DLM local network to a BACnet-compliant segment network for communication between rooms, relay panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication and an optically isolated EIA/TIA RS-485 transceiver.
1. The network bridge shall be provided as a separate module connected on the local network through an available RJ-45 port.
2. Provide Plug n' Go operation to automatically discover room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.
3. The network bridge shall automatically create standard BACnet objects for selected DLM devices to allow any BACnet-compliant BAS to include lighting control and power monitoring features as provided by the DLM devices on each local network. BACnet objects will be created for the addition or replacement of any given DLM device for the installed life of the system. Products requiring that an application-specific point database be loaded to create or map BACnet objects are not acceptable. Systems not capable of providing BACnet data for control devices via a dedicated BACnet Device ID and physical MS/TP termination per room are not acceptable. Standard BACnet objects shall be provided as follows:
   a. Read/write the normal or after hours schedule state for the room.
   b. Read the detection state of each occupancy sensor.
   c. Read the aggregate occupancy state of the room.
   d. Read/write the ON/OFF state of loads.
   e. Read/write the dimmed light level of loads.
   f. Read the button states of switches.
   g. Read total current in amps, and total power in watts through the load controller.
   h. Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings.
   i. Activate a preset scene for the room.
   j. Read/write daylight sensor fade time and day and night setpoints.
   k. Read the current light level, in footcandles, from interior and exterior photosensors and photocells.
   l. Set daylight sensor operating mode.
   m. Read/write wall switch lock status.
   n. Read watts per square foot for the entire controlled room.
   o. Write maximum light level per load for demand response mode.

p. Read/write activation of demand response mode for the room.
q. Activate/restore demand response mode for the room.

B. WattStopper product numbers: LMBC-300.

2.11 LMCP LIGHTING CONTROL PANELS AND LMZC ZONE CONTROLLER

A. Hardware:
1. Provide LMCP lighting control panels in the locations and capacities as indicated on the plans and schedules. Each panel shall be of modular construction and consist of the following components:
   a. Enclosure/Tub shall be NEMA 1, sized to accept an interior with 1 - 8 relays, 1 - 24 relays and 6 four-pole contactors, or 1 - 48 relays and 6 four-pole contactors.
   b. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans. LMCP panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.
   c. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide total isolation of high voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel. The interior assembly shall include intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. The panel interiors shall include the following features:
      1) Removable, plug-in terminal blocks with connections for all low voltage terminations.
      2) Individual terminal block, override pushbutton, and LED status light for each relay.
      3) Direct wired switch inputs associated with each relay shall support 2-wire momentary switches only.
      4) Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches; digital IO modules capable of receiving 0-5V or 0-10V analog photocell inputs; digital IO modules capable of receiving momentary or maintained contact closure inputs or analog sensor inputs; digital daylighting sensors; and digital occupancy sensors. Inputs are divided into two separate digital networks, each capable of supplying 250mA to connected devices.
      5) True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems via BACnet.
      6) Automatically sequenced operation of relays to reduce impact on the electrical distribution system when large loads are controlled simultaneously.
      7) Group and pattern control of relays shall be provided through a simple keypad interface from a handheld IR programmer. Any set of relays can be associated with a group for direct on/off control or pattern (scene) control via a simple programming sequence using the relay override pushbuttons and LED displays for groups 1-8 or a handheld IR programmer for groups 1-99.
      8) Relay group status for shall be provided through LED indicators for groups 1-8 and via BACnet for groups 1-99. A solid LED indicates that the last group action called for an ON state and relays in the group are on or in a mixed state.
   d. Single-pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:
      1) Electrical:
         a) 30 amp ballast at 277V.
         b) 20 amp ballast at 347V.
         c) 20amp tungsten at 120V.
         d) 30 amp resistive at 347V.
         e) 1.5 HP motor at 120V.
         f) 14,000 amp short circuit current rating (SCCR) at 347V.
         g) Relays shall be specifically UL 20 listed for control of plug-loads.

2) Mechanical:
    a) Replaceable, 1/2 IN KO mounting with removable Class 2 wire harness.
    b) Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel.
    c) Dual line and load terminals each support two #14 - #12 solid or stranded conductors.
    d) Tested to 300,000 mechanical ON/OFF cycles.

e. Isolated low voltage contacts provide for true relay status feedback and pilot light indication.

f. Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.

g. Where indicated, lighting control panels designated for control of emergency lighting shall be provided with factory installed provision for automatic by pass of relays controlling emergency circuits upon loss of normal power. Panels shall be properly listed and labeled for use on emergency lighting circuits and shall meet the requirements of UL924 and NFPA 70 - Article 700.

h. Integral system clock shall provide scheduling capabilities for panel-only projects without DLM segment networks or BAS control.
    1) Each panel shall include digital clock capability able to issue system wide automation commands to up to (11) eleven other panels for a total of (12) twelve networked lighting control panels. The clock shall provide capability for up to 254 independent schedule events per panel for each of the ninety-nine system wide channel groups.
    2) The clock capability of each panel shall support the time-based energy saving requirements of applicable local energy codes.
    3) The clock module shall provide astronomic capabilities, time delays, blink warning, daylight savings, and holiday functions and will include a battery back up for the clock function and program retention in non-volatile FLASH memory. Clocks that require multiple events to meet local code lighting shut off requirements shall not be allowed.
    4) The clock capability of each panel shall operate on a basis of ON/OFF or Normal Hours/After Hours messages to automation groups that implement pre-configured control scenarios. Scenarios shall include:
        a) Scheduled ON / OFF.
        b) Manual ON / Scheduled OFF.
        c) Astro ON / OFF (or Photo ON / OFF).
        d) Astro and Schedule ON / OFF (or Photo and Schedule ON / OFF).
    5) The user interface shall be a portable IR handheld remote control capable of programming any panel in the system (LMCT-100).
    6) The clock capability of each panel shall employ non-volatile memory and shall retain user programming and time for a minimum of 10 years.
    7) Schedules programmed into the clock of any one panel shall be capable of executing panel local schedule or Dark/Light (photocell or Astro) events for that panel in the event that global network communication is lost.

i. The lighting control panel can operate as a stand-alone system, or can support schedule, group, and photocell control functions, as configured in a Segment Manager controller, via a segment network connection.

j. The lighting control panel shall support digital communications to facilitate the extension of control to include interoperation with building automation systems and other intelligent field devices. Digital communications shall be RS485 MS/TP-based using the BACnet® protocol.

1) The panel shall have provision for an individual BACnet device ID and shall support the full 222 range (0 – 4,193,304). The device ID description property shall be writable via the network to allow unique identification of the lighting control panel on the network.
2) The panel shall support MS/TP MAC addresses in the range of 0 – 127 and baud rates of 9600k, 38400k, 76800k, and 115.2k bits per second.
3) Lighting control relays shall be controllable as binary output objects in the instance range of 1 – 64. The state of each relay shall be readable and writable by the BAS via the object present value property.
4) Lighting control relays shall report their true on/off state as binary input objects in the instance range of 1 – 64.
5) The 99 group Normal Hours/After Hours control objects associated with the panel shall be represented by binary value objects in the instance range of 201 – 299. The occupancy state of each channel group shall be readable and writable by the BAS via the object present value property. Commanding 1 to a channel group will put all relays associated with the channel into the normal hours mode. Commanding 0 or NULL shall put the relays into the after hours mode.
6) Setup and commissioning of the panel shall not require manufacturer-specific software or a computer. All configuration of the lighting control panel shall be performed using standard BACnet objects or via the handheld IR programming remote. Provide BACnet objects for panel setup and control as follows:
   a) Binary output objects in the instance range of 1 – 64 (one per relay) for on/off control of relays.
   b) Binary value objects in the instance range of 1 – 99 (one per channel) for normal hours/after hours schedule control.
   c) Binary input objects in the instance range of 1 – 64 (one per relay) for reading true on/off state of the relays.
   d) Analog value objects in the instance range of 101 – 199 (one per channel group) shall assign a blink warn time value to each channel. A value of 5 shall activate the blink warn feature for the channel and set a 5-minute grace-time period. A value of 250 shall activate the sweep feature for the channel and enable the use of sweep type automatic wall switches.
7) The description property for all objects shall be writable via the network and shall be saved in non-volatile memory within the panel.
8) The BO and BV 1 – 99 objects shall support BACnet priority array with a relinquish default of off and after hours respectively. Prioritized writes to the channel BV objects shall propagate prioritized control to each member relay.
9) Panel-aggregate control of relay Force OFF at priority 2 shall be available via a single BV5 object. Force ON at priority 1 shall be available via a single BV4 object.
10) Lockout of all digital switch buttons connected to a given panel shall be commandable via a single BV2 object. The lock status of any connected switch station shall be represented as BV101-196.

k. In addition to the LMCP Relay Panels, an LMZC Zone Controller panel shall be available for zero-relay applications. The panel is designed for applications where LMFC-011 Fixture Controllers or other distributed load controllers are used to switch and/or dim the controlled loads. Key similarities to and differences from the LMCP panel design shall include:
   1) The LMZC shall use the same intelligence board as the LMCP relay panel.
   2) The LMZC shall not include relay driver boards or relays.
   3) The LMZC shall have a removable interior section to facilitate installation, and a Tub/Cover. Cover is for surface mounting applications only.
   4) The LMZC tub shall have two interior KOs to allow installation of LMPB-100 Power Boosters. Each installed Power Booster can provide an additional 150 mA for either of the two available DLM local networks provided by the LMZC.

5) All programming and networking (whether DLM Local Network and/or Segment Network) capabilities in the LMZC Zone Controller shall be similar to capabilities for LMCP relay panels, except for functions designed for panel-mounted HDR relays.

l. To aid in project start up, if LMFC Fixture Controllers are connected to an LMZC Zone Controller, Plug n'Go automatic configuration will establish a unique sequence of operation so that all LMFC-controlled fixtures will turn on to 50 PCT output when any digital occupancy sensor detects motion..

m. WattStopper Product Number: Relay Panels: LMCP8, LMCP24 or LMCP48, Zone Controller: LMZC-301.

B. User Interface:

1. Each lighting control panel system shall be supplied with at least (1) handheld configuration tool (LMCT-100). As a remote programming interface the configuration tool shall allow setup, configuration, and diagnostics of the panel without the need for software or connection of a computer. The user interface shall have the following panel-specific functions as a minimum:

a. Set network parameters including panel device ID, MS/TP MAC address, baud rate and max master range.

b. Relay Group creation of up to 99 groups. Group creation shall result in programming of all seven key relay parameters for member relays. The seven parameters are as follows:

1) After-hours Override Time Delay.
2) Normal Hours Override Time Delay.
3) Action on Transition to Normal Hours.
4) Action on Transition to After Hours.
5) Sensor Action During Normal Hours.
6) Sensor Action During After Hours.
7) Blink-Warn Time for After Hours.

c. Program up to 254 separate scheduled events. Events shall occur on seven day intervals with each day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays. Holidays are also defined through the User Interface.

d. Program up to 32 separate Dark/Light events. Events shall have a selectable source as either calculated Astro with delay, or a digital IO module with an integral 0-5V or 0-10V analog photocell. Dark/Light events shall occur on seven day intervals with each day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays.

e. Button binding of digital switches to groups shall be accessible via the handheld IR remote and accomplished from the digital switch station.

f. Programming of panel location information shall be accomplished by the handheld IR remote and include at a minimum LAT, LON, DST zone, and an approximate city/state location.

g. WattStopper Product Number: LMCT-100.

2.12 SEGMENT MANAGER

A. For networked applications, the Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser utilizing either unencrypted TCP/IP traffic via a configurable port (default is 80) or 256 bit AES encrypted SSL TCP/IP traffic via a configurable port (default is 443).

B. Each segment manager shall have integral support for at least three segment networks. Segment networks may alternately be connected to the segment manger via external BACnet-to-IP interface routers and switches, using standard Ethernet structured wiring. Each router shall accommodate one segment network. Provide the quantity of routers and switches as shown on the plans.

C. Operational features of the Segment Manager shall include the following:
   1. Connection to PC or LAN via standard Ethernet TCP/IP via standard Ethernet TCP/IP with the option to use SSL encrypted connections for all traffic.
   2. Easy to learn and use graphical user interface, compatible with Internet Explorer 8, or equal browser. The Segment Manager shall not require installation of any lighting control software on an end-user PC.
   3. Log in security capable of restricting some users to view-only or other limited operations.
   4. Segment Manager shall provide two main sets of interface screens – those used to initially configure the unit (referred to as the config screens), and a those used to allow users to dynamic monitor the performance of their system, and provide a centralized scheduling interface.
   5. Capabilities using the Config Screens shall include:
      a. Automatic discovery of DLM devices and relay panels on the segment network(s). Commissioning beyond activation of the discovery function shall not be required to provide communication, monitoring or control of all local networks and lighting control panels.
      b. Allow information for all discovered DLM devices to be imported into the Segment Manager via a single XML based site file from the WattStopper LMCS Software, significantly reducing the time needed to make a system usable by the end user. Importable information can include text descriptions of every DLM component and individual loads, and automatic creation of room location information and overall structure of DLM network. Info entered into LMCS should not have to be re-entered manually via keystrokes into the Segment Manager.
      c. After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree will allow the device settings and operational parameters to be viewed and changed by the user.
      d. Ability to view and modify DLM device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation including sensor time delays and sensitivities, and load response to sensor including Manual-ON or Auto-ON.
      e. Provide capabilities for integration with a BAS via BACnet protocol. At a minimum, the following points shall be available to the BAS via BACnet IP connection to the segment manager: room occupancy state; room schedule mode; room switch lock control; individual occupancy sensor state; room lighting power; room plug-load power; load ON/OFF state; load dimming level; panel channel schedule state; panel relay state; and Segment Manager Group schedule state control. Any of above items shall be capable of being moved into an "Export Table" that will provide any integrator with only the data they need, and by using the Export Table effectively create a firewall between the integrator's request for info and the overall system performance.

6. Capabilities using the Segment Manager's Dashboard Screens shall include:
   a. A dynamic "tile" based interface that allows easy viewing of each individual room's lighting and plug load power consumption, and lighting and plug load power density (power consumption information requires Enhanced DLM Room and Plug Load Controllers with integral current transducers such as LMRC-21x).Tiles will be automatically organized according to location so a single tile for the building summarizes all information for tiles beneath it on every floor, in every area, in every room. Tiles shall be color coded based on three energy target parameters, allowing an owner to quickly identify rooms that are not performing efficiently. Tiles for rooms with occupancy sensors shall include an icon to indicate whether that room is occupied. Tiles shall be clickable, and when clicked the underlying hierarchical level of tiles shall become visible. The tile interface shall be accessible via mouse, or touch screen devices. Tiles shall be created automatically by the segment manager, based on the information found during the device discovery and/or information included in a file imported in from LMCS (such as tagged descriptions for each room) without any custom programming.
   b. Ability to set up schedules for DLM local networks (rooms) and panels. Schedules shall be capable of controlling individual rooms with either on/off or normal hours/after hours set controlled zones or areas to either a normal hours or after hours mode of operation. Support for annual schedules, holiday schedules and unique date-bound schedules, as well as astro ON or astro OFF events with offsets. Schedules shall be viable graphically as time bars in a screen set up to automatically show scheduled events by day, week or month.
   c. Ability to provide a simple time vs. power graph based on information stored in each Segment Manager's memory (typically two to three days' data).
7. If shown in the contract drawings, Segment Managers shall be integrated into a larger control network by the addition of a Network Supervisor package. The Supervisor is a server level computer running a version of the Segment Manager interface software with dedicated communication and networking capability, able to pull information automatically from each individual Segment Manager in the network. By using a Supervisor, information for individual Segment Managers can be accessed and stored on the Supervisor's hard drive, eliminating the risk of data being overwritten after a few days because of Segment Manager memory limits.
8. The Segment Manager shall allow access and control of the overall system database via Native Niagara AX FOX connectivity. Systems that must utilize a Tridium Niagara controller in addition to the programming, scheduling and configuration server are not acceptable.

D. Segment Manager shall support multiple DLM rooms as follows:
   1. Support up to 120 network bridges and 900 digital in-room devices (LMSM-3E).
   2. Support up to 300 network bridges and 2,200 digital in room devices, connected via network routers and switches (LMSM-6E).

E. WattStopper Product Numbers: LMSM-3E, LMSM-6E, LM-SUPERVISOR, NB-ROUTER, NB-SWITCH, NB-SWITCH-8, NB-SWITCH-16.

2.13 PROGRAMMING, CONFIGURATION AND DOCUMENTATION SOFTWARE

A. PC-native application for optional programming of detailed technician-level parameter information for all DLM products, including all parameters not accessible via BACnet and the handled IR configuration tool. Software must be capable of accessing room-level parameter information locally within the room when connected via the optional LMCI-100 USB programming adapter, or globally for many segment networks simultaneously utilizing standard BACnet/IP communication.

B. Additional parameters exposed through this method include but are not limited to:
   1. Occupancy sensor detection LED disable for performance and other aesthetic spaces where blinking LEDs present a distraction.

2. Six occupancy sensor action behaviors for each controlled load, separately configurable for normal hours and after hours modes. Modes include: No Action, Follow OFF Only, Follow ON Only, Follow ON and OFF, Follow ON Only with Override Time Delay, Follow OFF Only with Blink Warn Grace Time, Follow ON and OFF with Blink Warn Grace Time.
3. Separate fade time adjustments per load for both normal and after hours from 0 - 4 HRS.
4. Configurable occupancy sensor re-trigger grace period from 0 - 4 minutes separate for both normal hours and after hours.
5. Separate normal hours and after hours per-load button mode with modes including: Do nothing, ON only, OFF only, ON and OFF.
6. Load control polarity reversal so that on events turn loads off and vice versa.
7. Per-load DR (demand response) shed level in units of percent.
8. Load output pulse mode in increments of 1second.
9. Fade trip point for each load for normal hours and after hours that establishes the dimmer command level at which a switched load closes its relay to allow for staggered ON of switched loads in response to a dimmer.

C. Generation of reports at the whole file, partial file, or room level. Reports include but are not limited to:
1. Device list report: All devices in a project listed by type.
2. Load binding report: All load controller bindings showing interaction with sensors, switches, and daylighting.
3. BACnet points report: Per room Device ID report of the valid BACnet points for a given site's BOM.
4. Room summary report: Device manifest for each room, aggregated by common BOM, showing basic sequence of operations.
5. Device parameter report: Per-room lists of all configured parameters accessible via hand held IR programmer for use with O&M documentation.
6. Scene report: All project scene pattern values not left at defaults (i.e. 1 = all loads 100 PCT, 2 = all loads 75 PCT, 3 = all loads 50 PCT, 4 = all loads 25 PCT, 5-16 = same as scene 1).
7. Occupancy sensor report: Basic settings including time delay and sensitivity(ies) for all occupancy sensors.

D. Network-wide programming of parameter data in a spreadsheet-like programming environment including but not limited to the following operations:
1. Set, copy/paste an entire project site of sensor time delays.
2. Set, copy/paste an entire project site of sensor sensitivity settings.
3. Search based on room name and text labels.
4. Filter by product type (i.e. LMRC-212) to allow parameter set by product.
5. Filter by parameter value to search for product with specific configurations.

E. Network-wide firmware upgrading remotely via the BACnet/IP network.
1. Mass firmware update of entire rooms.
2. Mass firmware update of specifically selected rooms or areas.
3. Mass firmware upgrade of specific products.

F. WattStopper Product Number: LMCS-100, LMCI-100.

2.14 EMERGENCY LIGHTING CONTROL DEVICES

A. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:
1. 120/277 volts, 50/60 Hz, 20 amp ballast rating.
2. Push to test button.
3. Auxiliary contact for remote test or fire alarm system interface.

B. WattStopper Product Numbers: ELCU-100, ELCU-200.

2.15 SYSTEM PERFORMANCE REQUIREMENTS

A. The lighting control "system" shall include a fully distributed WAN/LAN network of global controller/routers, individually addressable System Field Devices that are not integral to luminaires, sensors, switches, relays and other ancillary devices required for a complete and operable system. The system WAN/LAN start-up shall be by the control system manufacturer or contractors certified by the manufacturer.

B. The basis of system design shall utilize non-proprietary industry standard 0-10V dimming or fixed output ballasts and/or 0-10V LED drivers, occupancy sensors, daylight sensors, etc.

C. UL 924 listed devices shall have the ability to control 120V/277V/347V/480V loads.

D. System software interface shall have the ability to notify communication failures to system users via system & email messages. Email messages shall be available in html and text formats.

E. On-going system expansion, service and support shall be available from multiple factory certified vendors. Recommended service agreements may be submitted at the time of bid complete with manufacturers suggested inventory and pricing for system parts and technical support labor.

F. Lighting control software system shall offer two separate levels of lighting control:
  1. Central lighting:
     a. Shall allow the facility lighting administrator to perform energy management, configuration maintenance, monitoring operations, and providing support to building occupants.
        1) Native central control software shall be utilized for energy reporting status and complete programming without the need for any third party hardware or software. Systems that require any third party linked software or graphics shall be unacceptable.
        2) Software shall provide information on general system settings via mouse click on a floor plan. Left clicking over a device on the graphical software interface shall show a description of the selected device/function attribute.
     b. Shall provide an Interactive, Web-based graphical user interface (GUI) showing floor plans and lighting layouts that are native to the lighting control software. The only means required to program and operate the lighting control system shall be programmed and operated from a user interface that is based on a plan view graphical screen on the user's computer or the lighting control system's main computer. Shall include the navigational features listed below to allow for user's orientation within the controlled space, geographic heading and/or landmarks:
        1) Interactive.
        2) Vector based.
        3) Zoom.
        4) Rotate.
        5) Pan.
        6) Tilt.
     c. Shall allow building operator to navigate through an entire facility both in two-dimensional and three-dimensional multi-floor view, allowing for fast and easy navigation.
     d. Three-dimensional view shall exclude walls and other structural features to avoid shadowing and cluttering of the plan view.
     e. Shall display multiple floors in single view resulting in easier system performance visualization for the entire site as well as individual zones or spaces.
     f. Shall allow system performance visualization across a portfolio of buildings via a single interface.

g. All programming, assignments of lighting loads to control strategies, lighting status and lighting energy reporting shall be native to the software and executed from this GUI. Editing shall be available from this GUI in a drag and drop format or from drop down menus without the need for any third party software. Systems that utilize or require third party linked graphics are unacceptable. The GUI shall continuously indicate the status of each connected device on the system and a warning indicator on the software if a device goes offline. Systems requiring spreadsheet editing for programming and that don't offer real time feedback are not acceptable.
h. Software settings and properties shall be selectable per individual device, room based, floor based or global building based.
   1) Lighting Control Software interface shall provide current status and enable configuration of all system zones including selected individual luminaire availability, current light level, maximum light level, on/off status, occupancy status, and emergency mode (response to an emergency signal) status.
i. Shall have the ability to display various lighting system parameters such as Lighting status (ON/OFF); Lighting levels, Load shedding status, or Lighting energy consumption, Occupancy status in a colorized gradient ("weather" map) type of graphical representation.
j. Energy Analysis data shall be exportable in CSV or image file formats.
k. Shall allow import of native AutoCAD files.

G. Daylight Harvesting (Light Regulation Averaging): In a photo sensor-equipped system, the Central Controller Unit shall rationalize changes to light levels when ambient (natural) light is available and shall maintain a steady light level when subjected to fluctuating ambient conditions where 0-10V dimming ballasts and/or drivers exist. Areas equipped with fixed output ballasts and/or drivers shall energize when natural light falls below foot-candle levels specified. System shall utilize light level inputs from common and/or remote sensor locations to minimize the number of photo sensors required. The System shall operate with multiple users in harmony and not react adversely to manual override inputs.

H. Time Clock Scheduling:
1. The system shall be programmable for scheduling lights on or off via the Lighting Control Software interface.
2. Programming: User friendly, Outlook style interface shall be available for programming schedules.
3. Override: Manual adjustments via wall stations or personal control software shall temporarily override off status imposed by time clock schedule.
4. Response to Power Failure: In the event of a power failure, the time clock shall execute schedules that would still be in progress had they begun during the power outage.
5. Flick Warning: Prior to a scheduled lights-off event or expiry of a temporary override, the system shall provide two short light level drops as a warning to the affected occupants. Flick warning time shall have the ability to be programmed via software between 1 and 5 minutes.
6. Option to automatically turn on or wait for an input: Using this option, a group of luminaires can be made to turn on automatically in response to a scheduled event or wait for a signal from a wall station to turn the same group of luminaires on (and stay on) for the reminder of the scheduled event.
7. Shall support BAS Schedules/Calendars.

I. Load Shed Mode: An automatic load shedding mode shall be available where, when activated through the system, the control unit will reduce its output to a programmable maximum electrical demand load. The system shall not shed more load than required and load shedding priority shall be centrally configurable by control zone or by common uses (i.e., all hallways can be treated as one load shed group), with subsequent load shed priority groupings being utilized until the required defined load has been shed, for either a defined period, or until the demand response input has been removed. Systems that simply select a "load shed scene" whereby there is no guarantee that the defined required load will actually be shed are not acceptable.

J. Emergency Mode: There shall be a mode, when activated through the system, that will immediately adjust lights to full light output and retain that level until the mode is deactivated in the event of an emergency. This setting shall override all other inputs. The system shall interface with the building emergency monitoring system at a convenient point and not require multiple connections.

K. Addressing: Ballasts and/or drivers shall be centrally addressable, multiple luminaire/zone basis, through the Central Control Software. The basis of design shall 0-10V LED Drivers connected to an Output Module. To simplify ongoing maintenance, the system shall not require manual recording of addresses for the purpose of start-up or reconfiguration.

L. Continuous Dimming: Dimming group of luminaires in response to user initiated or system generated signal shall be over a continuous range.

M. Unoccupied State: The system shall provide two states when occupancy status is vacant as per an occupancy sensor - lights turn off or lights adjust to configurable (dimmed) light level.

N. Occupied State: The system shall be capable of creating "comfort" or "support" zones to ensure that occupants are not isolated by turning off lights in adjacent areas, such as a hallway path to exit the premises for occupant comfort and safety.

O. Overlapping Zones: System shall be capable of creating "overlapping" zones to ensure continuous lighting and safety of the occupants as they move from one lighting zone to another (for example, hallways) while minimizing the energy use.

P. Participation in Intelligent Building Framework: The system shall have the ability to be a component of Intelligent Building framework. Control Units and System server communication shall be based on TCP/IP over Ethernet backbone.

Q. LAN Operations: System shall be capable of operating independent of building's existing network infrastructure if desired and shall not rely on tenant supplied PCs for operation.

R. Network Security: Firewall Technologies & VLAN Configuration methods shall be utilized to separate tenants from the lighting control network and ensure the integrity of lighting control network.

S. Lighting Maintenance:
   1. Percentage left in Lamp and Driver Life Time shall be programmed to display in different colors for easier visual representation and quicker maintenance turnaround time.
   2. 0-10V Dimming and/or Fixed Output Ballast/LED Driver replacements shall not require re-programming of the system or re-addressing of the said components.

T. Group (zone) Configuration: The assignment of individual or group of system components to zones shall be performed via Central Control Software such that physical rewiring will not be necessary when workspace reconfiguration or re-zoning is performed. Removal of covers, faceplates, ceiling tiles, etc. shall not be required.

U. Sensor Control Parameters: Occupancy sensor time delays shall be configurable through software. Light level sensor parameters shall be configurable through software.

V. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight savings time and shall provide weekly routine and annual holiday scheduling.

W. The system software shall provide an optional web based energy dashboard to show real time energy savings data and carbon footprint reductions.

X. Contact closure input: System shall be capable of receiving a momentary and sustained contact closure input from third party sources to control lighting zones.

Y. The system shall have the ability to control (dim/switch) a group of luminaires with loads up to 20A.

Z. System shall automatically lock wallstations and/or disable sensors based on one of the following system inputs: contact closure, a time schedule or the status of a monitored space.

AA. BAS Interface: The light management system shall be capable of interfacing digitally with a building automation system via either BACnet/IP or Tridium Niagara AX interface. The lighting control system shall be capable of communicating the status of lighting loads as well as input devices (dry contacts, switches, occupancy sensors, vacancy sensors, and photocells) to the BAS. Building Automation System, utilize data from lighting control system input devices such as occupancy sensors to determine the occupied or unoccupied status of mechanical control zones and perform climate adjustments accordingly.

BB. AV Interface: The light management system shall be capable of interfacing with audio-visual system (e.g. LCD Touch Screen Panel) via TCP/IP interface.

CC. Minimized System Down Time: Communication bus shall be able to self-diagnose and display communication shorts or open loops resulting in minimum system down time.

DD. AC Phase Cut Dimming Circuit Integration: System shall have the ability to control Incandescent, Fluorescent or LED lighting load that are otherwise controlled by manual AC Phase Cut Dimmers.

EE. System design shall ensure seamless communication among devices when hybrid wired/wireless control systems are implemented. Hybrid control system refers to devices that communicate over a field bus that carry low voltage control signals and/or wireless medium that uses non-proprietary open protocol (e.g., ZigBee) for communication. Devices in the hybrid control system shall communicate with all the devices in the system regardless of their native protocol they are designed to work with.

2.16 LOW VOLTAGE WALLSTATIONS

A. System shall connect with the wallstations via field bus that carry low voltage or 0-10V control signals on NEC/CEC Class 2 communication wire.
   1. Software configurable wall station shall provide ON/OFF switching and dimming control for up to six lighting zones/ five lighting scenes per wallstation or more with allowable multi-gang configurations.
   2. Shall allow manual dimming of light levels and override of the time schedule.
   3. Scenes/zones in the system control software shall be synchronized with the buttons on the wallstation.
   4. Wallstations shall be individually addressable and reconfigurable via System Control Software.
   5. Wall stations shall feature status LED's.
   6. Lighting scenes shall automatically reconfigure based on scene changes from personal control software.

B. Electrical:
   1. Class 2 Low Voltage device.
   2. Power source: Communication bus.

C. Performance:
   1. Wallstation configuration shall be via GUI in a drag and drop format.
      a. Custom button cap configuration shall allow combination of scene & zone in one wallstation.
      b. Custom commands shall be applied to individual wallstation buttons.
      c. Status LED: Wall station shall display its current status (zone/scene under system control or OFF) when motion is detected in the close proximity of the wallstation.
   2. The following User Interface and custom labelling options shall be available:
      a. Up to five (5) scene switching & dimming.
      b. Up to six (6) zone switching.
      c. One (1) zone switching.

3. Shall have icons that will illuminate when loss of communication with system control unit, Fire Alarm and Wall Station Lock statuses are detected.
4. Allow vacancy sensor configuration.

D. Mechanical:
1. Dimensions: Meet NEMA WD-6 specifications.
2. Color: Meet NEMA WD1 color specifications.
3. Support following mounting options:
a. Mount in standard size wall box.
b. On mounting brackets for low voltage devices.
4. Shall be used with "Decorator" style wall plate.

E. Reliability:
1. Operating temperature range: 14 DEGF to 140 DEGF.
2. Humidity: 5 PCT to 95 PCT RH non-condensing rated for indoor locations.

2.17 TOUCH SCREEN PANEL

A. General: Shall enable the ability to display light level, status and recall multiple lighting scenes.

B. Electrical:
1. Input voltage: Power over Ethernet or +9VDC to +16VDC, 1A max.

C. Communication: Ethernet connection employing TCP/IP protocol

D. Performance:
1. Full color 7 IN TFT LCD, Full VGA (800 x 480 pixels) with 65K colors.
2. CPU: 32 bit, 533 MHz.
3. Memory: 128 Non-volatile Flash Memory.
4. Flexible configurations for custom buttons, text and graphics.
5. Integrated high-resolution capacitive touch screen.

E. Mechanical: Wall mountable.

2.18 LOW VOLTAGE SENSORS

A. General: Occupancy sensor connectivity shall be via field bus that carry low voltage control signals.

B. Electrical:
1. Class 2 Low Voltage device.
2. Power source: Communication bus.

C. Communication: Class 2 communication bus.

D. Occupancy Sensor Performance:
1. Shall allow timeouts configurable via system software.
2. Sensors using passive infrared, ultrasonic, and multi-technology shall be available.
3. Shall allow occupancy and vacancy sensor configurations via system software.
4. Depending on the software configuration shall switch or dim the luminaires.
5. Shall allow overlapping and comfort zone configurations via system software.
6. Shall allow flexible timer settings.
7. Shall have the ability to self-calibrate and retain settings during power interruptions.
8. Shall have the ability to automatically analyze and adjust sensitivity and time delay.
9. Shall provide the following coverage:
a. Ceiling mount: 450 SQFT to 2000 SQFT.
b. Wall mount: 1200 SQFT to 2500 SQFT.

E. Photo Sensor Performance:
1. Accuracy: +/-1 PCT at 70 DEGF, derated to +/-5 PCT at 120 DEGF or at 0 DEGF.
2. Indoor sensor range shall be between 0 and 750 FC.
3. Outdoor sensor range shall be between 0 and 750 FC.

4. Atrium sensor range shall be from 2 to 2,500 FC.
5. Skylight sensor range shall be between 10 and 7,500 FC.

F. Mechanical:
1. Mounting options shall include the following:
   a. Junction Box mounting.
   b. Knock-out mounting.

G. Reliability:
1. Operating temperature range: 13 DEGF to +140 DEGF.
2. Humidity: 5 PCT to 95 PCT RH, non-condensing.

2.19 AREA LIGHTING CONTROLLER (ALC)

A. General: Shall provide a common interface (DIM/SWITCH) to a group of 0-10V Dimming, Fixed Output Ballasts and/or 0-10V LED Drivers via field bus that carry low voltage control signals.
1. Addressing: Area Lighting Controllers shall be addressable via Control Software.
2. System shall automatically address individual area lighting controllers during system start-up thus eliminating the need to pre-address devices or record serial numbers during installation.

B. Electrical:
1. Maximum load ratings:
   a. 20A 120-347 VAC Ballast.
   b. 20A 120-347 VAC Resistive.
   c. 20A 120-347 VAC Tungsten.
   d. 20A 120-347 VAC General Purpose.
   e. 1.5 HP 120-277 VAC Motor.

C. Communication: NEC/CEC Class 2 communication wire.

D. Performance:
1. Control options.
   a. ON/OFF Switching.
   b. Continuous 0-10V dimming.
   c. Communicate with 0-10V ballasts/drivers.
2. Use for general purpose plug load control.
3. Group Control: Control up to 30 ballast/LED Drivers.
4. Air Gap Off: Enforce physical disconnection of AC power to ballast or driver when “OFF” is selected either automatically or manually.
5. Memory: Retain all system settings in non-volatile memory.

E. Mechanical:
1. Mounting: Standard 1/2 IN electrical box knockout.
2. Material: Plenum rated black plastic per UL2043.

F. Reliability:
1. Operating temperature range: 32 DEGF to 131 DEGF.
2. Humidity: 5 PCT to 95 PCT RH non-condensing rated for indoor locations.

G. Regulatory:
1. Safety: UL916, UL924 and UL2043 listed.
2. Environmental protection: Rated for damp location; RoHS compliant.
3. Radio Interference: FCC Part 15/ICES-003.

2.20 RELAY-BASED LIGHTING CONTROL PANELS (RP/RPM)

A. General: An addressable lighting control panel that allows each relay to be individually controlled and configured.
1. Lighting control panel relays shall be individually addressable via Central Control Software.

2. Wiring: Lighting control panels shall be interconnected on the same field bus as all other system components.
3. Relay Panel Modules are suitable for 35 MM DIN rail mounting.

B. Electrical:
1. Input Power Supply: 40 VA, 50/60 Hz.

C. Communication:
1. Shall be via NEC/CEC Class 2 communication wire.

D. Performance:
1. ON/OFF Switching at Circuit level.

2.21 COMMUNICATION WIRE

A. The system shall have the capability to use both NEC/CEC Class 1 and Class 2 wiring to integrate peripheral devices such as ballasts/LED drivers, occupancy sensors, photo sensors, relay-based controls, area lighting controllers, and wallstations into a complete, networked programmable lighting control system.

B. Electrical: NEC/CEC Class 2 Communication bus.

C. Mechanical:
1. Multi-conductor cable with stranded-copper conductors.

D. Performance:
1. Shall power photo sensors, PIR and dual-technology occupancy sensors.
2. Shall allow random devices connection without the need for special network channel termination.
3. Minimize system down time by self-diagnosing the field bus for any shorts and open loops.

E. Regulatory:
1. Flame rated jacket for plenum use NFPA 262 (UL: FT6, CSA: CMP).

2.22 SYSTEM SERVER (SSU)

A. System Server shall host the lighting control system database for all the lighting control devices. In addition, it shall provide remote accessing capability to change system settings and/or parameters. Server shall have the ability to:
1. Analyze system performance or energy data or generate system report.
2. Record energy consumption with average sampling every 5 minutes for unlimited duration.
3. Host the web interface required for the web enabled Personal Control Software or web based Central Control Software.
4. Reside on a client server (virtual server).
5. Interconnect with Control Units over standard Ethernet connection that employs TCP/IP protocol.

B. Electrical:
1. Power Supply: 120V/60Hz/200W. Provide dedicated 120V receptacle fed from a dedicated normal power circuit.

C. Communication:
1. Each System Server shall have two Ethernet 10/100Base - Tx Cat 5 RJ45 ports that employ TCP/IP protocol.

D. Mechanical:
1. Shall mount in a standard 19 IN rack (1U width), or alternatively where no rack is shown, via an individual wall mount.

E. Reliability:
1. Operating temperature range: 50 DEGF to 95 DEGF.
2. Operating Relative Humidity: 10 PCT to 90 PCT, non-condensing.

2.23 LIGHTING CONTROL SYSTEM SOFTWARE

A. Technical Information: Adobe Flash based user interface.
   1. System shall require:
      a. Internet web browser with Flash Player 8 or later.
      b. Internet/Intranet connection.
      c. SSU enabled and configured to host dynamic website.
      d. Network connection with access to a network-enabled CU.

B. Web Based Central Control Software: Central control software application shall be used to start-up, configure and manage the system. Every system parameter in a building, or campus of buildings, shall be configured for each individual user or space and baseline settings shall be established for each of the following, depending on the basis of design, system features:
   1. Daylight harvesting.
   2. Occupancy control.
   3. Smart time scheduling.
   4. Task tuning.
   5. Personal control.
   6. Load shedding.

C. Software shall utilize a web based interface that permits a user to easily navigate between zones, floors or different buildings and allows a user to zoom in or zoom out of specific areas of a building. Both 3-dimensional and two-dimensional multi-floor views shall be available. System features such as creation of zone hierarchies, overlapping and support zone definitions, user access rights, timeout settings for occupancy sensors, calibration of light levels for daylight harvesting and the configuration of multiple time schedule profiles shall be available. A web based Graphical User Interface (GUI) application integral to the system shall be used to develop a dynamic, real-time, point-and-click graphic of each floor plan with representation of all light luminaire, wall stations, sensors, switches, etc. A central system server shall be provided to support system data base and enterprise control management.
   1. System shall require:
      a. Software that can run on a Windows Operating systems, Windows XP or newer, and Apple Mac Intel PCs, Mac OS 10.4 or newer.
      b. The ability to support common browsers.
      c. Network connection/access to network enabled ECUs.
      d. Native Energy Performance Monitoring capability.
      e. Color gradient, weather map type, data view to display the following criteria:
         1) Lamp and ballast life time.
         2) Current energy consumption.
         3) Current energy savings.
         4) Current luminaire brightness.
         5) Current luminaire status.
         6) Current occupancy data.
         7) Current load shedding status.
         8) Other custom modes that may be specified elsewhere.

2.24 AUDIO-VISUAL INTERFACE

A. Allow users command, e.g. LCD Touch Screen Panel, various lighting scenarios depending on the audio and visual requirements of the room or building.
   1. Lighting control system shall interface to the AV system via TCP/IP protocol using Telnet.
   2. Lighting control system shall allow a common AV processor to individually control multiple rooms from a single TCP/IP port through unique room, zone, and scene addresses for lighting in each room.

2.25 BUILDING AUTOMATION SYSTEM INTERFACE

A. Two separate software interfaces, BACnet/IP or Tridium Niagara AX, shall be available for integration with Building Automation System. The lighting control system, via these interfaces, shall communicate lighting loads as well as input devices, such as dry contacts, switches, occupancy sensors, vacancy sensors, and photocells, over to Building Automation System (BAS). BAS shall utilize data from lighting control system to switch/dim lighting, perform load shedding of lighting load, turn lights on in response to emergency signal through fire alarm, and perform HVAC adjustments.
   1. Lighting Control System shall support the following BACnet Objects:
      a. Binary value:
         1) Light Zone State: State of the defined lighting zone – ON or OFF.
      b. Analog Value:
         1) Light Zone Dimming: Light output level of defined lighting zone, from 100 PCT (maximum light output) to 0 PCT, minimum light output.
      c. Scheduling:
         1) Support for BACnet Schedules/Calendars.
      d. Analog input:
         1) Shed Request: Requested total amount of load reduction, defined in watts or as a percentage of sheddable load.
         2) Shed Request (Group): (As above, for the selected group).
      e. Analog output:
         1) Photo Sensor Daylight Readings, available via BACnet interface only: Reports daylight readings by photo sensors.
         2) Sheddable Load: Reports the total lighting load available for load reduction according to the Light Management System, defined in watts.
         3) Sheddable Load (Group): (As above, for the selected group).
         4) Shed Status: Reports the total current load reduction achieved according to Light Management System defined prioritization, defined in watts.
         5) Shed Status (Group): (As above, for the selected group).
         6) Load Shedding Total Demand: Reports the total lighting demand of all devices in a load shedding group (in Watts).
      f. Binary input:
         1) Fire Alarm State: State of the fire alarm system – alarm activated or alarm not activated.
      g. Binary output:
         1) Occupancy State: State of the defined occupancy sensor – occupancy detected or not detected.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION MEETING

A. Factory authorized manufacturer's representative shall provide electrical contractor functional overview of lighting control system prior to installation.

B. Schedule pre-installation site visit after receipt of approved submittals:
   1. Confirm location and mounting of digital devices, with special attention to placement of occupancy and daylighting sensors.
   2. Review specifications for low voltage control wiring and termination.
   3. Discuss functionality and configuration of products, including sequences of operation, per design requirements.
   4. Discuss requirements for interface with other trades.

3.2 CONTRACTOR INSTALLATION AND SERVICES

A. Coordinate, receive, mount, connect, and place into operation all equipment.
   1. Furnish conduit, wire, connectors, hardware, and other incidental items necessary for properly functioning lighting control as described herein and shown in Drawings including but not limited to System Field Devices, 0-10V LED drivers and communication wire.
   2. Maintain performance criteria stated by manufacturer without defects, damage, or failure.

B. Power:
   1. Test branch load circuits for operation before connecting loads to sensor system load terminals.
      a. De-energize circuits before installation.

C. Install devices and wiring and tag line voltage connections to indicate circuit and switched legs.

D. Install room/area devices using manufacturer's factory tested Cat 5e cable with pre-terminated RJ-45 connectors.
   1. Low voltage wiring topology must comply with manufacturer's specifications.
   2. Route network wiring as shown in submittal drawings.
   3. Document final wiring location, routing and topology on as built drawings.

E. Install work in accordance with manufacturer's instructions unless otherwise indicated.

F. Before start up, test devices to ensure proper communication.

G. Calibrate sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings.
   1. Adjust time delay so controlled area remains lighted while occupied.

H. Provide written or computer-generated documentation on configuration of system including room by room description including:
   1. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
   2. Sequence of operation, e.g., manual ON, Auto OFF.
   3. Load Parameters, e.g., blink warning.

3.3 SOFTWARE INSTALLATION

A. Install and program software with initial settings of adjustable values.

B. Generate backup copies of software and user-supplied values.

C. Provide current site licenses for software.

3.4 FIELD QUALITY CONTROL

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

B. Perform following field tests and inspections with assistance of factory-authorized service representative:
   1. Start units to confirm operation after electrical circuitry has been energized, prior to installation of wall stations and sensors.
   2. Test and adjust controls and safeties.
      a. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Replace damaged and malfunctioning controls and equipment and retest.
   1. Repeat until system passes inspection.

D. Prepare test and inspection reports.

3.5 SYSTEM START-UP REQUIREMENTS AND SUPPORT SERVICES

A. Manufacturer trained representatives to start-up lighting control system.

B. Train facility staff responsible for changing lighting characteristics in operation of system.
   1. Provide Owner with system operating manuals.

C. Perform functional testing under guidance of technical service agent and in accordance with manufacturer's guidelines.

D. Provide technical services for lighting control system, including:
   1. Verification of communication over control wires.
   2. Map addresses of devices and provide documentation showing addresses and locations of addresses to Owner and Engineer.
   3. Verify communication to wireless managers and system server.
   4. Software configuration of occupancy sensors, light level sensors, wallstations and other contacts to suit design requirements.
   5. Configure and program lighting control sequences as described in Contract Documents.
   6. Demonstrate to Owner and Engineer proper operation of areas system is installed.

E. Field start-up shall be complete prior t system commissioning.

3.6 COMMISSIONING

A. Lighting Control System manufacturer shall work with independent commissioning firm to commission all component of the lighting control system.

B. Any change made to software scheduling to aid in commissioning process shall be restored to proper working order. Restoration shall be part of commissioning process.

C. Manufacturer shall review and provide comment on Commissioning agent's check list protocols to verify system testing procedures are accurate for validation of system operation.

3.7 TRAINING

A. Lighting Control System manufacturer shall provide one day of on-site training after successful completion of system commissioning. Training shall be videotaped and provided to Owner. Training session shall include, but not be limited to:
   1. Explanation and demonstration of the operation and adjustable settings native to each type of control device.
   2. Explanation and demonstration of the adjustable settings within the software control program.
   3. Explanation and demonstration of the current status monitoring screens as well as the ability to generate reports.
   4. Explanation of all alarm types, how alarm notification occurs, how alarm conditions are cleared, and how alarms are recorded.
   5. Explanation of password protection. Explanation of how password access is modified shall only be provided to select Owner specified personnel.

B. Lighting Control System O&M manuals shall be provided to each person in attendance.

C. Sign-in sheet for training session shall be included in Lighting Control System O&M manuals.

3.8 MAINTENANCE

A. Spare Parts:
   1. One (1) 0-10VDC Digital Room Controller, one relay.
   2. One (1) Digital Room Controller, dual relay (Forward Phase).
   3. One (1) Occupancy Sensor.

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SECTION 26 11 16
LOAD CENTER UNIT SUBSTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Load Center Substation, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Unit substation design, testing and assembly: Conform to ANSI and NEMA standards.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Include all equipment dimensions, ratings, high and low voltage terminal connections, arrestors, air switches, etc.
   2. Coordinate connections to bus duct and switchboard with their manufacturers.

B. Product Data:
   1. Technical data on each component.
   2. Specification comparison.

C. Contract Closeout Information:
   1. Operation and Maintenance Data.
      a. See Section 01 78 23.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Load Center Unit Substations:
   1. Base:
      a. Schneider Electric/Square D.
   2. Optional:
      a. General Electric.
      b. Siemens Energy & Automation.

2.2 MATERIALS

A. Load Center Unit Substations: Consisting of high voltage (HV) incoming line section, transformer section, low voltage (LV) outgoing line section, factory or field assembled to form single integral, free standing, totally enclosed unit.
   1. Provide individual units with provisions for jacking, lifting, skidding and rolling.
   2. NEMA 3R Enclosure: Non-walking-in type with sloping roof downward toward rear. Front and rear hinged pad-lockable doors with wind stops for each section. Thermostatically controlled space heaters to minimize internal condensation. Power for heaters shall be internally to the switchgear.
   3. All components comply with applicable NEMA and ANSI standards.
   4. Brace entire assembly including HV section and core and coil assembly of transformer as a unit to withstand the mechanical and thermal forces caused across the low voltage external terminals without any damage, either thermal or mechanical, while operating at HV rating; calculate bracing on the basis of 2000 MVA available on the incoming side of the unit substation.
   5. Connect sections by bolted flanges.

B. HV Incoming Line Section:
   1. HV incoming line section: Construct for entrance and termination of three (3) single conductor, 15 KV cables.
      a. Cable entry: From bottom.
      b. Provide loop feed terminal connectors.
      c. Provide ground bus in HV terminal compartment to connect to area ground.
      d. Provide 15 KV, intermediate class, metal oxide gapless type lightning arrestors for ______ system. Select arrestors to limit sparkover voltage to less than 80 PCT of transformer BIL HV rating.
   2. Air-interrupter switch: Two position (open-closed), 3-pole, group operated.
      a. Fused.
      b. Use interlock to prevent access to switch compartment with switch closed.
      c. Switch rating: 600 amperes continuous.
      d. Load interrupting rating: 600 amperes at rated voltage.
      e. Fault closing and short time ratings not less than assembly short circuit rating.
      f. Kirk key interlock: Provide to insure that secondary main device must be opened prior to opening air-interrupter switch.
   3. Power fuses:
      a. Minimum interrupting rating: Not less than assembly short circuit rating.
      b. Capable of clearing their minimum melting current.

C. Transformer Section:
   1. Transformer: Natural draft cooled with provisions for future forced air cooling (OA/FFA), outdoor liquid-filled transformer.
      a. Oil immersed.
      b. Capacity rating: 2000 KVA without fans and 2300 KVA with fans, 3 phase, 60 Hz.
      c. HV voltage rating: 15 KV, connected delta.
         1) Provide two 2-1/2 PCT FCAN taps and two 2-1/2 PCT FCBN taps.
         2) Provide tap changing mechanism, externally operable in de-energized condition only. Mechanism shall be padlockable.
      d. Basic impulse level: 110 KV BIL, HV rating and 45 KV BIL, LV rating.
      e. LV rating: 480 V, connected wye.
      f. 55 DEGC rise above a 40 DEGC ambient. Transformer shall be capable of carrying a 12 PCT continuous overload without exceeding 65 DEGC rise above a 40 DEGC ambient.
      g. Impedance: 5.75 PCT on its base KVA rating plus or minus 7.5 PCT.
      h. Rated sound level: Not greater than ANSI/NEMA standards.
      i. Core and coil assembly: Wound core (five-legged) type with aluminum windings.
      j. Tank: Sealed, for top oil temperature from 50 DEGC to 106 DEGC, and to withstand 7-1/2 PSI pressure without permanent distortion.
         1) Bolted on cover with tamperproof fastenings.
         2) Cooling panels on back and sides, if required.
         3) Lifting lugs and jacking pads welded to tank.
      k. No fastening devices externally removable.
      l. One IN drain valve with sampling device.
      m. Dial type thermometer with resettable high temperature indicator.
      n. One IN upper filter press and filling plug.
      o. Liquid level indicator.
      p. Pressure relief valve.

D. Low Voltage Outgoing Section:
   1. Provide LV switchgear distribution sections as indicated on drawings.
   2. Refer to Switchgear Section 26 23 00 for NEMA 3R outdoor rated switchgear.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all components as indicated and in accordance with manufacturer's instructions and recommendations.

3.2 LABELING

A. Provide labeling as specified in Section 26 00 10.

END OF SECTION

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SECTION 26 22 13
LOW VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Low Voltage Distribution Transformers, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Provide transformers conforming to following standards:
   1. NEMA ST20 Dry Type Transformers for General Applications
   2. NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
   3. ANSI/IEEE C57.12.91 Standard Test Code for Dry-Type Distribution and Power Transformers
   4. DOE 10 CFR Part 431 (DOE 2016) Energy Efficiency Program for Certain Commercial and Industrial Equipment
   5. UL 1561 Standard for Dry-Type General Purpose and Power Transformers

1.3 SUBMITTALS

A. Product Data:
   1. Technical data on each type of transformer.
   2. No load core loss and full load coil loss data.
   3. Percent impedance and X/R ratio data.
   4. Load efficiency curve plots for each type of transformer.
   5. Specification comparison.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
      a. See Section 01 78 23.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Dry-type Transformers:
   1. Base:
      a. Schneider Electric/Square D.
      b. Eaton Electrical.
      c. Siemens.
      d. GE.

2.2 MATERIALS

A. Insulating materials are to exceed NEMA ST20 standards and be rated for 220 DEGC UL component recognized insulation system.

B. Three phase transformers 15kVA and larger shall be 150 DEGC temperature rise above 40 DEGC ambient.

C. Transformers 30kVA and larger and less than or equal to 112.5kVA shall be 115 DEGC temperature rise above 40 DEGC ambient and shall be capable of carrying a 15 PCT continuous overload without exceeding a 150ºC rise in a 40 DEGC ambient.

D. Transformers greater than 112.5kVA shall be 80 DEGC temperature rise above 40 DEGC ambient and shall be capable of carrying a 30 PCT continuous overload without exceeding a 150 DEGC rise in a 40 DEGC ambient.

E. Transformers shall be supplied with quality, full width electrostatic shields resulting in a maximum effective coupling capacitance between primary and secondary of 33 picofarads. With transformers connected under normal loaded operating conditions, attenuation of line noise and transients shall meet or exceed following limits:
1. Common Mode:
   a. 0 to 1.5kHZ: 120dB.
   b. 1.5kHZ to 10kHZ: 90dB.
   c. 10kHZ to 100kHZ: 65dB
   d. 100kHZ to 1MHZ: 40dB.
2. Transverse Mode:
   a. 1.5kHZ to 10kHZ: 52dB.
   b. 10kHZ to 100kHZ: 30dB.
   c. 100kHZ to 1MHZ: 30dB.

F. Neither primary nor secondary temperature shall exceed 220ºC at any point in coils while carrying their full rating of non-sinusoidal load.

G. Transformers are to be UL listed and labeled for K-4 or K-13 as indicated and defined as sum of fundamental and harmonic $I_h(pu)^2h^2$ per UL 1561. Transformers evaluated by UL K-Factor evaluation shall be listed for 150 DEGC average temperature rise.

H. K-Factor rated transformers shall have an impedance range of 3 PCT to 6 PCT, and shall have a minimum reactance of 2 PCT in order to help reduce neutral current when supplying loads with large amounts of third harmonic current.

I. Three phase transformers 15kVA and larger shall have a minimum of 4 - 2.5 PCT FCBN primary taps and 2 – 2.5 PCT FCAN taps for 480V primaries and a minimum of 2 – 5 PCT FCBN taps for 208V primaries.

J. Maximum temperature of top of enclosure shall not exceed 50 DEGC rise above a 40 DEGC ambient.

K. Transformer efficiencies shall be minimum in accordance with DOE 10 CFR Part 431 defined levels effective January 1, 2016. Older in-stock transformers are unacceptable. Efficiency values shall be determined in accordance with DOE 10 CFR Part 431.

Single Phase		Three Phase	
kVA	Efficiency percent	kVA	Efficiency percent
15	97.70	15	97.89
25	98.00	30	98.23
37.5	98.20	45	98.40
50	98.30	75	98.60
75	98.50	112.5	98.74
100	98.60	150	98.83
167	98.70	225	98.94
250	98.80	300	99.02
333	98.90	500	99.14

2.3 CONSTRUCTION

A. Transformer coils (except buck/boost type) shall be dual winding of continuous wound construction and shall be impregnated with nonhygroscopic, thermosetting varnish.

B. Cores to be constructed with low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below saturation point to prevent core overheating.

C. Completed core and coil shall be bolted to base of enclosure but isolated by means of rubber vibration-absorbing mounts.

D. Provide copper windings.

E. There shall be no metal-to-metal contact between core and coil and enclosure except for a flexible safety ground strap.

F. Sound isolation systems requiring complete removal of all fastening devices will not be acceptable.

G. Core of transformer shall be visibly grounded to enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.

H. Transformer enclosures shall be ventilated (30 kva and above) and fabricated of heavy gauge, sheet steel construction.

I. Provide finish suitable for outdoor applications as applicable.

J. Provide weather shields for outdoor units.

K. Sound levels shall be warranted by manufacturer not to exceed following:
   1. 15 to 50KVA: 45dB
   2. 51 to 150kVA: 50dB
   3. 151 to 300kVA: 55dB.
   4. 301 to 500kVA: 60dB.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Provide minimum of 2 IN clearance on both sides and rear of all ventilated transformers or greater when required by manufacturer. Provide 6 IN of clearance at rear transformer.

C. External wiring connections: See Section 26 05 33.

D. Provide wall mounting brackets and/or trapeze mounting supports and bracing as indicated or as required.

E. Floor-mounted transformers shall be mounted on concrete pads per Section 26 00 10.

F. Provide labeling per Section 26 05 53.

G. When stacking transformers, provide sheet metal heat shield between transformers.

END OF SECTION

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SECTION 26 23 00
SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Switchgear, as indicated, in accordance with provisions of Contract Documents.

B. Section Includes:
   1. Low voltage metal-enclosed switchgear.

C. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 05 00 - Electrical: Basic Requirements.
   4. Section 26 09 13 - Electrical Metering Devices.
   5. Section 26 27 26 - Wiring Devices.
   6. Section 26 28 00 - Overcurrent and Short Circuit Protective Devices.
   7. Section 26 36 00 - Transfer Switches.
   8. Section 26 43 13 - Low Voltage Surge Protective Devices (SPD).

D. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. American National Standards Institute (ANSI).

B. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
   1. C37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

C. National Electrical Manufacturers Association (NEMA):
   1. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

D. Underwriters Laboratories, Inc. (UL):
   1. 1558, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
   2. UL 943 - Ground Fault Circuit Interrupters.
   3. UL 1053 - Ground-Fault Sensing and Relaying Equipment.

E. Verify space required for switchgear is equal to or less than space allocated.

F. Design, assemble, test and install secondary unit substation in accordance with latest standards of NEMA, IEEE and ANSI, in accordance to major sections:
   1. Medium Voltage Load Interrupter Switchgear – NEMA SG4, SG5; ANSI C37.
   2. Secondary Substation Transformers – NEMA 210, IEEE 100, ANSI C57.
   3. Low Voltage Metal Enclosed Switchgear – ANSI C37, UL 1558.
   4. Low Voltage Switchgear – UL 891.

G. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Submit switchgear Shop Drawings and Product Data along with, or subsequent to, a complete short circuit analysis and coordination study per Section 26 28 00. Product data or shop drawings submitted prior to power system studies will be rejected.

B. Shop Drawings:
   1. General arrangement plan view showing door swings, cable entrance locations, shipping splits.
   2. Cross sections, elevations and details.
   3. Mimic bus layout.
   4. Complete single-line and three-line diagrams.
   5. AC and/or DC schematics of breaker control, metering.
   6. Point-to-point/terminal block wiring diagrams.

C. Product Data:
   1. Provide submittal data for products specified in Part 2 of this Section.
   2. Nameplate data for equipment.
   3. Mounting details and equipment weights.
   4. Installation instructions and procedures.
   5. See Specification Section 26 05 00 for additional requirements
   6. Specification comparison.
   7. Overcurrent protective device time-current characteristic curves, specifications and ratings, for coordination with source and load protective devices.

D. Contract Closeout Information:
   1. Operation and maintenance data.
      a. See Section 01 78 23.
   2. Owner instruction report.
   3. Installation certification report signed by manufacturer's representative.
   4. Ground fault protection system test reports signed by the projects supervising electrical foreman.
   5. Fabrication and/or layout drawings updated with as-built conditions.

1.4 DELIVERY, STORAGE AND HANDLING

A. Remove loose packing and flammable materials from inside switchgear and install temporary electric heating (250W per section) to prevent condensation.

B. Handle and prepare switchgear for installation according to NEMA PB 2.1.

1.5 WARRANTY

A. Manufacturer warranty to repair or replace switchgear enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship for three (3) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Switchgear:
   1. Base:
      a. Square D Company.
   2. Optional:
      a. General Electric Company.
      b. Eaton.
      c. Siemens.

2.2 SWITCHGEAR

A. Ratings:
   1. Voltage, number of phases, number of wires, and main bus current rating as indicated on the Drawings.
   2. Assembly short circuit current and circuit breaker fault interrupting rating as indicated on the Drawings.

3. Service Entrance Equipment rated when indicated on the Drawings.
4. 100 PCT rated breakers.

B. Construction:
1. Standards: IEEE C37.20.1, UL 1558.
2. Completely enclosed, dead-front, self-supporting metal structure.
3. Vertical panel sections bolted together.
4. Each vertical panel section is a self-contained housing with individual breaker or instrument compartments, a centralized bus compartment and a rear cabling compartment.
5. Individual circuit breaker compartments are segregated from adjacent compartments and sections, including the bus compartment, by means of steel barriers.
6. Traveling-type overhead circuit breaker lifter, rail-mounted on top of switchgear.
7. Bus protected by appropriate metal or nonmetallic barriers, shields and shutters.
8. NEMA 1 rated enclosure.
9. Where labeled outdoors NEMA 3R rated weatherproof enclosure:
   a. Non-Walk-in type with sloping roof downward toward rear.
   b. Front and rear hinged padlockable doors with wind stops for each section.
   c. Thermostatically controlled space heaters to minimize internal condensation.
   d. Power for heaters:
      1) Internally to the switchgear.
10. Interior and exterior steel surfaces cleaned and painted with rust inhibiting primer and manufacturers standard paint.

C. Buses:
1. Tin-plated copper or silver-plated copper.
2. Main horizontal bus:
   a. Fully rated and continuous over length of switchgear with all three (3) phases arranged in the same vertical plane.
   b. Sufficient size to limit temperature rise to 65 DEGC over average air temperature outside the enclosure of 40 DEGC.
   c. Insulated with a minimum of 5 MIL thickness of epoxy resin coating.
      1) Removable non-PVC boots used to give access to the cross bus joints.
3. Neutral bus: Fully rated and continuous over length of switchgear.
4. Ground bus: 1/4 x 2 IN copper, continuous over length of switchgear, solidly grounded to each vertical section structure and meet the short time withstand rating of the largest breaker.
5. Bus joints connected using through bolts and conical spring-type washers for maximum conductivity.
6. Main switchgear: Solidly connect main grounding bus to grounding electrode system. Provide ground to neutral bus disconnecting link in service section.
   a. Provide UL "Service Entrance Label".
7. Provide lugs ahead of main device in main switchgear for the following:
   a. Firepump.

D. Vertical Sections:
1. Provide vertical section separation for Emergency main switchgear in compliance with NEC Section 700.

E. Overcurrent and Short Circuit Protective Devices:
1. Main overcurrent protective device:
   a. Drawout low voltage power circuit breaker.
2. Feeder overcurrent protective devices:
   a. Drawout low voltage power circuit breaker.
3. See Specification Section 26 28 00 for overcurrent and short circuit protective device requirements.
4. Factory installed.

F. Surge Protective Device:
   1. Integrally mounted, see Specification Section 26 43 13.

G. Metering:
   1. Power monitor:
      a. Separate compartment with hinged door.
      b. See Specification Section 26 09 13 for meter requirements.

H. Accessories:
   1. Coordinate installation methods and provide lay down brackets or other hardware to facilitate the installation of the gear without damage

I. Main Bus Ground Fault Current Protection:
   1. Provide ground fault protection for main bus:
      a. Zero phase sequence transformers for phase and neutral buses shall be split rectangular type.
      b. Design ground fault relays for semi-flush switchgear mounting, self-protecting, unaffected by asymmetric or harmonic load currents, with time delay adjustment from instantaneous to 60 cycle.
      c. Include:
         1) Solid state construction, encapsulated.
         2) Test circuit with cut-off switch.
         3) Fail-safe indicating lamp.
         4) Terminals for remote-alarm circuits.
         5) Reset controls.
         6) Adjustable sensitivity from 5 to 60 A and 100 to 1200 A as applicable.
      d. Provide 480/120V control transformers with current-limiting fuses.
      e. Ground fault relays and pilot lights shall be wired to auxiliary contacts in associated main or tie breaker such that when breaker is open the associated ground fault relay will be out of service.
      f. Main Bus Ground Fault Current Indication:
      g. Provide adjustable ground fault indication for main devices similar to that specified for main switchgear except main breaker shall not trip on ground fault. Ground fault shall be indicated at generator remote derangement signal annunciator. Post a sign at main breaker stating course of action in event of a ground fault. Verify contents of statement with Owner:
      h. Provide NC auxiliary switch for interconnection with generator derangement signal annunciator.

J. Provide ground fault indication on main emergency switchgear.

K. Arcflash Measures:
   1. Breaker Frames 1200A and greater shall include an Arc Flash Maintenance Switch with Local Annunciations.
   2. Rack out breakers shall be remotely racked in/out.
   3. Breakers shall include a 30 FT long remote breaker operation interface.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Perform standard factory tests on primary equipment provided under this section.
   1. Test in accordance with latest version of ANSI and NEMA standards.

B. Complete sequence of operation testing.
   1. Test sequence shall be preapproved by the Owner.

C. Factory tests as outlined above shall be witnessed by the Owner's Representative.
   1. Manufacturer shall notify Owner Four (4) weeks prior to the date tests are to be performed.

2. Manufacturer shall include cost of transportation, meals, and lodging for up to two (2) Owner's Representatives and two (2) Design Engineers.

D. Following standard factory tests shall be performed on switchgear.
   1. Tests shall be in accordance with the latest version of ANSI and NEMA standards.
   2. Switchgear shall completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchgear shall be tested to ensure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test in accordance with ANSI C37.20.1.
   3. Wiring and control circuits shall be tested in accordance with ANSI C37.20.1.

3.2 INSTALLATION

A. Install switchgear in accordance with manufacturer's instructions.

B. Arrange switchgear as shown on Drawings.

C. Indoor Locations:
   1. NEMA 1 enclosure.
   2. Install on concrete housekeeping pad.
      a. Align front of switchgear with top edge of pad chamfer and securely bolt to floor sills (C channel) set level (within 1/8 IN) and embedded in the concrete.

D. Outdoor location:
   1. NEMA 3R enclosure.
   2. Install on concrete pad, align front of switchgear with top edge of pad chamfer and securely bolt to floor sills set level and embedded in the concrete.

E. Miscellaneous:
   1. Provide circuit protective devices and other associated equipment as indicated on the Drawings.
   2. Neatly lace all control wires and have flexibility at hinge locations.

3.3 FIELD QUALITY CONTROL

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. Test the ground fault protection and indication systems as indicated in Specification Section 26 28 00.
   1. Ground fault: Test installed ground fault system. Use high current injection method to test system and submit report indicating device settings, tripping time in cycles for each device, test current and date of test as well as name of certified testing firm that performed the test.
      a. Ground fault protection for operation of the main and feeder overcurrent protective devices shall be fully selective such that main device will not open and feeder device will open on ground faults on load side of feeder device. A six cycle minimum separation between main and feeder ground-fault tripping bans shall be provided. Comply with all NEC requirements.

3.4 LABELING

A. Provide switchgear labeling as specified in Section 26 00 10.

3.5 TRAINING

A. A qualified factory-trained manufacturer's representative shall provide the Owner with 2 days of on-site training, for multiple staff shifts, in the operation and maintenance of the switchgear and its' components. Training shall be Video Recorded.

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SECTION 26 24 13
SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Switchboards, as indicated, in accordance with provisions of Contract Documents.

B. Section Includes:
   1. Low voltage switchboards.
   2. Completely coordinate with work of other trades.

C. Related Specification Sections include but are not necessarily limited to:
   1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 01 - General Requirements.
   3. Section 26 00 10 – Electrical General Requirements.
   4. Section 26 27 26 - Wiring Devices.
   5. Section 26 28 00 - Overcurrent Protective Devices.
   6. Section 26 36 23 – Automatic Transfer Switches.
   7. Section 26 51 13 - Interior Lighting.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI).
      a. ANSI/IEEE C12.16 – Solid State Electricity Metering.
      b. ANSI C39.1 - Electrical Analog Indicating Instruments.
      c. ANSI C57.13 - Instrument Transformers.
   2. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   3. Underwriters Laboratories, Inc. (UL):
      a. UL 489 – Molded Case Circuit Breakers.
      b. UL 891 – Dead-Front Switchboards.
      c. UL 943 - Ground Fault Circuit Interrupters.
      d. UL 1053 - Ground-Fault Sensing and Relaying Equipment.

B. Verify space required for switchgear is equal to or less than space allocated.

C. Secondary unit substation shall be designed, assembled, tested and installed in accordance with latest applicable standards of NEMA, IEEE and ANSI, applicable to its major sections:
   1. Medium Voltage Load Interrupter Switchgear – NEMA SG4, SG5; ANSI C37.
   2. Secondary Substation Transformers – NEMA 210, IEEE 100, ANSI C57.
   3. Low Voltage Metal Enclosed Switchgear – ANSI C37, UL 1558.
   4. Low Voltage Switchboards – UL 891.

D. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Submit Switchboard Shop Drawings and Product Data along with, or subsequent to, a complete short circuit analysis and coordination study per Section 26 28 00. Product data or shop drawings submitted prior to power system studies will be rejected.

B. Shop Drawings:
   1. Product technical data:
   2. Fabrication and/or layout drawings:
      a. General arrangement plan view showing door swings, cable entrance locations, shipping splits, instrument details, etc.
      b. Cross sections, elevations and details.
      c. Mimic bus layout.
      d. Complete single-line and three-line diagrams.
      e. AC and/or DC schematics of breaker control, metering, etc.
      f. Point-to-point/terminal block wiring diagrams.
      g. Cable terminal sizes.
      h. Busway connection.
      i. Key interlock scheme drawing and sequence of operations.

C. Product Data:
      a. Technical data on each component.
      b. Nameplate data and legends for equipment.
      c. Mounting details and equipment weights.
      d. Installation instructions and procedures.
      e. See Specification Section 26 00 10 for additional requirements.
      f. Component list
      g. Conduit space locations within assembly.
      h. Assembly ratings including:
         1) Short circuit rating.
         2) Voltage.
         3) Continuous current rating.
      i. Major component ratings including:
         1) Voltage.
         2) Continuous current rating.
         3) Interrupting ratings.
   2. Specification comparison.
   3. Overcurrent protective device time-current characteristic curves, specifications and ratings, for coordination with source and load protective devices.

D. Project Information:
   1. Certified test reports on protective devices, in enclosures if requested by Architect/Engineer.

E. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.
   3. Installation certification report signed by the manufacturer's representative.
   4. Fabrication and/or layout drawings updated with as-built conditions.

1.4 DELIVERY, STORAGE AND HANDLING

A. Remove loose packing and flammable materials from inside switchboard and install temporary electric heating (250W per section) to prevent condensation.

B. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.5 WARRANTY

A. Manufacturer warranty to repair or replace switchgear enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship for three (3) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Switchboards:
   1. Base:
      a. Square D Company.
   2. Optional:
      a. Eaton Electrical.
      b. Siemens.

2.2 SWITCHBOARDS

A. Ratings:
   1. Voltage, number of phases, number of wires, and main bus current rating as indicated on the Drawings.
   2. Assembly short circuit current and circuit breaker fault interrupting rating as indicated on the Drawings.
   3. Bus system with a minimum ANSI 4-cycle short circuit withstand rating of 100 KAIC.

B. Construction:
   1. Standards: NEMA PB2, UL891.
   2. Accessibility: Front.
   3. Completely enclosed, dead-front, self-supporting metal structure.
   4. Vertical panel sections bolted together.
   5. Frames bolted together to support and house bus, cables and other equipment.
   6. Frames and insulating blocks to support and house bus, cables and other equipment. Frames and insulating blocks to support and brace main buses for short circuit stresses up to rating indicated on the drawings.
   7. NEMA 1 rated enclosure.
   8. Interior and exterior steel surfaces cleaned and painted with rust inhibiting primer and manufacturers standard paint.

C. Buses:
   1. Material: Silver-plated copper.
   2. Main horizontal bus:
      a. Fully rated and continuous over length of switchboard with all three (3) phases arranged in the same vertical plane with provisions for future extension.
      b. Heat rise of all buses shall not exceed ANSI/UL-891 listings.
   3. Neutral bus: Fully rated and continuous over length of switchboard with provision for future extension.
   4. Ground bus: 1/4 x 2 IN copper, continuous over length of switchboard, solidly grounded to each vertical section structure and meet the short time withstand rating of the largest breaker.
   5. Bus joints connected using through bolts and conical spring-type washers for maximum conductivity.

D. Vertical Sections:
   1. Provide vertical section separation for Emergency main switchboard in compliance with NEC Section 700.

E. Overcurrent and Short Circuit Protective Devices:
   1. Main overcurrent protective device:
      a. Individually mounted molded case circuit breaker.
   2. Feeder overcurrent protective devices:
      a. Group mounted molded case circuit breaker.
   3. See Section 26 28 00 for overcurrent and short circuit protective device requirements.
   4. Factory installed.
   5. Means to padlock all devices in the open position.

F. Surge Protective Device:
   1. Integrally mounted.

G. Accessories:
   1. Coordinate installation methods and provide lay down brackets or other hardware to facilitate the installation of the gear without damage
   2. Provide each circuit with engraved nameplate with white cut letters to designate purpose of circuit.

H. Insulated Case Circuit Breakers:
   1. Individually mounted devices.
   2. Operation: Manual with manual closing lever.
   3. Construction: Fixed.
   4. For normal switchboard, provide adjustable ground fault protection to selectively open main, tie, when provided, and feeder devices. Provide ground fault indication on emergency switchgear.

I. Molded Case Circuit Breakers:
   1. Individually mounted devices.
   2. Operation: Manual with manual closing lever.
   3. Construction: Fixed.
   4. Provide integral customer metering at each feeder device. Connect cold sequence.
   5. Provide adjustable ground fault protection for each device.

J. Ground fault indication shall be provided on the main emergency switchboard.

K. Arcflash Measures
   1. Breaker Frames 1200A and greater shall include an Arc Flash Maintenance Switch with Local Annunciations.
   2. Rack out breakers shall be remotely racked in/out.
   3. Breakers shall include a 30 FT long remote breaker operation interface.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Standard factory tests shall be performed on the primary equipment provided under this section.
   1. Tests shall be in accordance with latest version of ANSI and NEMA standards.

B. Sequence of operation testing shall be completed. The test sequence shall be preapproved by the Owner.

C. Factory tests as outlined above shall be witnessed by the Owner’s Representative.
   1. The manufacturer shall notify the Owner Four (4) weeks prior to the date the tests are to be performed.
   2. The manufacturer shall include cost of transportation, meals, and lodging for up to two (2) Owner’s Representatives and two (2) Design Engineers.

D. The following standard factory tests shall be performed on the switchgear. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
   1. The switchgear shall completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchboard shall be tested to ensure the accuracy of the wiring and the functioning of all equipment. The main bus system shall be given a dielectric test in accordance with ANSI C37.20.1.
   2. The wiring and control circuits shall be tested in accordance with ANSI C37.20.1.

3.2 INSTALLATION

A. Install switchgear in accordance with manufacturer's instructions.

B. Arrange switchgear as shown on the Drawings.

C. Indoor Locations:
   1. NEMA 1 enclosure.
   2. Install on concrete housekeeping pad.
      a. Align front of switchgear with top edge of pad chamfer and securely bolt to floor sills (C channel) set level (within 1/8 IN) and embedded in the concrete.

D. Miscellaneous:
   1. Provide circuit protective devices and other associated equipment as indicated on the Drawings.
   2. Neatly lace all control wires and have flexibility at hinge locations.

3.3 FIELD QUALITY CONTROL

A. A qualified factory-trained manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

B. Test the ground fault protection and indication systems as indicated in Specification Section 26 28 00.
   1. Ground fault: Test installed ground fault system. Use high current injection method to test system and submit report indicating device settings, tripping time in cycles for each device, test current and date of test as well as name of certified testing firm that performed the test.
      a. Ground fault protection for operation of the main and feeder overcurrent protective devices shall be fully selective such that main device will not open and feeder device will open on ground faults on load side of feeder device. A six cycle minimum separation between main and feeder ground-fault tripping bans shall be provided. Comply with all NEC requirements.
   2. Confirm Ground Fault Indication provides signal at generator derangement signal annunciator as required.

3.4 LABELING

A. Provide switchboard labeling as specified in Section 26 00 10.

3.5 TRAINING

A. A qualified factory-trained manufacturer's representative shall provide the Owner with 2 days of on-site training, for multiple staff shifts, in the operation and maintenance of the switchgear and its' components. Training shall be Video Recorded.

END OF SECTION

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SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Panelboards, as indicated, in accordance with provisions of Contract Documents.

B. Provide distribution panelboards and lighting and appliance panelboards as specified and indicated on schedules and drawings.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. System Standards:
   1. NEMA PB-1 – Panelboards.
   2. NEMA PB-1.1 – Instructions for Safe Installation, Operation and Maintenance of Panelboards rated 600 volt or Less.
   3. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
   4. UL 50 – Enclosures for Electrical Equipment.
   5. UL 67 – Panelboards.
   6. CSA Standard C22.2 No. 29-15– Panelboards and Enclosed Panelboards.
   7. Federal Specification W-P-115C – Type I Class 1.
   8. Federal Specification W-P-115C – Type II Class 1.

B. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Identify panelboards by alphanumeric designation with branch circuit breaker sizes and types indicated in panelboard schedules or one-line-diagram.
   2. Shop drawings and product data shall be submitted along with, or subsequent to, a complete short circuit analysis and coordination study per Section 26 28 00. Product data or shop drawings submitted prior to power system studies will be rejected.
   3. Coordination drawings showing final layout of equipment in all electrical rooms with actual panelboards submitted.

B. Product Data:
   1. Technical data on each type of panelboard.
   2. Specification comparison.

C. Contract Closeout Information:
   1. Operating and maintenance data.

1.4 DEFINITIONS

A. Lighting and appliance branch circuit: Branch circuit that has a connection to the neutral of the panelboard and that has overcurrent protection of 30 amperes or less in one or more conductors.

B. Lighting and appliance branch-circuit panel boards: Panelboard having more than 10 PCT of its overcurrent devices protecting lighting and appliance branch circuits.

C. Power Panelboard: Panelboard having 10 PCT or fewer of its overcurrent devices protecting lighting and appliance branch circuits. The terms “power panelboard” and “distribution panelboard” will be used interchangeably.

D. Load Center: Panelboard used in residential or light commercial applications shall not be used.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Panelboards:
1. Base:
    a. Schneider Electric/Square D.
    b. Eaton Electrical.
    c. Siemens.
    d. GE.

2.2 MATERIALS

A. Panelboards:
1. Dead front type.
2. Provide with non-insulated equipment grounding terminal strip located in top or bottom gutter including main grounding lug and individual terminals for at least 50 PCT of panel circuits including spare circuits and space provisions; increase gutter space accordingly for grounding strip.
3. Provide lighting panelboards with branch circuit connection to main bus arranged for sequence phasing.
4. Provide feed-thru lugs from multi-section panels and where indicated.
5. Equip bus bars for panelboard with main lugs, main fused switch or main circuit breaker, capacity as required or indicated.
6. Panelboard bussing to be copper.
7. Provide special features such as split bus, lighting contactors, extra-width gutters as required.
8. Provide panelboard busses fully rated for specified interrupting rating. Series rating of panelboards and overcurrent protective devices is not acceptable.
9. Provide full length bussing including areas indicated as space only.
10. Panelboards served by K-rated transformer shall be provided with neutral bus rated approximately 200 PCT of panel bus rating.
11. Provide integral surge protection per Section 26 43 13 where indicated on plans or schedules.

B. Circuit Breaker Panelboards:
1. Provide bolted-on circuit breakers for branch circuits serving lighting and receptacle circuits.
2. Main circuit breaker shall not be located in branch circuit section of panel unless specifically indicated.
3. Provide main busses and back panels which permit changing of circuit breakers without additional machining, drilling or tapping.
4. All multi-pole breakers provide single handle with common trip.
5. All multi-pole breakers, 100A rated and larger shall include means for padlocking in “OFF” position.
6. Include provisions for locking specific circuit breakers in the “ON” position where indicated.
7. Provide shunt trip mechanism on breakers where indicated.
8. Provide ground fault protection as indicated coordinated with upstream devices.
9. Design so a combination of one, two and three pole circuit breaker can readily be assembled in the same panelboard.

10. Circuit breakers operable in horizontal or vertical position and removable from front of panelboard without disturbing adjacent units.
11. Tandem or half-size circuit breakers not allowed.
12. Panelboard ratings:
    a. In 120/208 V panelboards: Minimum 10,000 AIC symmetrical, as indicated on drawings, or as required by power systems studies, whichever is greatest.
    b. In 277/480 V panelboards: Minimum 35,000 AIC symmetrical, as indicated on drawings, or as required by power systems studies, whichever is greatest.
13. Lighting and appliance branch-circuit panelboards:
    a. Types NQOD and NF.
    b. Branch circuits: Provide thermal-magnetic circuit breaker.
14. Distribution panel boards:
    a. I-Line.
    b. Feeder circuits: Provide electronic trip circuit breaker with independently adjustable instantaneous pick-up, longtime pick-up and delay, short time pick-up, short time delay, and ground fault pick-up and delay.

C. Load Centers: Shall not be allowed.

D. Ground fault circuit interrupter circuit breakers:
   1. Provide separate neutral for each interrupter circuit where neutral is required.

E. Cabinets:
   1. Galvanized sheet steel, code thickness.
   2. 5-3/4 IN deep by 20 IN wide minimum.
   3. Multi-section panels shall have equal height enclosures in finished areas.
   4. Fasten trim to cabinet by means of adjustable clamps on one side and piano hinge on the other side.
   5. Equip door with chrome-plated combination lock and catch; supply two milled keys with each lock; key locks alike.
   6. Provide directory frame on inside of door.
   7. Identify all circuit locations in each respective panel with load and location served.
      a. Directory shall be typed.
      b. Typed directory database (Microsoft Excel file, Microsoft Word file, or equivalent) to be given to Owner to incorporate future circuit changes.
      c. Mechanical equipment identified in directory shall be Owner-furnished designation and not designation indicated on plans.
      d. Room names and numbers in directory shall be final building room names and numbers as identified by Owner and not name or number indicated on plans.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Panelboard Cabinet Supports:
   1. Finished areas:
      a. Attach to studs via unistrut cross members or metal backing bolted or welded to studs where not otherwise shown.
   2. Masonry or concrete walls:
      a. Attach to wall via unistrut cross members where not otherwise shown.

C. Wall mounted panelboards shall be installed 6 IN above floor minimum.
   1. Large panels that rest on floor shall be mounted on house-keeping pads per Section 26 00 10.

D. Provide spare conduits into accessible ceiling space from all flush wall mounted panelboards.
   1. Provide one spare 3/4 IN conduit for each 3 spare and/or space branch circuit poles or fraction thereof but no less than two spare 3/4 IN conduits.

E. Electrical Room layout and panelboard installation shall maximize the ability to install additional equipment in rooms. Contractor to submit coordination drawings indicating final layout of equipment with actual panelboards and spare conduits submitted.

3.2 LABELING

A. Provide panelboard labeling as specified in Section 26 05 53.

B. Permanently post, at each panelboard, the conductor color coding scheme specified in Section 26 05 19.

END OF SECTION

SECTION 26 24 19
MOTOR CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Motor Control Equipment, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 SUBMITTALS

A. Shop Drawings:
   1. Motor control equipment:
      a. Outline drawings of assembly.
      b. One line diagrams and wiring diagrams for assembly and components.
      c. Interconnection wiring diagrams.
   2. Coordination drawings:
      a. Plan drawings showing location of each control equipment and associated motor equipment.
      b. Tabulated list of equipment and associated control equipment.

B. Product Data:
   1. Technical data on each type of controller and/or feeder device.
   2. Specification comparison.

C. Contract Closeout Information:
   1. Operation and Maintenance Data.
   2. Owner instruction report.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Motor Control Equipment:
   1. Base:
      a. Schneider Electric/Square D.
      b. Eaton Electrical.
      c. Siemens.

2.2 MATERIALS

A. Motors:
   1. Motors 1/2 HP and above: 460V, three phase, 60 cycle; provide 3 phase combination magnetic starters.
   2. Do not provide starters if indicated as part of Mechanical Specifications Divisions work.
   3. Motors below 1/2 HP: 115V, single phase, 60 cycle; provide manual thermal element units.

B. Enclosures:
   1. General:
      a. Service voltage: 480 V, 3 phase, 60 cycle.
      b. Branch circuit short circuit protection: Motor circuit protector (MCP).
         1) Operating handle shall clearly indicate whether MCP is on, off or tripped.
         2) Provide means to lock each operating handle in off position with cover closed by means of one to three padlocks.

3) Interlock so that operating handle must be in off position before door can be opened.

c. Finish: Thoroughly clean structure inside and out after fabrication and apply prime coat, and two coats of light gray (ANSI Color 61) or medium light gray (ANSI Color 49) enamel, inside and out.

2. Combination controller/disconnect: NEMA standard construction, Type A wiring in NEMA 1 general purpose enclosure.
   a. Combination motor controller with motor circuit protector.
   b. Eaton Electrical Class A206 with motor circuit protector.

C. Automatic Controllers:
1. General:
   a. Provide with three overload relays for complete single-phasing and overload protection.
   b. Provide START-STOP push button station or selector switch and red pilot light, or pilot light only, for each motor starter on cover of each unit where indicated on drawings or schedules.
   c. Provide with two extra NO interlocking contacts in addition to seal-in contacts.
   d. Provide 480/120 volt control transformer with 2 primary and one secondary fuse.
   e. Overload relays:
      1) Bimetallic type.
2. Combination full voltage non-reversing starters:
   a. External manual reset thermal overload relays.
   b. Eaton Electrical class A-206 with motor circuit protector.

D. Manual Controller:
1. Manual thermal element units: 120/240 volt, single phase, maximum 1 HP, with overload protection and toggle switch.
   a. Provide means for padlocking in off position.
   b. Eaton Electrical Type MS.

E. VFD:

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

B. Set adjustable trip settings of motor circuit protectors to match characteristics of motor installed.

C. Provide heater elements which match characteristics of motor installed.

3.2 LABELING

A. Provide labeling as specified in Section 26 00 10.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Wiring Devices, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Provide wiring devices conforming to the following standards:
   1. Underwriter's Laboratories (UL).
      a. UL 498 – Standard for Attachment Plugs and Receptacles.
      b. UL 514D – Cover Plates for Flush-Mounted Wiring Devices.
      c. UL 943 – Standard for Safety for Ground-Fault Circuit-Interrupters.
   2. National Electric Manufacturers Association (NEMA).
      a. WD-1 – General Color Requirements for Wiring Devices.
      b. WD-6 – Wiring Devices – Dimensional Requirements.
   3. US Federal Specifications.
      a. Fed Spec receptacles (WC-596F).
      b. Fed Spec device plates (W-P-455).

B. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Product Data:
   1. Technical data on each type of device.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Wiring Devices:
   1. Base:
      a. Hubbell.
   2. Optional:
      a. Cooper.
      b. Leviton Manufacturing.
      c. Pass & Seymour (Legrand).
      d. Bryant.
   3. All wiring devices shall be provided by the same manufacturer.

2.2 MATERIALS

A. Duplex and Single Receptacles:
   1. Flush, grounding convenience outlets for side wiring, or side and back wiring.
   2. Listed per UL 498 for general use and certified by UL to Fed Spec WC-596F, and shall be visibly marked with the "UL-FS" mark to confirm certification.
      a. Constructed with impact resistant nylon or polyester face and body.
      b. 0.050 IN brass nickel-plated back strap with one piece (non-riveted) ground design.
      c. 0.040 IN brass nickel-plated contacts.

3. Use white devices for "normal" circuits.
4. Use red devices on "emergency" circuits.
5. Refer to Symbol Legend on Drawings.
6. Receptacles:
   a. Specification grade for general use.
   b. 20A, 125V, 2 pole, 3-wire grounding, duplex, specification grade, NEMA 5-20R; Hubbell HBL5362.
7. Ground Fault Circuit Interrupter (GFCI) type receptacle:
   a. With built-in ground fault interruption, 4 to 6 mA trip sensitivity, 0.025 second trip time, 10,000 A maximum interrupting capacity, self-testing technology, indicator and reset.
   b. 20A, 125V, 3-wire duplex, specification grade, NEMA 5-20R; Hubbell GFRST20.
8. Isolated ground receptacles:
   a. Device type as indicated with receptacle ground isolated from conduit grounding system.
   b. IG symbol imprinted on face of receptacle.
   c. Use orange devices.
   d. 20A, 125V, 3-wire duplex, specification grade, NEMA 5-20R; Hubbell IG-5362.
9. USB charger duplex receptacles:
   a. Two USB Type 2.0 ports 3 amp, 5 volts DC.
   b. Complies with battery charging specification USB BC1.2.
   c. Compatible with USB 1.1/2.0/3.0 devices, including Apple products.
   d. Complies with Part 15 of the FCC rules.
   e. 20A, 125V, 3-wire duplex, specification grade, NEMA 5-20R; Hubbell USB20X2.
10. Surge suppression receptacle.
   a. Device type as indicated with integral surge protection rated at 240 joules/15000 amps per mode.
   b. Power on indicator light.
   c. Beeper to sound when protection is no longer functioning.
   d. Comply with UL-1449 and ANSI/IEEE-62.41.
   e. Blue device.
   f. 20A, 125V, 3-wire duplex, specification grade, NEMA 5-20R; Hubbell HBL5362S.

B. Special Purpose Receptacles:
   1. Straight Blade:
      a. NEMA 6-20R receptacle: 20A, 250V, 2 pole, 3 wire grounding, side and back wired, single; ivory, Hubbell HBL5461I.
      b. NEMA 14-20R receptacle: 20A, 125/250V, 3 pole, 4 wire, 1 phase grounding, single; black; Hubbell HBL8410.
      c. NEMA 15-20R receptacle: 20A, 250V, 3 pole, 4 wire, 3 phase grounding, single, black; Hubbell HBL8420.
      d. NEMA 5-30R receptacle: 30A, 125V, 2 pole, 3 wire grounding, single, black; Hubbell HBL9308.
      e. NEMA 6-30R receptacle: 30A, 250V, 2 pole, 3 wire grounding, single, black; Hubbell HBL9330.
      f. NEMA 10-30R receptacle: 30A, 125/250V, 3 pole, 3 wire, 1 phase, single, brown; Hubbell HBL9350.
      g. NEMA 14-30R receptacle: 30A, 125/250V, 3 pole, 4 wire, 1 phase grounding, single, black; Hubbell HBL9430A.
      h. NEMA 15-30R receptacle: 30A, 250V, 3 pole, 4 wire, 3 phase, grounding, single, black; Hubbell HBL8430A.
      i. NEMA 6-50R receptacle: 50A, 250V, 2 pole, 3 wire, 1 phase, grounding, single, black; Hubbell HBL9367.
      j. NEMA 10-50R receptacle: 50A, 125/250V, 3 pole, 3 wire, 1 phase; black; Hubbell HBL7962.

k. NEMA 14-50R receptacle: 50A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single, black; Hubbell HBL9450A.
l. NEMA 15-50R receptacle: 50A, 250V, 3 pole, 4 wire, 3 phase, grounding, single, black, Hubbell HBL8450A.

2. Twist-Lock:
   a. NEMA L5-20R receptacle: 20A, 125V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2310.
   b. NEMA L6-20R receptacle: 20A, 250V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2320.
   c. NEMA L14-20R receptacle: 20A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2410.
   d. NEMA L15-20R receptacle: 20A, 250V, 3 pole, 4 wire, 3 phase, grounding, single, twist-lock; black; Hubbell HBL2420.
   e. NEMA L5-30R receptacle: 30A, 125V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2610.
   f. NEMA L6-30R receptacle: 30A, 250V, 2 pole, 3 wire, 1 phase grounding, single, twist-lock; black; Hubbell 2620.
   g. NEMA L14-30R receptacle: 30A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2710.
   h. NEMA L21-30R receptacle: 30A, 250V, 3 pole, 4 wire, 3 phase, grounding, single, twist-lock; black; Hubbell HBL2810.

C. Device Plates:
   1. Device plates for concealed wiring: Same manufacturer as devices to suit device covered; single, or ganged, in one piece with beveled edges that match faces of plates.
      a. Flush, brushed-finish, type 304 stainless steel.
   2. Device plates for surface type cast-metal boxes: Corrosion resistant cast ferrous metal designed for application.
   3. Labeling:
      a. General:
         1) Where labeling of device plates is required, provide engraved laminated nameplate or engraved device plate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate devices as indicated and as scheduled in Section 26 00 10.

B. Center outlets with regard to paneling, furring, trim, tile, etc.

C. Where several outlets occur in a room, symmetrically arrange them.

D. Any outlet which is improperly located must be corrected at Contractor's expense.

E. Set outlets plumb or horizontal and extending to finished surface of wall, ceiling or floor as case may be without projecting beyond same.

F. Install receptacles indicated on wood trim, cases or other fixtures symmetrically. Where necessary, set with long dimension of plate horizontal, or gang in tandem.

G. GFCI receptacles shall be connected so that downstream devices are not protected by GFCI receptacle.

END OF SECTION

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SECTION 26 28 00
OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Overcurrent Protective Devices, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. System standards:
   1. NEMA AB 1 1993 - (National Electrical Manufacturers Association) Molded Case Circuit Breakers and Molded Case Switches
   2. UL 489 - (Underwriters Laboratories Inc.) Molded Case Circuit Breakers and Circuit Breaker Enclosures
   3. UL 943 - Standard for Ground Fault Circuit Interrupters
   4. CSA C22.2 No. 5.1 - M91 - (Canadian Standard Association) Molded Case Circuit Breakers
   5. Federal Specification W-C-375B/GEN - Circuit Breakers, Molded Case; Branch Circuit and Service
   6. All power circuit breakers shall be constructed and tested in accordance with ANSI C37.13, C37.16, C37.17, C37.50, UL 1066 and NEMA SG-3 standard.
   7. IEEE 399 (Brown Book) – Recommended Practice for Industrial and Commercial Power Systems Analysis.
   8. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations.
   9. NFPA 70E – Standard for Electrical Safety Requirements for Employee Workplaces.
   10. IEEE 519 – Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

1.3 SUBMITTALS

A. Shop Drawings:
   1. Power system study:
      a. Power system study shall be completed using SKM computer software. Both hard paper copies, PDF, and the electronic SKM model shall be submitted at each submission.
      b. Submittal 1:
         1) Prior to or at same time as distribution equipment shop drawings and prior to release of equipment for manufacturer. No distribution equipment shall be released for manufacture until Engineer has reviewed and approved power system study submittal 1. Submittal 1 to include preliminary:
            a) Short circuit study.
            b) Coordination study.
            c) Arc flash study.
            d) Harmonics study.
      c. Submittal 2:
         1) Field verify conductor lengths after installation. Update power system study with actual installed equipment, conductor lengths and any changes in conductor sizes. Submit updated study at least 3 months prior to applying final settings for testing and 6 months prior to substantial completion of project. Include any recommended changes in Submittal 2. Submittal 2 to include final:
            a) Short circuit study.
            b) Coordination study.
            c) Arc flash study.
            d) Harmonics study.

d. Performed by independent, third party firm or by manufacturer of electrical distribution equipment. Study to be stamped and signed by registered professional engineer. Submit credentials of individual(s) performing study and background of firm for approval prior to start of work. Minimum of five years experience in high and low voltage power system analysis is required for individual in charge of producing study.
e. Provide computer generated system one-line diagram clearly identifying individual equipment buses, bus numbers, device numbers and maximum available short-circuit current at each bus.
f. Use specified conductor sizes and estimated conductor lengths for shop drawing.
g. Short circuit study:
    1) Provide calculation methods and assumptions, base per unit quantities selected, one-line diagrams, source impedance data including utility company system characteristics, typical calculations, tabulations of calculation quantities and results, conclusions and recommendations.
    2) Notify Engineer in writing of equipment not properly rated for fault conditions. Identify any prohibited operating/switching scenarios that would over-duty certain identified equipment.
h. Coordination study:
    1) Provide determination of settings, ratings, or types for overcurrent protective devices supplied. Where necessary, appropriate compromise shall be made with system protection and service continuity considered to be of equal importance.
    2) Breakers shall be set to trip as quickly as possible without compromising overall coordination to limit arc flash hazard energy to the lowest level possible.
    3) Provide sufficient number of log-log plots to indicate degree of system protection and coordination. Log-log plots shall include transformer ANSI withstand points and inrush currents of transformers and motors where appropriate.
    4) Computer printouts or equivalent tabular format to accompany log-log plots containing descriptions for all devices indicated on plot, settings of adjustable devices, device numbers to simplify location of devices on system one-line diagram.
    5) Provide data in tabular format of suggested settings of adjustable overcurrent protective devices, equipment where each device is located, device number corresponding to device on system one-line diagram, and number of time-current log-log plots where they are illustrated. Similar or like devices may be illustrated by using “typical” plots. Every device need not be separately illustrated.
    6) Provide discussion section evaluating degree of system protection and system continuity with overcurrent devices, with recommendations as required for increased protection or coordination.
    7) Include complete title and one-line diagram with legend with each curve sheet identifying specific portion of system covered by that particular curve sheet.
    8) Include detailed description of each protective device identifying its type, function, manufacturer and time-current characteristics.
    9) Tabulate recommended device tap, time dial, pickup, instantaneous and time delay settings.
    10) Provide time-current curves graphically indicating coordination proposed for system, centered on 8.5 x 11 IN, log-log forms.
    11) Any inadequacies shall be called to attention of Engineer and recommendations shall be made for improvements.
i. Arc flash study:
    1) Provide arc flash study in conjunction with short circuit and protective device coordination study.
    2) Include all electrical distribution equipment in study including but not limited to:
        a) Switchgear and switchboards.
        b) Distribution and branch circuit panel boards.
        c) Automatic transfer switches.

3) Arc flash boundary distances and incident energy at each device shall be determined by worst case incident energy at that device resulting from maximum and minimum available fault current at main distribution switchgear or switchboard for each valid system operating/switching mode under all probable source conditions. For low voltage equipment (600 volt and below), incident energy calculations shall be made at 100 PCT and 85 PCT arcing current per IEEE 1584.
4) Provide tabulation of data for each bus analyzed.
5) Provide Arc Flash warning Labels for each piece of equipment.

j. Harmonics study:
1) Submit scope, process, basis of calculations, data collection, assumption, etc.
2) Perform complete Preliminary Harmonic Analysis based on approved equipment and compare results with specified criteria.
3) If criteria is not achieved provide recommendations on additional harmonics mitigation.
4) Perform additional Harmonic Analysis based on recommendations that achieve specified criteria.
5) Include discussion on potential impact(s) if recommendations are not implemented.

B. Product Data:
1. Technical data on each type of device including:
a. Outline drawings with dimensions.
b. Ratings for voltage, amperage and maximum interrupting ratings.
c. Trip unit functions and adjustments
d. Accessories.
e. Wiring diagrams.
f. Manufacturer shall provide hard copy time/current characteristic trip curves (and Ip & I^2t let through curves for current limiting circuit breakers) for each type of circuit breaker.
2. Specification comparison.
3. Submit with associated switchgear, switchboard, panelboard or other assembly.

C. Contract Closeout Information:
1. Operation and Maintenance Data.
a. Include instructions for circuit breaker mounting, trip unit functions and adjustments, trouble shooting, accessories and wiring diagrams.
2. Final power system study based on actual installed equipment, field measured conductor lengths and any applicable modifications to contract documents.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Overcurrent Protective Devices.
1. Base:
a. Eaton Electric.
b. Schneider Electric/Square D.
c. Siemens.
d. General Electric.

B. Fuses:
1. Base:
a. Bussmann.
b. Ferraz Shawmut.
c. Brush.
d. Littelfuse.

C. Equipment and devices by same manufacturer.

2.2 MATERIALS

A. Circuit Breakers:
  1. Provide circuit breakers as required by other specifications and drawings. Provide special features as indicated including but not limited to:
     a. Drawout construction.
     b. Electrical operation.
     c. Key interlock for main-tie-main arrangements.
     d. Ground fault protection.
  2. Provide lugs rated for 75 degree C wire minimum.
  3. Contractor shall review one line diagrams and confirm that circuit breakers have adequate lugs to accommodate size and quantity of conductors indicated on one line diagrams, panel and motor control schedules.
  4. Lugs shall be UL Listed to accept solid (not larger than #8 AWG) and/or stranded copper and aluminum conductors.
  5. Circuit breakers shall be capable of accepting bus connections.
  6. Overcurrent devices shall be fully rated for available fault current unless otherwise specifically indicated.
  7. Frame sizes 1000 and greater shall include ground fault protection.
  8. Frame sizes 1200 and greater shall include "Arc Flash Maintenance Mode" switch and local annunciator.
  9. Molded case type
     a. Constructed of glass reinforced insulating material. Current carrying components shall be completely isolated from handle and accessory mounting area.
     b. Provide over center, trip free, toggle operating mechanism which shall provide quick-make, quick-break contact action. Provide common tripping of two and three pole circuit breakers.
     c. Circuit breaker handle shall reside in a tripped position between ON and OFF to provide local trip indication. Circuit breaker escutcheon shall be clearly marked ON and OFF in addition to providing International I/O markings.
     d. Maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker.
     e. Provide each circuit breaker with push-to-trip button, located on face of circuit breaker to mechanically operate circuit breaker tripping mechanism for maintenance and testing purposes.
     f. Provide factory seal with date code on face of circuit breaker.
     g. Provide circuit breakers equipped with UL Listed electrical accessories as noted on associated schedule or drawing.
     h. Provide circuit breaker handle accessories with provisions for locking handle in ON and OFF position as noted on associated schedule or drawing.
     i. Provide circuit breakers UL Listed for reverse connection without restrictive line and load markings and suitable for mounting in any position.
     j. Provide circuit breakers UL Listed to accept field installable/removable mechanical type or compression type lugs. Provide lug body bolted in place; snap in design not acceptable.
     k. Thermal-Magnetic Circuit Breakers:
        1) Used only as follows unless otherwise indicated:
           a) Main, feeder and branch circuit breakers in lighting and appliance panelboards as defined in Section 26 24 16.
           b) Main, feeder and branch circuit breakers rated 125 amps and less in distribution panel boards as defined in Section 26 24 16.
           c) Motor circuit protectors.
        2) Do not use in switchboards rated over 400 amps.
        3) Provide permanent trip unit containing individual thermal and magnetic trip elements in each pole.

4) Thermal trip elements shall be factory preset and sealed. Circuit breakers shall be true rms sensing and thermally responsive to protect circuit conductor(s) in a 40 DEGC ambient temperature.
5) Provide circuit breaker frame sizes above 150 amperes with magnetic trip adjustment located on front of circuit breaker.
6) Provide UL Listed HACR type for two- and three-pole circuit breakers rated up to 250 amperes at 600 VAC.
7) Provide Class A (5 ma) sensitivity breaker where GFCI circuit breakers are indicated.
8) Provide equipment ground fault protection where indicated with following provisions:
   a) Modified zero sequence sensing system.
   b) Ground fault sensing system:
      (1) Requiring no external power to trip circuit breaker.
      (2) Suitable for use on grounded systems and suitable for use on three-phase, three-wire circuits where system neutral is grounded but not carried through system or on three-phase, four-wire systems.
      (3) Include ground fault memory circuit to sum time increments of intermittent arcing ground faults above pickup point.
      (4) Shall not affect interrupting rating of companion circuit breaker.
   c) Companion circuit breaker equipped with ground-fault shunt trip and capable of group mounting.
   d) Field adjustable Ground fault pickup current setting and time delay with switch for setting ground fault pickup point and means to seal pickup and delay adjustments.
   e) Means of testing ground fault system to meet on-site testing requirements of NEC.
   f) Local visual ground fault trip indication.

l. Electronic trip circuit breakers with standard function trip system
1) Provide standard function trip system on circuit breakers rated less than 400 amps unless otherwise indicated.
2) Provide circuit breaker trip system with microprocessor-based true rms sensing design with sensing accuracy through thirteenth (13th) harmonic and sensor ampere ratings as indicated on associated schedules or drawings.
3) Provide integral trip system independent of any external power source and with industrial grade electronic components.
4) Determine ampere rating of circuit breaker by combination of interchangeable rating plug, sensor size and long-time pickup adjustment on circuit breaker. Clearly mark sensor size, rating plug and adjustment positions on face of circuit breaker.
5) Provide circuit breakers UL listed to carry 80 PCT of ampere rating continuously.
6) Provide following time/current response adjustments, each with discrete settings independent from other adjustments:
   a) Instantaneous Pickup.
   b) Long time pickup and delay.
   c) Short time pickup.
   d) Short time delay (I^2t IN only).
   e) Ground fault pickup and delay (I^2t OUT only) where indicated.
7) Provide means to seal trip unit adjustments in accordance with NEC..
8) Provide local visual trip indication for overload, short circuit and ground fault trip occurrences as applicable.
9) Provide ammeter to individually display all phase currents flowing through circuit breaker including indication of inherent ground fault current flowing in system on circuit breakers with integral ground fault protection. Display current values in true rms with 2 PCT accuracy.

10) Provide Long Time Pickup indication to signal when loading approaches or exceeds adjusted ampere rating of circuit breaker.
11) Provide trip system with Long Time memory circuit to sum time increments of intermittent overcurrent conditions above pickup point and means to reset Long Time memory circuit during primary injection testing.
12) Provide circuit breakers equipped with thermal protection in trip unit to protect breaker from catastrophic failure and instantaneous magnetic override set at the withstand rating of the circuit breaker.
13) Provide trip system equipped with externally accessible test port for use with Universal Test Set. Disassembly of circuit breaker shall not be required for testing. Provide test set capable of verifying operation of trip functions with or without tripping circuit breaker.
14) Provide circuit breakers with Zone Selective Interlocking (ZSI) communications capabilities on short time and ground fault functions compatible with other electronic trip circuit breakers and external ground fault sensing systems as noted on schedules or drawings. Provide ZSI on the emergency branch where required by the coordination study.

m. Electronic trip circuit breakers with full function trip system:
1) Provide full function trip system on circuit breakers rated 400 amps and greater.
2) Provide circuit breaker trip system with microprocessor-based true rms sensing design with sensing accuracy through thirteenth (13th) harmonic and sensor ampere ratings as indicated on associated schedules or drawings.
3) Provide integral trip system independent of any external power source and with industrial grade electronic components.
4) Determine ampere rating of circuit breaker by combination of interchangeable rating plug, sensor size and long-time pickup adjustment on circuit breaker. Clearly mark sensor size, rating plug and adjustment positions on face of circuit breaker.
5) Provide circuit breakers UL listed to carry 80 PCT of ampere rating continuously.
6) Provide following time/current response adjustments, each with discrete settings independent from other adjustments:
    a) Instantaneous pickup.
    b) Long time pickup and delay.
    c) Short time pickup.
    d) Short time delay (I^2t IN and I^2t OUT).
    e) Ground fault pickup and delay (I^2t IN and I^2t OUT) where indicated.
    f) Ground fault alarm only where required by NEC.
7) Provide circuit breakers with adjustable short-time function with defeatable instantaneous adjustment and 30 cycle short-time withstand ratings. Provide short-time withstand ratings in rms symmetrical amperes, as specified on drawings or schedules.
8) Provide means to seal rating plug and trip unit adjustments in accordance with NEC.
9) Provide ammeter to individually display all phase currents flowing through circuit breaker including indication of inherent ground fault current flowing in system on circuit breakers with integral ground fault protection. Display current values in true rms with 2 PCT accuracy.
10) Provide Long Time Pickup indication to signal when loading approaches or exceeds adjusted ampere rating of circuit breaker.
11) Provide trip system with Long Time memory circuit to sum time increments of intermittent overcurrent conditions above pickup point and means to reset Long Time memory circuit during primary injection testing.
12) Provide circuit breakers equipped with thermal protection in trip unit to protect breaker from catastrophic failure and instantaneous magnetic override set at the withstand rating of the circuit breaker.

13) Provide trip system equipped with externally accessible test port for use with Universal Test Set. Disassembly of circuit breaker shall not be required for testing. Provide test set capable of verifying operation of trip functions with or without tripping circuit breaker.
14) Provide communications capabilities for remote monitoring of circuit breaker trip system, to include phase and ground fault currents, pre-trip alarm indication, switch settings, and trip history information. Required communications protocol(s):
15) Provide circuit breakers with Zone Selective Interlocking (ZSI) communications capabilities on short time and ground fault functions compatible with all other electronic trip circuit breakers and external ground fault sensing systems as noted on schedules or drawings. Provide ZSI on the emergency branch where required by the coordination study.

n. Equipment Ground Fault Protection (Electronic Trip Circuit Breakers)
1) Provide circuit breakers with integral equipment ground fault protection where indicated for grounded systems. Provide circuit breaker suitable for use on three-phase, three-wire circuits where system neutral is grounded but not carried through system or on three-phase, four-wire systems.
2) Provide separate neutral current transformer for three-phase four-wire systems as indicated on schedules or drawings.
3) Provide ground fault sensing system with residual sensing, source ground return or modified differential type.
4) Provide trip system with ground fault memory circuit to sum time increments of intermittent ground faults above pickup point.
5) Provide means of testing ground fault system to meet on-site testing requirements of NEC.
6) Provide local visual trip indication for ground fault trip occurrence(s).

10. Electronic trip power circuit breakers with full feature trip system and following provisions:
a. Constructed and tested in accordance with ANSI C37.13, C37.16, C37.17, C37.50, UL 1066 and NEMA SG-3 standard.
b. Draw-out or fixed mounting as indicated.
c. Manually operated or electrically operated as indicated.
d. Suitable for required instantaneous rating without use of current limiting fuses.
1) Field interchangeable electrical accessories including shunt trip, spring release, electrical operator, auxiliary contacts and Trip Unit.
e. Secondary connections made directly to front of circuit breaker cradle.
f. Built-in contact temperature and contact wear sensors.
g. Padlocking provisions to receive up to three padlocks when circuit breaker is in disconnected position, positively preventing unauthorized closing of circuit breaker contacts.
h. Up to two key locks allowing locking in disconnected position.
i. Capability for locking in connected, test and disconnected positions by padlock or key lock.
j. Buttons on face of circuit breaker, with lockable clear cover, to open and close circuit breaker and indicators to show:
1) Position of circuit breaker contacts.
2) Status of closing springs
3) Circuit breaker position in cell.
k. Indicator to show "charged–not OK to close" if closing springs are charged but circuit breaker is not ready to close.
l. Circuit breaker racking system with positive stops at connected, test, disconnected and withdrawn positions.
m. Circuit breaker equipped with interlock to discharge stored energy spring before circuit breaker can be withdrawn from its cell.

1) Positive ground contact check between circuit breaker and cell when accessory cover is removed while circuit breaker is in connected, test or disconnected positions.

n. Trip Units:
   1) Removable to allow for field upgrades.
   2) Incorporate "True RMS Sensing" and LED long-time pickup indications.
   3) Provide following time/current response adjustments, each with discrete settings independent from other adjustments.
      a) Instantaneous pick-up including "OFF" setting.
      b) Long-time pickup and delay (adjustable and field-replaceable).
      c) Short-time pickup.
      d) Short-time delay (I^2t IN and I^2t OUT).
      e) Ground fault pickup and delay (I^2t IN and I^2t OUT) where indicated.
      f) Ground-fault protection shall be available for solidly grounded three-phase, three-wire or three-phase, four-wire systems. Trip unit shall be capable of residual, source ground return, and modified differential ground fault protection. Ground-fault sensing systems shall be field-modifiable. Provide where indicated.
      g) Ground fault alarm only pickup where required by NEC.
   4) Provide capability for adjustments to be set and read locally by rotating a switch.
   5) Provide capability to electronically adjust settings locally and remotely to fine increments below switch settings. Fine increments for pickup adjustments are to be one ampere. Fine increments for delay adjustments are to be one second.
   6) Provide local trip indication and capability to indicate local and remote reason for trip, i.e., overload, short circuit or ground fault as applicable.
   7) Provide neutral current transformers for four-wire systems.
   8) Capable of communicating on **MODBUS** ® networks.
   9) Provide real time metering. Metering functions include current, voltage, power and frequency.
   10) Provide harmonic waveform capture.

11. Motor circuit protector (MCP) with adjustable instantaneous short circuit protection only by means of a magnetic or solid state trip element.
    a. Molded case construction.
    b. Current-limiting as indicated or required providing 200,000 AIC by means of a current-limiter attachment.
    c. See motor control center schedules for required sizes and interrupting ratings.

B. Individually Enclosed Circuit Breakers:
   1. Provide circuit breakers of types specified herein and mounted in individual listed enclosures.
      a. Rate enclosures NEMA 1 unless otherwise indicated.
      b. Flush mount enclosures located in finished areas unless otherwise indicated. Coordinate depth of enclosure with wall depth. Install enclosure cover flush with finished wall. Advise Engineer if enclosure is too deep for available wall depth prior to installation of enclosure.

C. Fuses:
   1. UL Class L fuses: Dual-element time-delay and current-limiting type fuses; UL Class L listed for 200,000 rms AIC symmetrical; Bussmann "Low-Peak" 600V, 601-6000A, Type KRP-C.
      a. Use for main and main feeder devices over 600A, where fuses are indicated.
   2. UL Class RK-1 dual-element fuses: Dual-element time-delay and current-limiting rejection type fuses; UL Class RK-1 listed for 200,000 rms AIC symmetrical; Bussmann "Low-Peak" 0-600A, 250V Type LPN-RK and 600V Type LPS-RK.
      a. Use for main feeder devices 600A and smaller where fuses are indicated.

3. UL Class RK-1 single-element fuses: Fast-acting current-limiting rejection type fuses; UL Class RK-1 listed for 200,000 rms AIC symmetrical; Bussmann "Limitron" 1/10-600A, 250V Type KTN-RK and 600V Type KTS-RK.
   a. Use as indicated.
4. UL Class RK-5 fuses: Dual-element time-delay and current-limiting rejection type fuses; UL Class RK-5 listed for 200,000 rms AIC; Bussmann "Fusetron" 1/10-600A, 250V Type FRN-RK and 600V FRS-RK.
   a. Use for motor feeder and branch circuit devices where fuses are indicated.
5. Elevator fuses: Type and rating as required by elevator manufacturer. Confirm requirements with elevator manufacturer prior to ordering fuses.

D. Fusible Switches:
   1. Provide panelboard type suitable for mounting in switchboards or panelboards as indicated.
      a. 200,000 AIC, 30 thru 1200 A, with fuses specified above.
      b. Provide ground fault protection system with current sensor, shunt trip and control power transformer where indicated.
   2. Provide bolted pressure contact switches suitable for mounting in switchboards as indicated.
      a. 200,000 AIC, 800 thru 4000 A, with fuses specified above.
      b. Electrically operated as indicated.
      c. Provide ground fault protection with current sensor, shunt trip and control power transformer where indicated.

2.3 POWER SYSTEM STUDY

A. Use SKM-PTW to provide computer generated power system study of specified electrical power distribution system in accordance with IEEE 141 and 399.
   1. Include electrical distribution system from main distribution equipment (including utility and generator sources) down to each 208 volt branch circuit panelboard. Study shall include each valid system operating/switching mode under all probable source conditions.
   2. Data collection:
      a. Provide required data for preparation of studies. Performer of studies shall furnish contractor with listing of required data immediately after award of contract.
      b. Expedite collection of data to assure completion of studies as required for final approval of equipment shop drawings.
      c. Input data shall include power company's short circuit contribution as calculated and verified by them.
      d. Verify characteristics of utility service overcurrent devices with power company.

B. Analysis shall include:
   1. Short circuit study:
      a. Scenarios that result in maximum fault conditions shall be adequately covered in study. For example, if closed transition transfer switches are provided or if utility is paralleled with standby generators at any time, combined contribution from utility and generators shall be considered.
      b. Include complete fault calculations as specified herein for each proposed and ultimate source combination. Note that source combinations may include present and future supply circuits, large motors and/or generators.
      c. Calculate 1/2 cycle (or 5 cycle where appropriate for MV equipment) short circuit interrupting and momentary (asymmetrical 'close and latch') duties, when applicable for an assumed 3-phase bolted fault at each load interrupter switchgear, transformer primary and secondary terminals, low-voltage switchgear, switchboard, distribution panelboards, bus duct, automatic transfer switch, motor control center, 480 volt panelboard, 208 volt panelboard and other significant locations throughout system.
      d. Include equipment/device ratings, X to R ratios and symmetrical fault currents in tabulations. Where actual (calculated) X/R ratio exceeds device test X/R ratio, appropriate fault duty adjustment shall be made in accordance with ANSI/IEEE standards and included in tabulations.

e. Base transformer impedance on lowest tolerance limit allowed by ANSI C57.12 (7.5 PCT below listed value). Use actual nameplate impedance when available.
f. Include fault contribution of motors.

2. Coordination study:
   a. All potential scenarios shall be considered in study. Scenarios to be considered include but are not limited to:
      1) For basic system with single service, study shall show coordination between main, feeders and downstream devices.
      2) If main switchgear or switchboard is double-ended with main-tie-main arrangement, study shall show coordination between main, tie, feeders and downstream devices when tie breaker is closed. Where overlap cannot be avoided, tie breaker shall be set to overlap downstream feeder overcurrent devices rather than main devices.
      3) If multiple levels of ground fault are provided time current curves shall be provided that indicate coordination of ground fault between main, tie and feeder breakers when tie breaker is closed. Where overlap cannot be avoided, tie breaker shall be set to overlap downstream feeder overcurrent devices rather than main devices.
      4) Provide graph to indicate coordination between typical 20 amp, 277 volt, single pole breaker and nearest upstream 480 volt overcurrent device with ground fault protection as applicable.
      5) Evaluate proper operation of ground relays in 4-wire distributions with more than one main service circuit breaker, or when generators are provided. Discuss neutral grounds and ground fault current flows during a neutral to ground fault.
      6) Include phase and ground coordination of generator protective devices. Indicate generator decrement curve and damage curve along with operating characteristic of protective devices. Obtain information from generator manufacturer and include generator actual impedance value, time constants and current boost data in study. Do not use typical values for generator.
      7) For motor control circuits, indicate distribution equipment full-load current plus symmetrical and asymmetrical of largest motor starting current and time to ensure protective devices will not trip during major or group start operation.
      8) All emergency system overcurrent protective devices shall fully coordinate per applicable requirements of NEC. Where this is not possible due to pre-determined device types, sizing or trip unit selections, notify Engineer immediately of inadequacies and include recommendations for resolution.
   b. Graphs shall include as applicable:
      1) Utility relay and fuse characteristics.
      2) Campus substation relay and fuse characteristics.
      3) Medium-voltage equipment relay and fuse characteristics.
      4) Low-voltage equipment circuit breaker trip device characteristics.
      5) Pertinent transformer characteristics.
      6) Pertinent motor and generator characteristics.
      7) Characteristics of other system load protective devices.
      8) All devices down to and including largest branch circuit overcurrent protective device in each motor control center, distribution panel and branch panelboard.
      9) All adjustable settings for ground fault protective devices.
      10) Manufacturing tolerance and damage bands in plotted fuse characteristics.
   c. Indicate transformer full load and 150, 400 or 600 PCT currents, transformer magnetizing inrush, ANSI transformer withstand parameters and significant symmetrical and asymmetrical fault currents.
   d. Select each primary protective device required for delta-wye connected transformer so that its characteristic or operating band is within transformer characteristics including point equal to 58 PCT of ANSI withstand point to provide secondary line-to-ground fault protection. Where primary device characteristic is not within transformer characteristics, indicate transformer damage curve.

e. Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device could be exposed.

3. Arc flash study:
   a. Perform arc flash analysis in accordance with NFPA 70E with calculations performed in accordance with IEEE 1584A.
   b. Provide following data for each bus analyzed.
      1) Flash Bus Name.
      2) Protective Device Name.
      3) Bus Operating Fault Current.
      4) Protective Device Bolted Fault Current.
      5) Protective Device Arcing Fault Current.
      6) Trip/Delay Time (SEC).
      7) Breaker Opening Time (SEC).
      8) Ground.
      9) Equipment Type.
      10) Gap (mm).
      11) ARC Flash Boundary (IN).
      12) Working Distance (IN) per IEEE Table 3 default values.
      13) Incident Energy (CAL/cm^2)
      14) Required Protective FR Clothing (PPE) Category.
   c. Provide following data on each arc flash hazard warning label:
      1) Flash Hazard Protection Boundary.
      2) Incident Energy Level.
      3) Required Personal Protective Equipment Category with brief description.
      4) Shock hazard when cover is removed.
      5) Limited Approach Boundary.
      6) Restricted Approach Boundary.
      7) Prohibited Approach Boundary.
      8) Include date of calculation, utility short circuit capacity and voltage as of that date.
4. Harmonic study:
   a. Provide harmonic study to predict as accurately as possible voltage and current harmonic distortion including line notching at point of common couple. Analysis shall conform to IEEE 519.
   b. Harmonic distortion criteria shall be as follows:
      1) Maximum voltage total harmonic distortion: 3 PCT.
      2) Maximum voltage line notch depth: 10 PCT.
      3) Maximum voltage line notch area: 16,400 V-mS.
      4) Maximum current total harmonic distortion: 5 PCT with individual harmonics as follows:
         a) 1 through 10: 4.0 PCT.
         b) 11 through 16: 2.0 PCT.
         c) 17 through 22: 1.5 PCT.
         d) 23 through 34: 0.6 PCT.
         e) 35: 0.3 PCT.
      5) Harmonic sources shall include but not be limited to:
         a) Variable frequency drives: Use harmonic profiles obtained from VFD manufacture's testing.
         b) Uninterruptible power supplies: Use harmonic profiles obtained from UPS manufacture's testing.
         c) Lighting ballast: Use standard harmonic profiles for ballast similar to ballasts used on this project.
         d) Receptacle loads: Assume that 10 PCT of receptacles will be serving electronic loads with high harmonic content similar to personal computers.
      6) Base calculations on following:
         a) Point of common couple:

(1) Normal distribution systems: Each main low voltage switchboard or switchgear bus indicated on one line diagram(s).
(2) Emergency distribution system: Generator main low voltage switchboard or switchgear bus.

b) Verify transformer and generator impedance with proposed equipment.
c) Primary UPS units serving 100 PCT non-linear loads and redundant units on-line but not serving any load.
d) Add an additional 25 PCT VFD controlled motor load to each bus serving motor load to simulate future growth. Use average VFD sizes and average branch circuit lengths.
e) All loads assumed to operate at full load or worst case harmonic load.
f) Do not include any effects of Surge Protective Devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide overcurrent protective devices in switchboards, panelboards and motor control centers as indicated in those sections.

B. Provide individually enclosed overcurrent protective devices:
1. Wall mounted:
   a. Finished areas: Attach to studs via unistrut cross members or metal backing bolted or welded to studs where not otherwise shown.
   b. Masonry or concrete walls: Attach to wall via unistrut cross members where not otherwise shown.
   c. Mounting height shall be as indicated on symbol legend or elsewhere in this specification but bottom of enclosure shall not be less than 12 IN AFF.
2. Where floor mounted provide pad per specification 26 00 10.

C. Field Settings:
1. Perform field adjustments of protective devices as required to place equipment in final operating condition. Settings shall be in accordance with approved power system study.
2. Provide certified calibration report for each protective device.

D. Arc Flash Labels:
1. Provide Arc flash hazard warning label on each piece of electrical equipment.

E. Arc Flash Boundaries:
1. Identify arc flash protection boundaries in front of all electrical switchboards, switchgear, panel boards, motor control centers, UPS distribution panels, automatic transfer switches and individual disconnects and circuit breakers. Provide outline of arc flash protection boundaries with 2 IN wide strip of red/white Seton M6356 OSHA warning tape or equivalent.

F. Harmonic Field Testing:
1. Perform field testing and record results at each point of common couple and compare test results with preliminary harmonic analysis and specified criteria.
   a. Perform test with building as loaded as possible. Record demand loads.
   b. Measure distortion for harmonics 1 through 49. Calculate total harmonic distortion.

END OF SECTION

SECTION 26 28 16

ENCLOSED SAFETY SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Enclosed Safety Switches, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Provide fuses in fusible-type devices by same manufacturer.

B. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Product Data:
   1. Technical data on each type of disconnect switch.
   2. Specification comparison.

B. Contract Closeout Information:
   1. Operation and Maintenance Data.
      a. See Section 01 78 23.

1.4 EXTRA MATERIAL

A. Extra Fuses:
   1. 10 PCT or minimum of three (3) of each type and rating of installed fuses.
   2. See Section 01 78 43.

B. Spare Fuse Cabinet
   1. Cabinet: Wall-mounted, 0.05 IN thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
      a. Size: Adequate for storage of spare fuses specified with 15 PCT spare capacity minimum.
      b. Finish: Gray, baked enamel.
      c. Identification: Provide black engraved laminated nameplate with white letters that reads “SPARE FUSES” in 1/2 IN high letters on exterior of door.
      d. Fuse Pullers: For each size of fuse.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Enclosed Safety Switches:
   1. Eaton
   2. Schneider Electric/Square D
   3. Siemens

B. Elevator Control Switch:
   1. Eaton
   2. Bussman

C. Fuses:
   1. Bussmann
   2. Ferraz Shawmut
   3. Brush Fuses
   4. Littelfuse

2.2 SAFETY SWITCHES

A. Safety Switches:
   1. Fusible and non-fusible type, NEMA Type HD Heavy Duty construction, unless otherwise indicated.
   2. Enclosure: NEMA 1 unless otherwise indicated.
   3. Provide weatherproof disconnect switches as required by Section 26 00 10.
   4. Switch blades fully visible in OFF position with door open.
   5. Contact operation quick-make and quick-break.
   6. Switches for motor circuits to be horsepower rated.
   7. Switches for motor circuits controlled by Variable Frequency Drives (VFD) shall include one N.O. and one N.C. contact which operate with the initial movements of the switch and prior to the opening of the main switch.
   8. Finish: Baked enamel over rust-inhibiting primer.
   9. Switches shall have interlock with cover in closed position.

B. Fuses
   1. UL Class RK-5 fuses: Dual-element time-delay and current-limiting rejection types fuses; UL Class RK-5 listed for 200,000 rms AIC symmetrical, 0-600A; Bussmann "Fusetron", 250 V FRN-RK and 600 V FRS-RK.
   2. Use for motor feeder and branch circuit devices where fuses are indicated.

C. UL Class RK-1 dual-element fuses: Dual-element time-delay and current-limiting rejection type fuses; UL Class RK-1 listed for 200,000 rms AIC symmetrical, 0-600 A; Bussmann "Low-Peak", 250 V LPN-RK and 600 V LPS-RK.
   1. Use for main feeder devices 600A and smaller where fuses are indicated.

D. UL Class RK-1 single-element fuses: Fast-acting current-limiting rejection type fuses; UL Class RK-1 listed for 200,000 rms AIC symmetrical, 1/10-600A; Bussmann "Limitron", 250 V KTN-RK and 600 V KTS-RK.
   1. Use as indicated.

E. UL Class L fuses: Dual-element time-delay and current-limiting type fuses; UL Class L listed for 200,000 rms AIC symmetrical; Bussmann "Low-Peak" 600 V, 601-6000A, Type KRP-C.
   1. Use for main and main feeder devices over 600A, where fuses are indicated.

F. Elevator Control Switch:
   1. Single NEMA enclosure with relays, control transformer and other options, as listed below, and shown on drawings.
   2. Construct, listed and certified to standards as listed in above.
   3. Elevator Control Switch shall have an ampere rating as shown on Contract Drawings, and include a horsepower rated fusible switch with shunt trip capabilities.
   4. Amp rating of switch shall be based upon elevator manufacturer requirements and utilize Class J Fuses, provided separately.
   5. Include 100VA control power transformer with primary and secondary fuses.
      a. Primary voltage rating: 480 volts with a 120volt secondary.
   6. Include an isolation relay, 3PDT, 10 amp, 120V.
      a. Isolation relay coil:
   7. Provide normally open dry contact to energize isolation relay and activate shunt trip solenoid, 140VA inrush at 120 volts.
   8. Module shall contain following options:
      a. Key to Test Switch
      b. “ON” Pilot Light - Green, Red or White.

c. Isolated Full Capacity Neutral Lug
d. 1P NC Mechanically Interlocked Auxiliary Contact.
e. Fire Alarm Voltage Monitoring Relay as required to comply with NFPA 72.
f. NEMA 1 Enclosure, optional 12, 3R or 4.

9. Group and mount multiple switches in panelboard.
   a. Group as shown on drawings and schedules.
   b. Meet requirements of Section 26 24 16.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturers instructions and recommendations.

B. Switches for motor circuits controlled by VFD's shall be electrically interlocked to the controlling VFD via contacts provided in switch.

C. Provide labeling per Section 26 00 10.

END OF SECTION

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SECTION 26 32 13
DIESEL ENGINE DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Diesel Engine Driven Generator Sets, as indicated, in accordance with provisions of Contract Documents.

B. Essential electrical system: Power source for connection to emergency and equipment lighting and power systems as indicated. These circuits will receive power supply from engine generator unit when normal power fails.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. National Fire Protection Association (NFPA)::
  1. NFPA 30 Flammable and Combustible Code
  2. NFPA 37 Stationary Combustion Engines and Gas Turbines.
  3. NFPA 99 Standard for Health Care Facilities.
  4. NFPA 110 Emergency and Standby Power Systems.

B. National Electrical Manufacturers Association (NEMA).
  1. Motors and Generators, NEMA #MG-1.1.

C. UL:
  1. UL 142 Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids.
  2. UL 2085 Standard for Protected Aboveground Tanks for Flammable and Combustible Liquids.
  3. Comply with UL2200 standards and listed by a Nationally Recognized Testing Laboratory (NRTL).

D. Local Air Quality Resources Board.

E. Factory Performance Test:
  1. Test engine instruments, control gauges, indicator lights and unit pre-alarms, alarms and shutdowns as described herein.
  2. Individually test each prime mover.
    a. Derating factors for proposed site shall be applied to test data. Test shall be for continuous period of no less than 2 HRS.
    b. Perform tests after assembly is complete.
    c. Provide certified test results in duplicate.
    d. Include, but not be limited to, manufacturer’s standard test plus one hour test at rated power factor for:
      1) 1/2 HR at 50 PCT rated load
      2) 1/2 HR at 75 PCT rated load and
      3) 1 HR at 100 PCT rated load.
      4) After 100 PCT test allow unit to cool down and shutdown.
      5) After 5 minutes, start engine and apply full rated load in a single step.
      6) Unit shall establish nominal voltage and frequency stability within 8 seconds maximum.
    e. Observe and record cranking time(s) to start and run for each prime mover.
    f. Observe and record time to come up to operating speed for each prime mover.

g. Model following step loads in sequence:
    1) 277 volt lighting: 33 PCT of rating.
    2) 480 to 120/208 step down transformer load: 33 PCT of rating.
    3) Mechanical VFD loads: 33 PCT.
h. Record voltage and frequency overshoot for each prime mover on each step load addition and removal.
i. Record voltage, frequency and amperes.
j. Record oil pressure, water temperature where applicable and battery charge rate at first load acceptance, at each step load, and at 15 minute intervals thereafter for each prime mover.
k. Determine compliance with performance criteria specified and adjust, repair or replace unit as required for conformance.

3. Transient performance:
    a. Start largest motor with coincidental loads operating.
        1) Voltage drop shall not exceed 10 PCT.
4. Engine exhaust emissions
    a. All equipment shall comply with applicable state and local government requirements
    b. EPA Tier 2.

1.3 SUBMITTALS

A. Shop Drawings:
1. Submit components together to permit checking of entire system, coordination between components and coordination of sensing devices required for local and remote annunciator panels.
2. Outline dimensions.
3. Weight Loading
4. Required Clearances
5. Construction Details and Field Connection Details.
6. Control and annunciator wiring diagrams.
7. Generator sets kW and voltage output rating at 0.8 PF.
8. Fuel tanks.
9. Calculations verifying unit submitted is sized to provide power for loads indicated and meeting performance criteria specified for unit installation location.
10. Control panel elevation.
11. Installation details and calculations for anchorage of the unit and its battery rack, certified by a licensed structural engineer in the state of installation, indicating conformance to seismic criteria for the appropriate zone location.
12. Block diagram clearly indicating quantity and size of conductors and conduits and types of conductors between control and/or annunciator enclosures mounted remote from generator unit.
13. Battery charger including calculations used to size battery charger and anticipated input current at rated output voltage.
14. Make and model of engine.
15. Number of cylinders.
16. Bore and stroke, inches.
17. Piston displacement, cubic inches.
18. Piston speed, feet per minute at rated rpm.
19. Vibration isolation.
20. Engine mounted circuit breaker(s) if required.
21. Number and type of bearings.
22. Exciter type.
23. Generator insulation class and temperature rise at 40degC ambient. Conform to MG-1.
24. Fuel delivery rate required and fuel consumption at full load.
25. Batteries. Include total gallons of electrolyte for NiCAD jars.
26. List of recommended spare parts with prices.

27. Unit enclosure.
28. Ambient air temperature calculations to verify battery heaters are required or not.
29. Remote annunciator panel.
30. Certified letter stating designed exhaust system, when previously designed, has been reviewed and found acceptable for unit provided or stating proposed modifications for engineering review.

B. Product Data:
   1. Technical data on all components.
   2. Specification comparison.

C. Project Information:
   1. Factory test reports prior to shipping.
   2. Certified letter stating generator set is in compliance with NFPA 110, Chapter 3, section headed “Rotating Equipment”.
   3. Certified letter stating unit was tested and found to be in conformance with “Installation Acceptance” criteria section of NFPA 110.
   4. Factory performance test report.

D. Contract Closeout Information:
   1. Operating and maintenance data.
      a. Factory and Field test results.
      b. Instructional Material: Provide complete instructions covering operation of engine-generator set and associated equipment, together with manual covering engine operation and maintenance. Include any minor adjustments necessary to obtain optimum operation of generator set(s), complete troubleshooting and diagnostic information, disassembly instructions, assembly instructions, preventative maintenance schedule, recommended lubricants and all necessary service checks.
   2. Owner instruction reports.

1.4 WARRANTY

A. The Generator Set shall include a two (2) year warranty after systems is fully commissioned, supporting ATS loads and turned over to Owner.
   1. Warranty is valid for up to 400 HRS of operation.

B. Provide a pricing option for a five (5) full year warranty.

1.5 SERVICE MAINTENANCE

A. Provide a maintenance program by skilled employees of the manufactures designated service organization for two (2) years after system is turned over to Owner.
   1. Include a semi-annual exercising to check proper starting, load transfer, and running under load.
   2. Include routine preventative maintenance as recommended by manufacturer and adjusting as required for proper operation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Diesel Engine Driven Generator Set with Outdoor Enclosure and Base Tank:
   1. Base:
      a. Caterpillar
      b. Rolls-Royce/MTU Onsite Energy.
      c. Kohler.

2.2 DESIGN CRITERIA

A. Diesel Engine Driven Generator Sets:
   1. Engine generator unit:
      a. Power circuits upon failure of normal power.
      b. Comply with site altitude and seismic location.
   2. Provide power source for connection to emergency and equipment lighting and power systems as indicated.

B. Start-up and Field Tests:
   1. Include load bank sized for 100 PCT minimum of generator full load kW rating plus 5 PCT additional to demonstrate overload reaction.

C. Interface Control Wiring:
   1. Provide accessories as required for a complete and operation system.
   2. Provide in conduit from generation system to equipment or systems including but not limited to:
      a. Paralleling switchgear.
      b. Automatic transfer switches:
         1) Start circuits.
         2) Load shed and Load add circuits as required.
         3) ATS Position.
         4) ATS Power Monitor Data.
      c. Annunciator/control panels.
      d. Building Automation System where indicated.

D. Communication Protocol:
   1. Modbus TCP/IP and BACnet IP.

2.3 MATERIALS

A. Engine Generator Set:
   1. Engine generator unit:
      a. Diesel engine direct-connected to alternating current generator mounted on rigid steel skid supports.
      b. Provide engine mounted control panel.
      c. Unit rating indicated is based on operation at rated RPM when equipped with all operating accessories.
      d. Provide unit mounted radiator.
      e. Mount unit on sub-base suitable for installation on concrete foundation.

B. Engine:
   1. Provide engine with following characteristics and/or associated accessory items of equipment:
      a. Engine to operate satisfactorily on No. 2 ultra-low sulfur fuel oil.
      b. Diesel, four cycle, water cooled radiator type, size adequate for generator load test specified at altitude and ambient temperature where unit is to be installed.
         1) Size engine to meet performance criteria specified.
      c. Operating speed 1800 RPM, piston speed at 2250 FPM maximum.
      d. Starting system per manufacturer's standard, but not less than 12 volt DC; starting motor with Bendix type drive. Provide dual starters and batteries sized to meet specified performance criteria.
      e. On units where fuel is utilized for injector cooling and fuel delivery rate is greater than two times fuel consumption rate, provide a fuel after cooler.
      f. Unit shall be capable of operating at idle or light loads for extended periods of time.

2. Oil pump:
   a. Gear-type lubricating oil pump
   b. Provide oil filters so located that lubricating oil is continuously filtered, except during periods when oil is automatically by-passed to protect vital parts when filters are clogged.
   c. Filter elements: Full flow, accessible and easily replaceable.
   d. Equip filter system with spring-loaded by-pass valve as insurance against stoppage of lubricating oil circulation in event filters become clogged.
   e. Oil cooler: Water-cooled, engine-mounted.
3. Fuel system:
   a. Electronic high pressure fuel injection system.
   b. Fuel pump
      1) Built-in gear-type, engine-driven fuel transfer pump.
      2) Supply fuel at constant pressure based on actual installation.
   c. Equip fuel system with replaceable fuel filter elements arranged for easy removal without breaking any fuel line connections or disturbing fuel pumps or any other part of engine.
   d. Replaceable primary fuel oil filter/water separator in addition to engine mounted fuel oil filter.
   e. Provide flexible fuel line connectors at engine.
4. Breather/filler pipe:
   a. Where unit is indoors, provide hose to radiator discharge to discharge back pressure to outdoors.
      1) Coordinate hose installation with radiator discharge ductwork fabricator.
      2) Vent to outside of unit enclosure away from radiator air intakes.
5. Governor:
   a. Unit-mounted with isochronous electronic speed sensing governor, including speed sensing modules of solid state type to maintain a steady state condition of zero speed droop.
   b. Throttle shall permit speed adjustment within 1/4 cycle.
   c. Steady state speed regulation from no load to full load: 0.25 PCT.
6. Air cleaners: Engine-mounted standard air cleaners of sufficient capacity with replaceable elements.
   a. Provide two (2) replacement elements.
7. Electric starting system:
   a. Cranking motor or motors shall be heavy duty type with adequate rating to crank engine continuously for 90 seconds at 32 DEGF without damage.
   b. Automatic controls shall provide automatic cranking of engine when normal power fails.
   c. Engine starting controls shall provide for a minimum of six (6) adjustable timed cranking cycles of fifteen (15) seconds “on” and fifteen (15) seconds “off.”
8. Cooling system:
   a. Sufficient capacity for cooling engine when delivering full output at the sites maximum ambient temperature and altitude.
   b. Unit mounted radiator.
      1) Pusher type fan with shroud and protective guard.
         a) Fan shall be of adequate capacity to overcome back pressure of air duct and louvers.
         b) Designed to have no greater than 0.5 IN of water static pressure loss.
      2) Provide radiator with adapter for connecting duct.
         a) Accessible drain system.
         b) Supply a minimum 50 PCT water and 50 PCT ethylene glycol solution or other lower temperature freeze protection corrosion prohibitor as recommended by engine manufacturer.

3) Provide a radiator coolant level gauge.
    a) Visible from an opened access door or weatherproof and mounted on exterior of enclosure with flexible connections.
4) Self supporting and suitable for seismic zone indicated.
5) Protect rotating parts from accidental damage by OSHA approved safety guards.
6) Reject 100 PCT of heat load measured at fan intake when having external static pressure indicated.

9. Jacket water heater:
    a. 208V, single phase.
    b. Maintain cooling jacket at 37 100 DEGF for ambient conditions per latest version of ASHRAE Fundamental Handbook for location indicated.
        1) Include thermostat.
    c. Immersion or forced circulation heater with thermostat or “Kim Hotstart” preheater.
        1) Water heaters shall be readily accessible.
        2) Electric heater supply shall be provided for voltage and phase indicated.
    d. Provide shutoff valves at the engine block on water jacket heaters, at both inlet and outlet sides.
10. Engine exhaust system:
    a. Exhaust manifold connections:
        1) Seamless, stainless steel, flexible, exhaust adapter for connection from exhaust manifold outlet to catalytic converter or silencer.
    b. Exhaust system insulation:
        1) When a catalytic converter is used, insulate the exhaust manifold connection piping and the body of the catalytic converter to maintain exhaust temperature through the catalytic converter.
        2) High temperature jacketed insulation.
    c. Exhaust pipe:
        1) Schedule 80, seamless black steel pipe.
        2) Welded joints and butt welded fittings.
        3) Coordinate exhaust pipe size with catalytic converter outlet and/or silencer inlet.
    d. Silencer:
        1) Attenuation 32 to 42 dBA
        2) Maxim Silencers, Inc. Model M51 or equal.
            a) Three chamber silencer
            b) Maximum exhaust pressure drop through silencer to be 7 IN wc at standby, full load exhaust flow.
            c) Coordinate silencer size and configuration with catalytic converter provided.
        3) Provide for each engine.
        4) Standard mounting.
    e. Provide rain cap to prevent moisture entering exhaust system.
    f. Location, size and routing of exhaust system shall be as required for engine furnished and as directed.
        1) Where this system is indicated, sizes shown are based on single manufacturer. Deviations required from this by selected manufacturer shall be included.
        2) Exhaust system installation, piping and connections, when not unit mounted, provided by Division 23.
    g. Diesel oxidation catalytic converter after treatment for odor reduction:
        1) Heavy Duty catalytic converter designed specifically for large emergency/stand by engine generator exhaust application.
        2) Design to reduce emissions of carbon monoxide, hydrocarbons, aldehydes and Diesel Particulate Matter (DPM) and reduce diesel exhaust odor.
        3) Catalyst:
            a) Flow-through honeycomb design with cellular Cordierite ceramic catalyst substrate.
                (1) Cell Density: 300 cells/SQ IN.
            b) High surface area activated aluminum oxide washcoat.

c) Hydrocarbon sequestering material for improved performance at low exhaust temperatures.
   (1) Zeolite (molecular sieve) material to capture hydrocarbons when exhaust temps are too low for effective catalyzation.
   (2) Designed to provide 15 – 30 MIN of continuous hydrocarbon/odor control under low load, low exhaust temperature operation.
   (3) Increased exhaust temperature shall regenerate zeolite material. Trapped hydrocarbons will be released from the zeolite material and oxidized when exhaust temperatures are sufficient to activate the catalyst (~500 DEGF.).
d) Precious metal diesel oxidation catalyst to oxidize carbon monoxide, hydrocarbons and aldehydes contained in diesel exhaust to nontoxic compounds of carbon dioxide and water vapor.
   (1) Precious metal formulation: 1/0/0 (Platinum/Palladium/Rhodium)

4) Catalyst performance:
   a) Maximum exhaust pressure drop through converter assembly to be 7 IN wc at standby, full load exhaust flow.
   b) Carbon monoxide conversion:
      (1) 0 PCT at 212 DEGF.
      (2) 85 PCT at 500 DEGF.
      (3) 95 PCT at 800 DEGF.
   c) Hydrocarbon conversion:
      (1) 40 PCT at 212 DEGF.
      (2) 50 PCT at 500 DEGF.
      (3) 85 PCT at 800 DEGF.
      (4) Performance includes effect of hydrocarbon sequestering material at low exhaust temperatures.
   d) Diesel Particulate Matter (DPM) conversion:
      (1) The catalyst acts on and reduces only the Soluble Organic Fraction (SOF) portion of the Diesel Particulate Matter. (The carbon and sulfate portions of DPM are not reduced. Black smoke from DPM Carbon is not reduced.)
      (2) Soluble Organic Fraction conversion of as much as 80 PCT.
      (3) Diesel Particulate Matter reduction of 20 PCT (due to SOF reduction above).
   e) Performance information above is for the catalyst. Actual emissions conversion performance of the installed engine generator exhaust system will vary based upon engine operation and fuel used.

5) Housing construction:
   a) Housing designed to hold multiple catalyst elements in flow-through arrangement.
   b) Solid welded construction, 304L stainless steel, minimum 16 gauge.
   c) Flanged inlet/outlet connections.
   d) Single or multiple housings as determined by the engine exhaust system configuration.

6) Exhaust pipe extension:
   a) Exhaust stack size to match outlet dimension of the generator.
   b) Support off generator enclosure by four tie-down points one in each of top corners of enclosure and guy wires with tensioners connected near top of stack.
   c) Generator enclosure shall include additional room supports to handle additional weight and stress of exhaust stack.

11. Unit mounted control panel:
    a. Vibration isolated from unit.
    b. Digital water temperature gauge.
    c. Digital oil pressure gauge.
    d. Digital oil temperature gauge.
    e. DC panel light with switch when backlit digital displays are not used.

f. Voltmeter.
g. Frequency meter
h. Phase Ammeters.
i. Wattmeter.
j. Running time meter reading in one hour minimum increments.
k. Digital voltage regulator, voltage adjusting means capable of +/-5 PCT minimum.
l. Control switch with "Automatic", "Off/Reset" and "Manual" positions; circuitry shall be such that generator will be able to deliver emergency power at any time during a normal power failure or an exercise period or when placed in manual position, providing generator set has established normal voltage and frequency.
m. Necessary relays and time delay to permit automatic cranking of the engine for an adjustable period as indicated. Controls shall be disabled by an overcrank position and initiate an alarm.
n. Controls to automatically run engine at no load and governed speed for an adjustable period of 0 to 15 minutes after load is transferred from emergency back to normal source. This period to be called "cool-down".
o. Separate indicator lights or displays and common audible alarm with necessary control for:
    1) Low engine water jacket temperature (less than 21 DEGC, 70degF) (amber).
    2) Low coolant level (red).
    3) Approach high engine temperature – pre-alarm (amber).
    4) Approach low lubricating oil pressure – pre-alarm (amber).
    5) Overcrank (failure to start) (red)
    6) Overspeed trip – shutdown (red).
    7) High water temperature – shutdown (red).
    8) Low oil pressures – shutdown (red).
    9) Low fuel (emergency) indicates a low level condition in the auxiliary (red) and indicates when less than a 3 HR fuel supply exists.
    10) Critical low fuel – shutdown set at 10 PCT of fuel remaining (red).
    11) Fuel tank leak detection (amber).
    12) Control switch position "Not in Automatic" (red).
    13) Battery Charger A.C. Failure (amber).
    14) Low Battery Voltage (red).
    15) Ground fault alarm (required for units 650kw at 277/480 volt, 3 phase and larger only) (amber).
    16) Generator Panel Emergency off – shutdown (red).
    17) Generator Remote Emergency Off – shutdown (red).
    18) Generator Circuit Breaker Open (where so equipped) (red).
    19) Generator Panel Misc. Pre-alarm (amber).
    20) Generator Panel Misc. Alarm (red).
    21) Main fuel tank low level pre-alarm (amber) and indicates when less than a 24 HR supply exists.
    22) Main fuel tank leak detection (amber).
    23) Common audible alarm shall consist of a unit battery operated DC horn on panel. Horn shall energize when any of above conditions exist. Panel will include an alarm silencing push-button and circuitry to allow subsequent malfunctions to resound alarm if previously silenced.
    24) All indicator lights shall have either a "push-to-test" feature or an individual momentary push-button that will test all lights and horn
    25) The "Generator Control Panel Pre-Alarm" and "Generator Control Panel Alarm" indicators above shall be summarized conditions of pre-alarms and alarms respectively which are annunciated at the generator control panel and not individually required above. These shall also annunciate at Remote Annunciator Panel.

26) System shall communicate to the switchgear, remote annunciator panel, and to BAS (Building Automation System) via Modbus or BACnet, provide interface to match communication requirements of system receiving the data.

p. Time delays and timers shall be solid state types. Timers shall maintain repetitive operating characteristics in a temperature range of 0 DEGC to 65 DEGC.

12. Engine protective devices including but not limited to:
    a. Low water temperature sensing device with visual warning to indicate that engine water jacket temperature is below 70 DEGF.
    b. Sensing devices and visual pre-alarm warning device shall be provided to indicate:
        1) High engine temperature (above manufacturer's recommended safe operating temperature range).
        2) Low lubricating oil pressure (below manufacturer's recommended safe operating range).
    c. Automatic engine shutdown device featuring intake air shutoff plus individual visual devices to indicate shutdown occurrences as follow:
        1) Overcrank, failed to start.
        2) Overspeed, device activated at approximately 110 PCT of unit operating RPM.
        3) Low lubricating oil pressure.
        4) Excessive engine temperature.
13. Auxiliary control devices:
    a. Either integral with specified engine instruments, control, and safety devices or as separate devices as required to operate various signal circuits specified for remote annunciator panel.
14. Provide 3 (three) normally open auxiliary contacts in addition to contacts required for operation described herein for interface with louvers, fans or other miscellaneous equipment.
    a. Contacts shall close when generator is started.

C. Main fuel tank:
1. Provided by Division 23 Contractor.

D. Day tank:
1. Provide UL-2085 protected sub-base day tank mounted underneath engine generator unit.
2. Double wall fuel tank with monitors for low fuel, high fuel and fuel in rupture basin alarms wired to generator set monitor lamps and auxiliary contacts for remote annunciator located inside facility.
3. Fuel station monitors shall have lamps showing fuel level with alarm for high fuel condition.
4. Install additional ports in the fuel tank base for main tank drain and rupture basin drain.
5. Install standard, emergency and rupture basin vents in tank and extend through roof of enclosure and seal.
    a. Provide exterior vent caps.
6. Heavy gauge steel with top and bottom baffles.
7. Heavy gauge steel channel side supports.
8. 1/4 IN drain.
9. 1-1/2 IN fuel level gauge.
10. 2 IN fill-locking fill cap.
11. Supply connection: Coordinate with Division 23.
12. Return connection: Coordinate with Division 23.
13. Primer and enamel exterior to match engine generator unit.
14. Vent sized to tank. Withstand pressure of day tank shall exceed total developed static head imposed by vent.
15. Double wall with alarm contact for rupture basin alarm. Provide contacts for remote alarm.
16. Solenoid valve to interface with remote transfer pumps.
17. Low level alarm float switch to indicate when operating supply is under 3 HRS. Provide contacts for remote monitoring.

a. Provide control wiring in conduit from sub-base tank low level alarm to generator mounted control panel and remote derangement annunciator.
b. Provide sub-base day tank capacity of minimum 2 HR.

E. Batteries:
1. Lead-acid type in hard rubber case, designed for diesel cranking, of ample capacity for duty as recommended by engine manufacturer.
2. Minimum 205 AMP-HR (20 Hour Rating) for sets in excess of 100kw.
3. Furnish electrolyte separately, or batteries, when installation is complete and unit is ready for testing.
4. Provide battery hydrometer.
5. Provide minimum three (3) year warranty on engine starting batteries.
6. Battery rack:
   a. Unless otherwise noted, provide free-standing, corrosion-resistant coated steel or fiberglass rack for batteries, independent from but adjacent to engine-generator set.
   b. Provide non-conductive fiberglass or plastic box and cover for battery protection.
   c. Where located in seismic risk zones, restrain to meet codes with importance factor indicated.
7. Battery Charger:
   a. Input voltage indicated.
   b. Solid state type or provide taper charging.
   c. Maintain rated output voltage within plus 1 PCT from no load to full load with input variations plus 10 PCT.
   d. Capable of fully charging a fully discharged set of batteries within maximum time period of 24 HRS.
   e. Automatic switching between float or equalize range with individual float/equalize adjustments.
   f. DC voltmeter, DC ammeter, AC and DC fuses, AC failure indicator and alarm relay, high and low DC voltage indicators and a common alarm relay.
   g. Relays shall have minimum of 1PDT each for remote monitoring.
   h. Listed by Underwriters Laboratories UL 1236 or UL 1564.
   i. Where unit is not shown as wall mounted, provide independent corrosion resistant steel floor mounted rack for support secured to slab.

F. Generator:
1. Ball bearing type, directly connected to engine with semi-flexible coupling.
   a. Direct connect exciter to end of generator shaft.
   b. Generator and exciter shall conform to USASI, IEEE and NEMA standards for Class H insulation, 105 DEGC (at 40degC ambient) rise by resistance.
   c. Nameplate ratings shall correspond to manufacturer's published data from period of not more than six months prior to bidding.
   d. Continuous standby duty rating at 0.8 PF. KW, kva and volts as indicated.
      1) Generator shall be rated to serve up to 95 PCT non-linear load, with a maximum of 10 PCT THDI, without exceeding standard NEMA temperature rise.
   e. Solid state, 3-phase, true rms sensing voltage regulator shall maintain regulation with 1/2 PCT above and 1/2 PCT below normal voltage. Instantaneous voltage drop when full load is applied shall not exceed criteria indicated in the performance specification. Locate in control panel.
   f. Provide excitation by series boost system for units less than 60 kW or a permanent magnet so as to maintain a 3-phase symmetrical short circuit current of 3 times full load current for period of at least 5 seconds.
   g. Voltage waveform harmonic distortion shall not exceed 5 PCT total rms measured line to line and line to neutral where neutral is provided at rated load. Distortion in any one harmonic order shall not exceed 3 PCT at rated load.
   h. Minimum efficiency: 92 PCT at 50 to 110 PCT of nominal standby rating.
   i. Self ventilating with suitable fan, air inlet and outlet openings.

j. Free from critical torsional vibration within operating range.
k. Provide generator mounted main circuit breaker: Solid state molded case type, 100 PCT rated, with auxiliary contacts for status and adjustable electronic trips for frame sizes greater than 100 amps. Rating shall be as indicated.
   1) Provide ground fault alarm.
      a) Provide a ground fault sensor system, sized as a minimum for trip setting indicated.
      b) Indicate when there is a ground fault on main breaker.
      c) Ground fault shall not trip main breaker, but shall be indicated at generator remote annunciator panel. Include following:
         (1) Test circuit with cut-off switch.
         (2) Fail safe indicating lamp.
         (3) Terminals for remote alarm.
         (4) Reset controls.
         (5) Adjustable pick up, set at .2 of the sensor rating.
         (6) Adjustable delay, set at .1 seconds minimum.
         (7) Post sign at main breaker stating course of action in event of a ground fault. Verify contents of statement with Owner.

G. Digital Voltage Regulator:
   1. SCR type.
      a. Maintain 0.5 PCT voltage regulation from 0 to full load with steady state modulation not exceeding plus 1/2 PCT.
      b. Provide maximum of 5 PCT unbalance in kva load sharing between this unit and possible future generators.
   2. Provide automatic protection against short circuits on system.
   3. Permit unit to operate at no load below rated frequency for engine start up and shut down procedures.
   4. Provide voltage level and gain controls for normal operating adjustments.
   5. Provide voltage level control with minimum range of plus or minus 5 PCT from rated voltage.
   6. Mount regulator, volts per hertz type, in generator housing on suitable vibration isolators.

H. Provide communication interface with Building Automation System.
   1. Communicate status and alarms to BAS.

I. Generator Remote Annunciator Panel:
   1. Locate for each generator in paralleling switchgear room, mechanical control room, and 24-hour monitored location.
   2. Provide remote annunciator panel per NFPA 110, flush or surface as indicated, powered from unit batteries, with following:
      a. Individual visual signals shall indicate:
         1) When emergency or auxiliary power source is operating to supply power to load (green).
      b. Individual visual signals for each generator plus a common audible signal to warn of an engine-generator alarm condition for:
         1) Low water temperature (amber).
         2) Low coolant level (red).
         3) High engine temperature pre-alarm (red).
         4) High engine temperature (red).
         5) Low lubricating oil pressure pre-alarm (red).
         6) Low lubricating oil pressure alarm (red).
         7) Overcrank – failed to start (red).
         8) Overspeed (red).
         9) Low fuel main tank pre-alarm (amber).
         10) Main fuel tank leak detection (amber).
         11) Low fuel auxiliary tank emergency (red).

12) Auxiliary fuel tank leak detection (amber).
13) Batter charger A/C Failure (amber).
14) Low Battery Voltage (red).
15) Control switch in "Not in Automatic" position (red).
16) Ground Fault Alarm (on units where required) (red).
17) Generator Panel Emergency Off (red).
18) Generator Remote Emergency off (red).
19) Generator Circuit Breaker Open (where so equipped) (red).
20) Generator Panel Pre-alarm (amber).
21) Generator Panel Alarm (red).
22) Distribution C/B open (red)
    a) Summary alarm for normally de-energized essential system circuit breakers where indicated.
23) Audible signal shall be a horn when located in high ambient noise area of 70 dba and above.
24) Buzzer or electronic audible device is to be used in a moderate ambient noise area below 70 dba.
25) Include alarm silencing push-button and circuitry in panel to allow subsequent malfunctions to resound alarm if previously silenced.

3. Generator remote annunciator sub-panel:
   a. Flush or surface mounted as indicated, 7IN x 6IN x 4IN deep.
      1) Circuits: DC powered from generator starting batteries. Verify circuit voltage to match battery voltage.
      2) Provide signal lamps, buzzer, NORMAL/OFF/TEST silencing switch, relays, solid-state components, and function identifications.
   b. Sub-panel functions:
      1) Green light to indicate that generator is supplying load. Label light "STANDBY POWER GENERATION SYSTEM SUPPLYING LOAD".
      2) Common amber or yellow light to indicate alarm or prealarm condition. Label light "STANDBY POWER GENERATION SYSTEM ALARM OR PREALARM".
      3) Common red light to indicate shut down or "NOT IN AUTO" condition. Label light "STANDBY POWER GENERATION SYSTEM SHUTDOWN".
      4) Common buzzer for all conditions.

J. Engine Generator Weatherproof Enclosure:
   1. Size enclosure to contain engine-generator set with accessories.
   2. On units 500 kW and larger, independently mount enclosure and separate from vibrating parts to eliminate excessive sheet metal noise and vibration.
      a. Provide enclosure with hinged lockable doors.
      b. Provide bird and rodent screens on openings.
      c. Provide ventilation openings to provide air cooling and combustion.
      d. Provide ambient temperature calculations to indicate enclosure air temperature will not drop below 32 DEGF or provide battery heaters as required thermostatically controlled to maintain battery temperature at 50 DEGF minimum and automatically shut off at a battery temperature of 90 DEGF.

K. Engine generator enclosure:
   1. Sound attenuated weatherproof requirements.
      a. Heavy gauge Aluminum with side servicing doors, air intake and exhaust louvers, pitched roof and muffler system installed inside the enclosure.
      b. Enclosure to allow full load operation of engine generator system with accessories and design for unit being installed
      c. Install additional wall and insulation thickness, plus air discharge and intake hoods or sound attenuators to meet design sound levels.

L. Generator Enclosure shall have the following features:
   1. Base (floor) of the enclosure shall incorporate a UL 2085 Listed and labeled double wall fuel tank
   2. Provide electrical stub-up area for electrical connections at generator circuit breaker and enclosure electrical distribution panel.
   3. Fuel tank heater:
      a. Minimum of 2,000 watts.
      b. Thermostatically controlled with safety shutdown feature for low fuel level conditions.
   4. Provide electrical distribution panel sized to operate the generator set block heater, jacket water heater, lights, louvers wall mounted battery charger, receptacles, fuel tank heaters, fuel pumps, battery jacket heater, and space heater.
      a. Prewire loads and install wiring in conduit.
      b. Provide electrical stub-up area through generator power conductor area for service to the distribution panel.
      c. Installation to include 15kVA 480:208/120V xf.
   5. Exterior color selected by Architect.
      a. Provide touch-up paint in finish color.
   6. Provide electric unit heaters to maintain internal temperature at 50 DEGF.
      a. Interlock so unit heaters shut off when generators are running.
   7. Resist intake of blown sand or rain through intake air assembly.
   8. Provide anchor bolts for casting into concrete base for attaching enclosure to pad.
      a. Coordinate enclosure with concrete pad and foundations.
   9. Coordinate the enclosure with the engine generator furnished to assure physical clearances, sound attenuation, airflow and pressure drop through the system.
   10. Provide doors and access panels for removal of large assemblies.
   11. Flash and seal exit of exhaust stack in roof.
   12. Provide ventilation fan with gravity damper, thermostatically controlled to operate continuously at internal temperatures adjustable from 60 to 90 DEGF.
      a. Interlock ventilation fans to prevent them from running when the engine generators are running.
      b. Interlock ventilation fan with motorized inlet dampers.
   13. Field test installation under load.
      a. Use precision sound measuring instrument meeting ANSI-S1.4 type 1.
      b. Provide measurements to Engineer.

2.4 REMOTE EMERGENCY STOP

A. Remote Emergency Stop Station:
   1. Stops associated engine generator.
   2. Label: "Generator Remote Emergency Off".
   3. Provide one with protective cover for each generator set.
   4. Locate outside and immediately adjacent to generator room door.

2.5 STAIRS

A. Provide stairs to access generator enclosure where required.

2.6 PORTABLE GENERATOR/LOAD BANK DOCKING STATION

A. General Requirements:
   1. Trystar Generator Docking Station
   2. Breaker Protecting Load Bank Connections W/ Shunt Trip
   3. Breaker Protecting Temporary Generator Connection (Controlled by Kirk Key)
   4. UL 1008 Standards
   5. UL 50 Listed
   6. 65kAIC Rated
   7. Kirk Key Interlocked Breaker Protecting Male Panel Mounts

8. Additional Kirk Key Lock Provided to be Mounted on Existing Equipment
9. Shunt Trip on Load Bank Breaker

B. Weatherproof Enclosure:
1. All Aluminum Construction
2. Powder Coat Color: To be selected by architect.
3. NEMA 3R with sloped cover
4. Silver Plated Copper Busbar
5. Protective Caps on All Panel Mounts to Prevent Accidental Contact
6. Padlockable Swinging Front Door
7. Phase Rotation Monitor
8. Attached Legs with Holes for Pad Mounting

C. Components:
1. 6 Sets of Male 16 Series Panel Mounts
    a. Brown, Orange, and Yellow Panel Mounts for Phases, White Panel Mounts for Neutral
2. 2 Male Green 16 Series Ground Panel Mounts
3. Male Panel Mounts Behind Kirk Key Interlocked Access Door
4. 6 Sets of Female 16 Series Panel Mounts
    a. Brown, Orange, and Yellow Panel Mounts for Phases
    b. No Neutral for Female Connection
5. 2 Female Green 16 Series Ground Panel Mounts
6. (6) 600 MCM Mechanical Lug Terminations per Phase, Neutral and Ground for Permanent Connection to Line
7. (6) 600 MCM Mechanical Lug Terminations per Phase, Neutral and Ground for Permanent Connection to Load
8. (6) 350 MCM Mechanical Lug Terminations per Phase and Neutral for Temporary Connection
9. (2) 350 MCM Mechanical Lug Terminations for Ground Temporary Connection

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install components as indicated and in accordance with manufacturer's recommendations and instructions.

B. Provide control wiring in conduit between generator control panel and other components as required including but not limited to generator switchgear, automatic transfer switches, remote alarm annunciator panel(s) and remote devices as required.

C. Install and connect batteries and fill with electrolyte.

D. Provide connection to driven electrode ground from set frame sized as a minimum in accordance with National Electrical Code, unless otherwise indicated.

E. Provide fuel, oil and coolant required for testing.

F. Make necessary adjustments to voltage regulator and time delay relays following manufacturer's recommendations. Manufacturer or his designated representative shall provide installation inspection and start-up service.

G. Entire installation shall be made in accordance with recommendations of manufacturer and within regulations of State Industrial Accident Commission and Fire Prevention Bureau of fire department having jurisdiction.

H. Provide concrete pad for engine generator unit.
1. See Section 26 00 10.

3.2 FACTORY PERFORMANCE TEST

A. Individually test each Generator at rated power factor per NFPA 110 requirements.
   1. Provide cost including travel, transportation, hotel and meals to send two Owner representatives and one Engineer to the Factory Test.
   2. Coordinate test date shall be coordinated with Owner and Engineer minimum of 30 days in advance of test.

3.3 FIELD PERFORMANCE TEST

A. Provide factory trained mechanic along with tools, test equipment and resistive or inductive load banks required to perform tests. Architect shall be notified a minimum of two weeks prior to following testing and may, at Architect’s discretion, witness testing.

B. Test safeties specified for generator instruments and controls, remote annunciator panels and annunciator sub-panels as recommended by manufacturer and as required to verify proper operation simultaneously.
   1. Demonstrate functioning of high temperature coolant circuit by restricting air flow through the radiator, or by shutting down the radiator fan motor, or by utilizing manufacturer’s pre-engineered test circuit.
   2. Verify engine shut down for low oil pressure. Removing lead conductors or using manufacturer’s test circuits are acceptable methods.
   3. Perform a battery starting test, with charger disconnected, consisting of minimum cycle cranking period indicated hereafter or more cycle cranking period when recommended by manufacturer.
   4. Demonstrate operation of engine overspeed circuit by increasing engine speed or by utilizing manufacturer's pre-engineered test circuit.
      a. Record speed at which trip operates.
   5. Demonstrate ground fault alarm circuit when required and note ground fault current flowing in accordance with ground fault manufacturer's test procedures.
   6. If proper operation of Safety System is not met during test, necessary readjustments and/or equipment replacements shall be made and step repeated until satisfactory results are obtained.

C. Transient Performance:
   1. Rerun factory transient performance test as outlined to assure installation conformance.

D. Perform tests as outlined in “Acceptance Test” section of NFPA 110. NFPA 110 edition utilized shall be that adopted by code authority having jurisdiction for this project or should this section not have been adopted, latest edition shall apply.

E. Checks to be made during on-site testing:
   1. Proper operation of controls.
   2. Proper operation of gauges, indicator lights, and instruments throughout operation at control and annunciator panels.
   3. Proper operation of auxiliary and accessory equipment.
      a. Check valves, including pilot valves, and injection pump during tests to assure proper operation.

F. Upon completion of on-site tests, make a general inspection for following defects:
   1. Leaks in engine, piping system, tanks, etc.
   2. Excessive blowby.
   3. Crankcase contamination.
   4. Other deficiencies which may impair proper operation.

G. Should equipment fail to function properly during operational testing, defect shall be repaired or replaced and entire operational test may be repeated at sole discretion of Architect.

H. Final acceptance shall be made when generator set has successfully completed on-site tests and after defects in material or operation have been corrected.

I. Furnish load banks of required ratings necessary for test.

J. Record engine fuel consumption.

K. Check and fill fluid levels including main fuel tank upon final acceptance.

3.4 PRIORITY LOADS

A. Prioritize loads as follows:
   1. Priority 1; ATS Life Safety and Emergency Branches.
   2. Priority 2; ATS Legally Required Systems.
   3. Priority 3; ATS Optional Standby Systems.

END OF SECTION

SECTION 26 33 54
UNINTERRUPTIBLE POWER SUPPLY SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Uninterruptible Power Supply Systems, as indicated, in accordance with provisions of Contract Documents.

B. Uninterruptible power supply system includes:
1. Battery charger.
2. Inverter.
3. Static switch.
4. Transformers and miscellaneous equipment.
5. Batteries and racks.

C. Completely coordinate with work of other trades.

1.2 SUBMITTALS

A. Shop Drawings:
1. Outline drawings of assembly.
2. One line diagrams and wiring diagrams for assembly and components.
3. Interconnection wiring diagrams.

B. Product Data:
1. Technical data on all components.
2. Specification comparison.

C. Contract Closeout Information:
1. Operation and Maintenance Data.
2. Owner instruction report.
3. Prorata warranty for batteries.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Uninterruptable Power Supply Systems:
1. Base:
   a. Eaton Powerware 9395.
   b. Liebert.

2.2 MATERIALS

A. System Rating:
1. Size each UPS system to maintain a load as indicated on drawings for 15 minutes.

B. Electrical Characteristics:
1. System input:
   a. Voltage: As indicated on drawings.
   b. Frequency: 60 Hz.
   c. Current in-rush limiting: 20 PCT to 100 PCT of full rated load over 15 seconds.
   d. Power factor: Unity to 0.8 lagging with full load at nominal input voltage and normal float voltage on battery.
2. System output:
   a. Voltage: Voltage as indicated on drawings, 4 wire, plus ground, manually adjustable (plus/minus 5 PCT).

3. Output voltage transient characteristics:
   a. 25 PCT load step: Plus/minus 2 PCT.
   b. 50 PCT load step: Plus/minus 4 PCT.
   c. 100 PCT load step: Plus/minus 14 PCT.
   d. Loss of return of AC input power: Plus/minus 1 PCT.
   e. Bypass transfer of 100 PCT load: Plus/minus 1 PCT.
4. Output voltage transient response: Make system output voltage return to within plus/minus 1 PCT of the steady-state value within 200 milliseconds.
5. Output voltage regulation: The steady-state output voltage shall not deviate by more than plus/minus 1 PCT from no load to full load.
6. Output frequency regulation: Make UPS be capable of providing 60 Hz plus/minus 0.5 PCT free running.
7. System overload: Make inverter capable of supplying regulated output during overloads of 125 PCT of the system rating for a period of 10 minutes or 150 PCT for 30 seconds.
8. System efficiency: Make over all efficiency, input to output, at least 85 PCT with the battery fully charged and the inverter supplying full-rated load.

C. Rectifier/Charger:
1. Input current limiting.
   a. Make rectifier/charger capable of supplying an overload current not less than 125 PCT of full load current. For greater output currents, make rectifier current limit. Upon removal of the overload condition, make rectifier/charger return to normal without degradation of performance or components.
2. Input harmonic suppression.
   a. Design rectifier/charger to limit the input harmonic current feedback into the source to a maximum of 10 PCT Total Harmonic Distortion (THD) with nominal input voltage and rated load on the inverter.
3. Power walk-in:
   a. Provide rectifier/charger with a walk-in circuit that causes the unit to assume the load gradually after the input voltage is applied. Currents shall increase gradually from 20 PCT to 100 PCT over a 15 second period after the battery open circuit voltage has been reached.
4. Magnetization inrush:
   a. Limit initial magnetization inrush surge to 600 PCT of the rectifier/charger full-load current.
5. Input power factor:
   a. Provide rectifier/charger with a minimum power factor of 0.8 lagging with nominal input voltage and frequency and the inverter operating at full-rated load.
6. Overload protection and disconnection:
   a. Provide an automatic input circuit breaker for rectifier/charger disconnection and overload protection. The overload devices shall not be activated when the rectifier/charger is started under any of the operating conditions listed.
7. Capacity:
   a. Provide rectifier/charger with sufficient capacity to support a fully loaded inverter and recharge the battery to 95 PCT of its full capacity within 10 times the discharge time when input current limit is set at 125 PCT of full load.

D. Inverter:
1. Voltage regulation. The inverter steady-state output voltage shall not deviate by more than plus/minus 1 PCT due to the following conditions:
   a. 0 PCT to 100 PCT load.
   b. Ambient temperature variations.
   c. Minimum to maximum DC bus voltage.
2. Voltage adjustments:
   a. Provide inverter with a control to manually adjust the output voltage plus 4/minus 1 PCT from the rated value.

3. Frequency control:
    a. Control output frequency of the inverter by an oscillator, which can be operated as a free-running unit or as a slave for synchronized operation with a separate AC source. Make inverters track the synchronizing source with plus/minus 2 PCT. If the external synchronizing source deviates from the preset frequency by plus/minus 0.5 to plus/minus 1.0 Hz (adjustable), make oscillator automatically revert to a free-running unit.
4. Frequency regulation:
    a. The inverter free-running, steady-state output frequency shall not deviate by more than plus/minus 0.5 PCT due to the following conditions:
        1) 0 PCT to 100 PCT load.
        2) Ambient temperature variation.
        3) Minimum to maximum DC bus voltage.
    b. Provide inverter output with zero frequency transients for the system disturbances listed under transient response.
5. Harmonic distortion:
    a. The inverter shall provide harmonic neutralization and filtering necessary to limit the total harmonic distortion in the output voltage to 5 PCT and single harmonics to 3 PCT over the entire linear load range.
6. Transient response: The inverter transient voltage shall not exceed plus/minus 8 PCT due to the following system disturbances:
    a. A 50 PCT step load application and rejection with zero initial load or 100 PCT initial load.
    b. Transfer of rated load to the bypass source due to inverter internal fault.
    c. Make output voltage return to within plus/minus 2 PCT of the steady-state value within 200 milliseconds.
7. Overload:
    a. Make inverter capable of supplying currents and regulated voltage for overloads up to 125 PCT of full load current for a selected period. Make audible alarm indicate overload operation. Make inverter transfer the load to bypass when the overload period expires.
8. Fault clearing and current limit:
    a. Make inverter capable of supplying an overload current of 150 PCT of its full load rating for 30 seconds. For greater currents or longer time duration, provide inverter with current limiting protection to prevent damage to components.
9. Inverter DC protection: Protect inverter by the following alarms and trips, independently adjustable for maximum system flexibility.
    a. DC overvoltage trip range: 2.62 to 2.28 VPC for the standard number of cells.
10. Output circuit breaker:
    a. Make inverter mechanically connected and disconnected from the critical load by a system automatic, or non-automatic circuit breaker located inside the UPS module.
11. Overcurrent protection:
    a. Protect inverter from excessive overloads, including faults and reverse currents, by fast acting fuses to prevent damage to power SCR's.
12. Surge protection:
    a. Provide inverter with built-in protection against undervoltage, overcurrent, and overvoltage surges on the output caused by load transfer between the UPS and an external synchronized bypass source.

E. System Status and Control:
1. General:
    a. Provide UPS with a system status panel to provide monitoring and control of the complete system.
2. System metering: Meter accuracy 2 PCT or better: Provide with the capability of monitoring the following system functions:
    a. AC input voltage.

b. DC voltage.
c. DC current.
d. AC output voltage, each phase.
e. AC output current, each phase.
f. AC output frequency.

3. System controls. Provide following controls for the system:
   a. UPS/bypass transfer switch.
   b. Battery circuit breaker trip pushbutton.
   c. Alarm test/reset pushbutton.
   d. Audio alarm reset pushbutton.
   e. Emergency power off (EPO) pushbutton.
4. System mimic: Provide diagram with indicating lights as a part of the system status panel. Make the mimic depict a complete single line diagram of the UPS and illuminate the following functions:
   a. AC input breaker open.
   b. AC input breaker closed.
   c. DC battery breaker open.
   d. DC battery breaker closed.
   e. AC output breaker open.
   f. AC output breaker closed.
   g. Bypass power available.
   h. Load on UPS.
   i. Load on bypass.
5. System alarms (latching type):
   a. Visual alarms: Provide following system operating conditions with visual and audible alarm annunciation:
      1) Overload.
      2) Rectifier active.
      3) Overtemperature.
      4) Fuse failure.
      5) Inverter active.
      6) Battery breaker open.
      7) Low battery.
      8) DC overvoltage.
      9) Inverter synchronized.
      10) Input power failed.
      11) Control power failed.
      12) Output over voltage.
      13) Load on bypass.
      14) Static switch unable.
   b. Audible alarm: Locate a horn on the control panel, which is activated upon any UPS alarm or when the inverter is on and the battery breaker is open.

F. Static Switch and Bypass:
1. General:
   a. Provide a static switch and maintenance bypass as an integral part of the UPS. Provide control unit with an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions to provide an uninterrupted transfer of the load to the bypass source without exceeding the transient limits specified herein when a malfunction occurs in the UPS.
2. Static switch:
   a. Make static switch a naturally commutated, high-speed static transfer device. Rate bypass static switch for continuous full load operation.
3. Bypass breaker:
   a. Provide a circuit breaker to allow complete electrical isolation of the UPS and static switch for maintenance.

4. Operation: Connect static and bypass switches to the bypass source and assume the critical load when required and provide the following features:
   a. Uninterrupted transfer: Make static bypass switch automatically assume the critical load after the inverter logic senses one of the following conditions:
      1) Inverter overload period expired.
      2) Critical bus overvoltage or undervoltage.
      3) Battery protection period expired.
      4) UPS failure.
   b. Uninterrupted automatic retransfer: If the transfer control circuit is set for automatic retransfer, make UPS capable of retransferring the critical load to the inverter when the overload is removed, or the critical bus voltage stabilizes. Make inverter automatically walk in smoothly to the output bus voltage, parallel and share the load with the bypass source, and assume the load in the "bumpless" manner prior to disconnection of the bypass source. Do not use static switch during retransfers.
   c. Transfer lockout: The static switch logic shall not allow a transfer to bypass if one of the following conditions exist:
      1) Bypass overvoltage/undervoltage (plus/minus 10 PCT of nominal).
      2) Bypass frequency out of limits (plus/minus 5-1.0 Hz, adjustable).
      3) Bypass out of sync.
      4) Static switch disabled.
   d. Uninterrupted manual transfer: Provide a manually initiated make-before-break transfer for routine maintenance purposes. This transfer shall be automatically inhibited if the bypass source is outside of the limits specified in paragraph (3) above.

G. Enclosures:
   1. House UPS in free-standing, dead-front enclosures with a welded steel framework. Door shall be of 14 GA steel; framework shall be of 12 GA steel. Mount instruments, status indicators, and controls at eye-level and accessible from the front of the UPS module.
   2. Provide forced-air cooling to ensure that components are operated within their environmental ratings. Equip blower motors with sealed bearings. Equip air inlets with standard type filters, which are replaceable from outside the unit. Protect all air inlet and exhaust openings by perforated or slotted metal guards.

H. UPS Battery System:
   1. Type and capacity:
      a. Use lead-calcium, high-rate type batteries as the stored energy source for the UPS. Size battery system to support the inverter at rated load or the kilowatt load specified for the protection time specified.
   2. Accessories. Supply the following accessories:
      a. Intercell, interunit, intertier, end-to-end interrack and back-to-back interrack connections.
      b. Anti-corrosion compound.
      c. Connector nuts and bolts.
      d. One portable hydrometer with 5-point increments.
      e. One wall-mounted hydrometer holder.
      f. One thermometer with a 2 DEGF scale and plus/minus 1 degree accuracy.
      g. One cell lifting device.
      h. One set of cell numbers.
   3. Racks: Provide steel racks, designed specifically for the battery cell type furnished. Make the racks three tier or step type designed for installation at this specific project location. Use the following materials:
      a. Rails: Steel channel, metallic-zinc finish, ASTM-A1011.
      b. Rail insulation: 6500 volt, preapplied insulation, 0.03 IN minimum thickness.
      c. Frames: A36 steel angle with acid-resisting epoxy, light gray coating of 6 MIL thickness.

d. Braces: A36 flat steel strap with acid-resisting epoxy, light gray coating of 6 MIL hickness.

4. Ground protection:
   a. Provide battery system with a high resistance ground and a ground detection alarm for maximum personnel safety.
5. Battery circuit breaker:
   a. Provide UPS with a circuit breaker to disconnect the DC circuit between the battery and the inverter input.
   b. Include a positive visible means of isolation of the battery from the rest of the system for maintenance or due to fault in the battery system.
   c. Equip with an undervoltage release to be used to open the breaker including remote release from the battery room.
   d. Provide in a NEMA 1 enclosure suitable for wall mounting.

I. Environmental Conditions:
   1. Make UPS capable of withstanding any combination of the following environmental conditions in which it must operate without mechanical or electrical damage, or degradation of operating characteristics.
   2. Ambient temperature:
      a. Operating: Plus 10 DEGC to plus 40 DEGC.
      b. Non-operating and storage: Minus 20 DEGC to plus 70 DEGC.
   3. Relative humidity:
      a. Operating: 0 to 95 PCT for temperature from plus 10 DEGC to plus 40 DEGC, excluding condensation due to temperature change.
      b. Non-operating and storage: 0 to 95 PCT, excluding condensation due to temperature change.
   4. Barometric pressure:
      a. Operating: From sea level to 3,000 FT above sea level.
      b. Non-operating and storage: From sea level to approximately 40,000 FT.

J. Remote Alarm for:
   1. Bypass.
   2. UPS in alarm.
   3. UPS OK.
   4. Provide individual indicating lights and tone with silence switch.
   5. Locate in computer room.

2.3 OPERATION

A. Make UPS automatically effect continuity of electric power within specified tolerances, without interruption, upon failure or deterioration of the normal power supply. Maintain continuity of electric power to the load for an emergency period with the inverters supplied by the batteries, up to the specified maximum time or until restoration of the normal power supply.

B. Modes of operation:
   1. Design UPS to operate as an on-line reverse transfer system in the following modes:
      a. Normal:
         1) Critical load is continuously supplied by the inverter.
         2) Rectifier/battery charger derives power from the utility AC source and supplies DC power to the inverter while simultaneously float charging the battery.
      b. Emergency:
         1) Upon failure of the utility AC power critical load is supplied by the inverter, which without any switching, obtains its power from the storage battery.
         2) There shall be no interruption to the critical load upon failure or restoration of the utility AC source.
      c. Recharge:
         1) Upon restoration of the utility AC source, the rectifier/charger automatically powers the inverter and simultaneously recharges the battery.

d. Bypass mode:
   1) If the UPS must be taken out of service for maintenance or repair of internal failures, the static switch transfers the load to the alternate source without an interruption.
   2) Retransfer of the load is accomplished by automatically synchronizing the UPS to the alternate source, paralleling the inverter with the alternate source, and allowing the inverter to ramp into the load and then disconnect the alternate source.
e. Downgrade:
   1) If the battery only is taken out of service for maintenance, it is disconnected from the rectifier/charger and inverter by means of a circuit breaker.
   2) The UPS shall continue to function herein, except for power outage protection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturer's recommendations and instructions.

END OF SECTION

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SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Automatic Transfer Switches, as indicated, in accordance with provisions of Contract Documents.

B. Provide automatic transfer switches with number of poles, amperage, voltage, withstand and close-on ratings as shown on plans.

C. Each automatic transfer switch shall consist of inherently double throw power transfer switch mechanism and microprocessor controller to provide automatic operation. All automatic transfer switches and controllers shall be products of same manufacturer.

D. Provide interface control wiring in conduit to other equipment as required for complete and operational system.

E. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Automatic transfer switch manufacturer shall maintain national service organization throughout contiguous United States. Service center's personnel must be factory trained and must be on call 24 HRS per day, 365 days per year.
   2. Manufacturer shall maintain records of each switch, by serial number, for minimum of 20 years.
   3. Manufacturer of switches shall have a certified service representative within 50 miles of job site.

B. Provide automatic transfer switches conforming to following standards:
   1. UL 508: Industrial Control Equipment.
   2. UL 1008: Standard for Transfer Switch Equipment.
   3. IEEE Standard 446: Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
   4. NEMA Standard ICS-10: Electromechanical AC Transfer Switch Equipment.
   5. NFPA-70: National Electrical Code
   6. NFPA-101: Life Safety Code
   7. NFPA-110: Emergency and Standby Power Systems

1.3 SUBMITTALS

A. ATS shop drawings and product data shall be submitted along with, or subsequent to, a complete short circuit analysis and coordination study per Section 26 28 00. Product data or shop drawings submitted prior to power system studies will be rejected.

B. Shop Drawings:
   1. Switches:
      a. Dimensional drawings of equipment, including:
         1) Plan, elevation, and side views
         2) Equipment weights and center of gravity.
         3) Location of all needed access points and required clearances.
         4) Mounting and anchoring points.
         5) Conduit entry points.
      b. One line diagrams and wiring diagrams for assembly and components.
      c. Interconnection wiring diagrams specific to project conditions.

C. Product Data:
   1. Technical data on each size and type of transfer switch.
   2. Withstand and close ratings of each switch.
   3. Specification comparison.

D. Project Information:
   1. Factory test reports, prior to shipping equipment.
   2. Letter certifying compliance with all requirements of specification including compliance with applicable codes and standards, and withstand and closing ratings. Certification shall identify, by serial number(s), equipment involved. No exceptions to specifications, other than those stipulated at time of submittal, shall be included in certification. Submit prior to shipping equipment.

E. Contract Closeout Information:
   1. Operating and maintenance data.
   2. Final time delay settings for each ATS, in tabular format.
   3. Owner instruction report.
   4. Approved factory test reports.
   5. Approved letter of compliance.
   6. Field test reports.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Automatic Transfer Switches:
   1. ASCO:
      a. 7000-Series ATSs with Group 5 controller and 5200-series Power Manager to provide real-time Voltage, Current, and Frequency metering.
   2. Russ Electric.
   3. Zenith.

2.2 MATERIALS

A. Automatic Transfer Switches:
   1. Provide ATSs in Utility-to-Generator configuration unless noted otherwise.
   2. Electrically operated and mechanically held.
   3. Electrical operator shall be momentarily energized, single or dual-solenoid mechanisms. Main operators which include overcurrent disconnect devices or gears are not acceptable.
   4. Transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.
   5. Switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at constant value and contact temperature rise is minimized for maximum reliability and operating life.
   6. Main contacts shall be silver composition.
   7. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.
   8. Inspection of all contacts shall be possible from front of switch without disassembly of operating linkages and without disconnection of power conductors.
   9. Switches rated 600 amps and higher shall have front removable and replaceable contacts.
   10. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.
   11. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources, are not acceptable.

B. Combination Bypass Isolation:
   1. Two-way bypass-isolation switches shall provide manual bypass of load to either source and permit isolation of automatic transfer switch from all source and load power conductors. All main contacts shall be manually driven.
   2. Power interconnections shall be silver-plated copper bus bar. Only field installed power connections shall be at service and load terminals of bypass-isolation switch. All control interconnecting wiring shall be provided with disconnect plugs.
   3. Separate bypass and isolation handles shall be utilized to provide clear distinction between functions. Handles shall be permanently affixed and operable without opening enclosure door. Designs requiring insertion of loose operating handles or opening of enclosure door to operate are not acceptable.
   4. Bypass to load-carrying source shall be accomplished with no interruption of power to load (make before break contacts). Designs which disconnect load when bypassing are not acceptable.
   5. Bypass handle shall have three operating modes: "Bypass to Normal," "Automatic," and "Bypass to Emergency." Operating speed of bypass contacts shall be same as associated transfer switch and shall be independent of speed at which manual handle is operated.
   6. In "Automatic" mode, bypass contacts shall be out of power circuit so that they will not be subjected to fault currents to which system may be subjected.
   7. Isolation handle shall provide three operating modes: "Closed," "Test," and "Open."
      a. "Test" mode shall permit testing of entire emergency power system, including automatic transfer switches with no interruption of power to load.
      b. "Open" mode shall completely isolate automatic transfer switch from all source and load power conductors. When in "Open" mode, it shall be possible to completely withdraw automatic transfer switch for inspection or maintenance to conform to code requirements without removal of power conductors or use of any tools.
      c. When isolation switch is in "Test" or "Open" mode, bypass switch shall function as manual transfer switch.
   8. Designs requiring operation of key interlocks for bypass isolation or ATS's which cannot be completely withdrawn when isolated are not acceptable.
   9. Provide closed transition combination bypass isolation automatic transfer switches.

C. Switch Construction:
   1. Automatic transfer switches shall be furnished in NEMA Type 1 enclosure unless otherwise shown on the plans.
   2. Standard and optional door-mounted switches and pilot lights shall be 16mm industrial grade type or equivalent for easy viewing and replacement.
   3. Transfer switches shall be 4-pole switches unless otherwise noted. Neutral pole current rating shall match phase pole current rating.
   4. Withstand and closing ratings:
      a. Automatic transfer switches shall be rated to close on and withstand available RMS symmetrical short circuit current at switch terminals with type of overcurrent protection shown on plans.
      b. Where manufacturer's ATS of required ampacity has a withstand and closing rating less than the available fault current at the ATS terminals, a larger-ampacity ATS with adequate fault current withstand and closing rating shall be provided.
      c. Automatic transfer switches shall be UL listed in accordance with UL 1008.
      d. Automatic transfer switches not tested and labeled with a minimum of 1-1/2 and 3 cycle (any breaker) ratings and have series, or specific breaker ratings only, are not acceptable.
   5. Switch shall have provisions for visual inspection of switch blades and contacts.
   6. Silver-surface main contacts, protected by arcing contacts.
   7. Make all contacts and coils readily accessible for replacement from front of panel without major disassembly.
   8. Provide red and green indicating lights with fuses, identification nameplates, and test switch on front to simulate normal power failure at switch.

9. Provide cable terminal lugs to accommodate conductors indicated on one line diagram.

D. Microprocessor Controller:
   1. Sensing and logic shall be provided by single built-in microprocessor in each switch for maximum reliability, minimum maintenance, and ability to communicate serially through optional serial communication module.
   2. Single controller shall provide selectable nominal voltages for maximum application flexibility and minimal spare part requirements.
      a. Voltage sensing shall be true RMS type and shall be accurate to plus or minus 1 PCT of nominal voltage.
      b. Frequency sensing shall be accurate to plus or minus 0.2 PCT.
      c. Panel shall be capable of operating over temperature range of minus 20 to plus 60 DEGC and storage from minus 55 to plus 85 DEGC.
   3. Controller shall be connected to transfer switch by interconnecting wiring harness with keyed disconnect plug to enable controller to be disconnected from transfer switch for routine maintenance.
      a. Sensing and control logic shall be provided on multi-layer printed circuit boards.
      b. Interfacing relays shall be industrial grade plug-in type with dust covers.
      c. Panel shall be enclosed with protective cover and be mounted separately from transfer switch unit for safety and ease of maintenance. Protective cover shall include built-in pocket for storage of operator's manuals.
   4. Customer connections shall be wired to common terminal block to simplify field-wiring connections.
   5. Provide LCD display three to four lines, up to 20 character and keypad as part of controller for viewing all available data and setting desired operational parameters.
   6. Controller shall meet or exceed all IEC requirements for Electromagnetic Compatibility (EMC) and field immunity.

E. Metering and Graphical User Interface:
   1. Provide a graphical touch display interface local to the transfer/bypass switch, power/energy metering, enable remote Ethernet monitoring via open protocols and a web app accessible from any mobile phone, tablet, or computer on the network. The local touchscreen shall interface to the ATS controller, Bypass controller (if applicable), power/energy meter and communications module. The following shall be included.
      a. 7 IN color touchscreen display with dual-Ethernet, front-accessible USB ports, (2) function push buttons and (2) alarm LED and audible buzzer.
      b. Four (4) 100 Mbps Ethernet copper RJ-45 ports, five (5) serial ports, Termination dip-switches and LEDs for diagnostics.
      c. Metering (Cat. 5210) which includes the following measurements: Voltage, current, power, energy and total harmonic distortion%.
      d. 25 seconds of power ride-through module for the ATS controller, power meter and remote monitoring, and 11 seconds for the display's computer.
      e. Display color-coded dynamic one line of transfer and bypass switch including ability to transfer and retransfer.
      f. Display with active and historical alarms by name, logic level and severity. Date, time and acknowledgement for each alarm shall be included.
      g. Display metering data including volts, amps, real power, reactive power, apparent power, max power demand, unbalance and energy usage from each source.
      h. Four (4) 100 Mbps Ethernet copper RJ-45 ports, five (5) serial ports, Termination dip-switches and LEDs for diagnostics.
      i. Metering (Cat. 5210) which includes the following measurements: Voltage, current, power, energy and total harmonic distortion%.
      j. Historical trending chart for the last 4-weeks of volts, amps, power and frequency. Option to switch to real-time trend view.
      k. Historical statistics chart displaying source availability and transfers due to source failure.

l. Single unified event log including the last 1000 events by transfer switch, bypass switch and engine-generator starts.
m. Operational and maintenance notes and logs for users can be entered to help keep track of transfer switch history.
n. All available controls, metering and monitoring settings shall be viewable and can be changed with proper user privileges.
o. There shall be a minimum of 3 user privilege levels, monitor (view only), control (view and control) and administrator (view, control and change settings).
p. Data shall be encrypted for remote communications using AES 128-bit advanced encryption standards.
q. Modbus TCP/IP, SNMP, HTTP, SMTP open protocols shall be simultaneously supported.
r. Email notifications and SNMP traps of selectable events and alarms may be sent to a smart phone, smart watch and PC.
s. Web app interface to monitor and control the transfer switch supporting modern smart phones, tablets and PC browsers. User will be able to view the dynamic one-line, ATS controls status, alarms, metering, event logging as well as settings.
t. The USB ports shall be capable of updating software and downloading event log and note log reports.

F. Provide three position maintained selector type test/normal automatic retransfer:
1. Test position will simulate normal source failure.
2. Reset position shall bypass time delays on either transfer to emergency or retransfer to normal.
3. Switches which require utilizing keypad and display function or have no manual time delay bypass means are not acceptable.
4. Test: Simulated normal power loss to control unit for testing of generator set, including transfer of load. Controls shall include provisions to automatically return the system to the normal power source if the generator set fails during any test or exercise period.
5. Normal: This is a normal operating position and it restores the load to the normal source after test and after time delays.
6. Retransfer: Momentary position to over-ride retransfer time delay and cause immediate return to normal source after test or actual outage. (This feature may be push-button activated.)

G. Provide SPDT contact, rated 5 amps at 30 VDC, for low-voltage engine start signal. Start signal shall prevent dry cranking of engines by requiring generator sets to reach proper output, and run for duration of cool down setting, regardless of whether normal source restores before load is transferred.

H. Provide minimum of two (2) sets of auxiliary contacts, rated 10 amps, 250 VAC consisting of one contact, closed when transfer switch is connected to normal source and one contact closed, when automatic transfer switch is connected to emergency source.

I. Provide LED indicating lights (16 MM industrial grade, type 12) shall be provided; one to indicate when automatic transfer switch is connected to normal source (green) and one to indicate when automatic transfer switch is connected to emergency source (red).

J. Provide LED indicating lights (16 MM industrial grade, type 12) energized by controller to provide true source availability of normal and emergency sources, as determined by voltage sensing trip and reset settings for each source.

K. Automatic Transfer Switches Serving Elevators:
   1. For each independently controlled elevator or elevator bank provide one NO, and one NC, auxiliary contact for connection to main elevator controller in each bank. On placing automatic transfer switch in test mode or on loss of normal power to transfer switch, auxiliary contacts shall operate to normal position and based on elevator manufacturer's requirements either NO contact(s) or NC contact(s) shall initiate emergency power operation outlined in Division 14.

L. Provide one of the following with equipment branch transfer switches:
   1. Dual operator with transition time delay field adjustable from 1-300 seconds in both directions when transferring from live source to live source.
   2. Neutral position integral to transfer switch with transition time delay field adjustable 1-300 seconds.

M. Time Delay Parameters:
   1. Provide time delay on engine start, field adjustable from 0 to 6 SEC to avoid unnecessary starting caused by short time outages.
   2. Provide time delay on transfer to emergency, field adjustable from 0-60 minutes.
   3. Automatic transfer switches serving the following branches shall have no delay in transferring to the non-preferred source. Transfer to the non-preferred source shall be made within 10 SEC of a loss of normal power in accordance with NFPA-110.
      1) Automatic transfer switches serving Emergency System.
         a) There shall be no delay in transferring to emergency. Transfer to be made to emergency automatically within 10 SEC of loss of normal power maximum In accordance with NFPA-110.
      2) Transfer switches serving Legally-Required Standby Loads:
      3) Transfer switches serving optional loads:
         a) Optional load ATS-1: Set delay at 1 minute.
         b) Optional load ATS-2: Set delay at 2 minutes.
      4) Automatic transfer switches serving Equipment System(s):
         a) Equipment System ATS-1: Set delay at 1 minute.
         b) Equipment system ATS-2: Set delay at 2 minutes.
   b. Provide adjustable time delay of 0 to 6 seconds to override momentary emergency source outage to delay all retransfer signals during initial loading of engine generator set.
   c. Provide two independently adjustable time delay modes on retransfer to normal, field adjustable from 0 to 60 minutes to avoid erratic operation caused by short time reestablishment of normal source.
      1) Mode 1: For actual normal power failures.
      2) Mode 2: For test mode function.
      3) Automatically bypass time delay if emergency source fails and normal source is available.
   d. Provide engine shut down time delay for engine generator cool down, adjustable from 0 to 60 minutes. .
   e. Provide time delay activated output signal to drive external relay(s) for selective load disconnect control.
      1) Controller shall have ability to activate adjustable 0 to 5 minute time delay in any of following modes:
         a) Prior to transfer only.
         b) Prior to and after transfer.
         c) Normal to emergency only.
         d) Emergency to normal only.
         e) Normal to emergency and emergency to normal.
         f) All transfer conditions or only when both sources are available.

2) Transfer switch serving elevator(s), send signal to elevator controller(s) 5 seconds prior to transfer in either direction when both sources are available. Contact shall reset 3 seconds after transfer. Contact(s) shall not create any additional transfer delay when transferring from dead source to live source.
   a) Verify quantity and type of contacts (NO, NC) with elevator supplier.

f. Controller shall include following built-in time delays for Closed Transition operation as required:
   1) 1 to 5 minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.
   2) 0.1 to 9.99 second time delay on extended parallel condition of both power sources during closed transition operation, adjustable in .01 second increments.

g. All time delays shall be adjustable in 1 second increments unless otherwise indicated,

h. All time delays shall be adjustable by using LCD display and keypad or with remote device connected to serial communications port. Time delay value displayed on LCD or remote device shall be remaining time until next event occurs.

N. Time Delay Settings (all times in mm: ss format):
1. Settings Common to all ATSs:
   a. Generator Start delay after S1 failure: 00:02
   b. Generator Cool down: 05:00
   c. Return to available S1 upon S2 failure: 00:00
      1) For delayed transfer ATSs, center-position delay shall be applied prior to return to S1.
2. Load shed scheme implementation:
   a. Load shall be shed upon overload/undervoltage condition of generator system:
   b. Loads shall be shed based on priority assigned in table above.
      1) Priority 0 loads shall never be shed from generator system.
      2) Priority 3 loads shall be shed first, followed by priority 2 loads and priority 1 loads shall be shed last.
      3) Provide sufficient delay between load shed blocks to allow generator system to re-stabilize.
   c. Load re-addition scheme implementation:
      1) Once generator system is determined to have sufficient capacity to accommodate additional load, ATSs shall be re-transferred to S2 based on the priority assigned in the table above.
         a) Priority 1 loads shall be re-added first, followed by priority 2 loads and priority 3 loads shall be re-transferred last.
         b) Provide delay between load blocks to allow generator system to stabilize.

O. Consolidated Remote Annunciator for Transfer Switches and Generator:
1. General:
   a. Shall be manufactured and provided by the same manufacturer as automatic transfer switches.
   b. Shall be ASCO 5705 8-Channel Remote Annunciator or annunciator that fully complies with specifications herein.
   c. Must be listed to cUL/UL 1008.
   d. Include industrial grade 10 IN resistive touchscreen panel with industrial controller, alarm LED, and audible alarm buzzer.
   e. Controller shall be industrial fan-less controller including the following minimum requirements: Quad-core x86 processor, 8GB RAM, 128GB SSHD, (2) gigabit Ethernet ports and (2) USB ports.
   f. Shall monitor and annunciate automatic transfer switches and generator.
2. Screens/Functions:
   a. Graphical Overview Screen: Display the status, alarm, power metering and enable user to perform transfer switch and generator testing. User must log in with appropriate authentication and security level for testing privileges.

b. Alarm Annunciator Screen: Display active alarms grouped by each device type or by each alarm type including color-coded security level. Provide user the ability to drill down to gain more detailed information.
c. Event Log Screen: Display up to 10,000 events by severity, date, and time stamps of alarm, when it was activated, deactivated and acknowledged. The user acknowledging each alarm shall be identified in the event log.
d. Device Annunciation Screen: Log and display 12 weeks of historical analog and discrete data trending with up to 8 simultaneous parameters for any of the configured devices.
e. Automated Reports: Include NFPA 110 test reports, NFPA 110 utility outage reports, energy reports, alarm reports, activity reports, and settings reports.
f. Power Quality Analytics: Shall be able to display and analyze cycle-by-cycle power waveforms for a minimum of 1-year when power quality meter is provided.

3. Control Power Supply:
    a. Annunciator shall include battery-less (capacitor-based) UPS to provide a minimum of 30 seconds of ride-through when neither utility nor generator power are available.
    b. Annunciator shall include dual control power supplies for external control power: 24VDC and 120VAC/220VAC.
    c. All monitored transfer switches shall be provided with ASCO accessory 1PS1 to provide 60 seconds minimum control power-ride through to controller, ASCO 72EE2 connectivity module, and power meters (when provided) such that communications/monitoring will not be hindered during power source outages.
4. Connectivity/Interface:
    a. Provide appropriate connectivity module for Ethernet TCP/IP devices, RS-458 devices, fiber interface, and/or hardwired discrete contacts. Device shall have integral minimum of 30 seconds ride-through control power.
    b. Transfer switches shall be provided with ASCO accessory 72EE2 Quad-Ethernet Connectivity Module.
    c. Provide AES 128-bit data encryption for security.
    d. Provide HTTPS/SSL using the facility's IT digital certificate.
    e. Provide minimum of 4-levels of user authentications.
    f. Provide compatibility for connection to BAS or other monitoring systems over Modus TCP/IP.
    g. Provide connectivity to SMTP server to send email alarm notifications and automated reports only to configured users.

2.3 OPERATION

A. Engine starting contacts shall be normally closed contacts that open to start engine(s).

B. Controller operational parameters shall be available for viewing and limited control through serial communications input port. Following parameters shall be adjustable on controller:
    1. Nominal line voltage and frequency.
    2. Single or three phase sensing.
    3. Operating parameter protection.
    4. Transfer operating mode configuration. (Open, closed or delayed transition as applicable)

C. All instructions and controller settings shall be easily accessible, readable and accomplished without use of codes, calculations or instruction manuals.

D. Repetitive accuracy of all settings shall be within plus or minus 0.5 PCT over an operating temperature range of minus 20 DEGC to plus 60 DEGC.

E. Voltage and frequency settings shall be field adjustable in 1 PCT increments either locally with display and keypad or remotely via serial communications port access.

F. Controller shall be capable (when activated by keypad or through serial port) of sensing phase rotation of both normal and emergency sources. Source shall be considered unacceptable if phase rotation is not preferred rotation selected (ABC or CBA).

G. Source differential sensing shall be provided for closed transition operating mode. Sensor shall enable transfer/re-transfer between live sources in closed transition mode only when two sources have maximum voltage differential of 5 PCT, frequency differential of 0.2 Hz and are within 5 electrical degrees.

H. Closed transition transfer shall be accomplished with no power interruption and without altering or actively controlling standby generator set.

I. Source status screens shall be provided for both normal and emergency to provide digital readout of voltage on all 3 phases, frequency, and phase rotation.

J. Following features shall be built into controller and shall also be capable of being activated through keypad programming or serial port when required by user:
   1. Provide ability to select "commit/no commit to transfer" to determine whether load should be transferred to the emergency generator if normal source restores before generator(s) are ready to accept load.
   2. Provide terminals for remote contact which opens to signal automatic transfer switch to transfer to emergency and for remote contacts which open to inhibit transfer to emergency and/or retransfer to normal. Both inhibit signals can be activated through keypad or serial port.
   3. Provide in-phase monitor in controller to control transfer so that motor load inrush currents do not exceed normal starting currents and shall not require external control of power sources. In-phase monitor shall be specifically designed for and be product of automatic transfer switch manufacturer.
   4. Controller shall be capable of accepting normally open contact that will allow transfer switch to function in non-automatic mode using an external control device.
   5. Provide internal engine exerciser that shall allow user to program up to seven different exercise routines.
      a. For each routine, user shall be able to:
         1) Enable or disable routine.
         2) Enable or disable transfer of load during routine.
         3) Set start time:
            a) Time of day.
            b) Day of week.
            c) Week of month (1st, 2nd, 3rd, 4th, alternate or every)
         4) Set duration of run.
      b. At end of specified duration switch shall transfer load back to normal and run generator(s) for specified cool down period.
      c. 10-year life battery that supplies power to real time clock in event of power loss will maintain all time and date information.

K. System Status:
   1. Controller LCD display shall include "System Status" screen which shall be readily accessible from any point in menu by depressing "ESC" key maximum of two times. This screen shall display clear description of active operating sequence and switch position. For example,

      Normal Failed
Load on Normal
TD Normal to Emerg
2min 15s

   2. Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in operator's manual, are not permissible.

L. Self Diagnostics:
   1. Controller shall contain diagnostic screen for purpose of detecting system errors. Screen shall provide information on status input signals to controller which may be preventing load transfer commands from being completed.

M. Communications Interface:
   1. Controller shall be capable of interfacing, through optional serial communication module, with network of transfer switches, locally (up to 4000 FT.) or remotely through modem serial communications.
   2. Standard software specific for transfer switch applications shall be available by transfer switch manufacturer.
   3. Software shall allow for monitoring, control and setup of parameters.

N. Data Logging:
   1. Controller shall have ability to log data and to maintain last 99 events, even in event of total power loss. Following events shall be time and date stamped and maintained in non-volatile memory:
      a. Event Logging:
         1) Date, time and reason for transfer normal to emergency.
         2) Date, time and reason for transfer emergency to normal.
         3) Date, time and reason for engine start.
         4) Date and time engine stopped.
         5) Date and time emergency source available.
         6) Date and time emergency source not available.
      b. Statistical Data:
         1) Total number of transfers.
         2) Total number of transfers due to source failure.
         3) Total number of day's controller is energized.
         4) Total number of hours both normal and emergency sources are available.

O. Communications Module:
   1. Full duplex RS485 interface shall be installed in controller to enable serial communications.
   2. Serial communications shall be capable of direct connect or multi-drop configured network.
   3. Module shall allow for seamless integration of existing or new communication transfer devices

P. Connection to Facility BMCS System:
   1. Communication to building management control system (BMCS):
      a. Data monitor shall have integral communication port for connection to BMCS.
      b. The following metered data shall be communicated to the BMCS:
         1) Phase-to-Neutral Voltages.
         2) Phase Currents.
         3) Power Factor.
         4) Peak kW demand.
      c. The following ATS status parameters shall be communicated to the BMCS:
         1) Generator Status.
         2) ATS Switch Position/Source Connection Status.
         3) Source 1 Status.
         4) Source 2 Status.
         5) ATS Alarm.
      d. All metered data listed in paragraphs above shall be communicated to the BMCS.
      e. Power metering data shall be communicated via open MODBus protocol.
      f. All components required for translation/conversion of data protocols shall be considered as part of the ATS data monitoring system and provided by this equipment vendor.
      g. Coordinate final connections and programming requirements with Division 23 contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate switches as indicated.

B. Adjust relays per manufacturer's recommendations unless otherwise noted.

C. Provide and terminate all interface control wiring in conduit from automatic transfer switches to other equipment or systems as required including but not limited to:
   1. Standby generator control panel:
      a. Engine start circuiting.
         1) Provide separate engine start circuit from each transfer switch to generator control panel.
      b. Load shed circuits.
      c. Transfer inhibit circuits.
   2. Annunciator/control panels if provided.
   3. Elevator controllers to initiate emergency operation. (Termination at elevator controllers by elevator manufacturer)
   4. Time delay signal prior to and after transfer from one source to another where indicated.
   5. Building Control Systems where indicated. (Termination at BCS control panels by Mechanical Contractor)
   6. Label both ends of all conductors noting points of opposite termination.

3.2 INTEGRATION OF DATA MONITOR INTO BUILDING MANAGEMENT CONTROL SYSTEM NETWORK

A. Coordinate anticipated network connections and data to be transmitted by new ATS data monitors with BMCS vendor prior to start of power meter integration.

B. All circuit monitor data, status of monitored switches, and PLC registers shall be provided to the BMCS vendor via circuit monitor and/or programmable controller register lists.

C. Provide all programming required to communicate power monitoring data to BMCS.

D. Provide a representative of power meter manufacturer to supervise integration, startup, and testing of system.

E. Testing to include a complete working demonstration of the power monitoring system with simulation of possible operating conditions which may be encountered.

3.3 TESTING

A. Each automatic transfer switch shall be factory tested to ensure proper operation of individual components, correct overall sequence of operation and to ensure that operating transfer time, voltage, frequency and time delay settings are in compliance with specification requirements. Document and submit report.

B. Each automatic transfer switch shall be field tested by authorized factory representative to confirm proper operation of individual components, correct overall sequence of operation and to verify that operating transfer time, voltage, frequency and time delay settings are in compliance with specification requirements. Document and submit report.

END OF SECTION

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SECTION 26 41 13
LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Lightning Protection System, as indicated, in accordance with provisions of Contract Documents.

B. Provide system complying with UL and provide Master-UL Certification Letter.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Certified member of Lightning Protection Institute to install lightning protection systems.
   2. UL listed manufacturer and installer.

B. System Standards:
   1. ANSI/UL 96, and NFPA 780.
   2. ANSI/UL 96 Standard for Safety for Lightning Protection Components.
   3. UL96A Standard for Installation Requirements for Lightning Protection Systems.
   4. NFPA 780 Standard for the Installation of Lightning Protection Systems.

C. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Lightning protection system:
      a. Roof penetration details.
      b. Complete layout indicating all connections, down conductors and grounding tripads.

B. Product Data:
   1. Technical data on each component.

C. Contract Closeout Information:
   1. UL Master Label Certification Letter.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Lightning Protection System:
   1. Thompson Lightning Protection.
   2. Robbins Lightning Inc.
   3. Heary Brothers Lightning Protection.
   4. Independent Protection.
   5. National Lightning Protection.
   6. Dillon.
   7. Erico.

2.2 MATERIALS

A. Lightning Protection System:
   1. Complete Master Label lightning protection system.

2. Labeled for lightning protection systems by UL.
3. Design components to blend with appearance of building.
4. Maximum concealed, semi-concealed or totally exposed system as required.

B. Conductors:
1. Copper or aluminum, grade ordinarily used for commercial electric work and of weight required by height of building.

C. Air Terminals:
1. Solid copper or aluminum rod with tapered point, of height required.
2. Attach rods to building with proper cast bronze or copper base to adapt to building design.

D. Ground Rods:
1. 3/4 IN x 10 FT copper weld.

E. Main Ground Connection Fittings:
1. See Section 26 05 26.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Do not install copper conductors or fastenings in contact with aluminum surfaces.

B. Install down conductors in PVC conduit concelled within the building envelope.

C. Structural steel may be used as main conductor in accordance with NFPA 780, only when concelled PVC is not possible.

D. Terminate each downlead cable in grounding arrangement suitable to local soil condition and applicable codes.
1. Maximum ground resistance: 10 ohms.
2. Use tripods each containing three rods, located as required.
3. Make connection to ground rods with Cadweld method or UL listed compression fitting for connections buried in earth.
4. If necessary, drive additional ground rods to obtain 10 ohms.
5. Do not cover or bury ground rods until observed by Architect.

E. Interconnect metal items on roof such as ventilators, stacks, pipes, gutters, downspouts, ducts, tracks, antennas, water pipes, ladders to main conductor system.

F. Provide connection to incoming electric and telephone service ground per NEC for common bonding.

G. Provide roof flashings or other method approved by roof manufacturer for down conductor or fittings passing through roofs.

H. Remove and replace lightning protection system components found not in compliance with specification requirements.

I. Installation of protection system to allow free movement of flashing and coping systems.

END OF SECTION

SECTION 26 43 13
SURGE PROTECTIVE DEVICES (SPD)

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Surge Suppression Devices, as indicated, in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 DESCRIPTION

A. This specification includes surge protective devices that clamps transient voltage, diverts surge current and attenuates high-frequency electrical line noise.

B. Surge protective devices shall be located at service entrance equipment and at downstream switchgear, switchboards, motor control centers, busway, distribution panelboards and/or branch circuit panelboards where indicated on Drawings or Panelboard Schedules.

C. Surge protective devices shall be internally mounted within the protected equipment enclosure.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Engaged in design and manufacturer of specified system for a minimum of five (5) years
   2. SPD manufacturer shall be same as manufacturer of protected equipment.

B. Design, manufacture, test, and install SPD equipment in compliance with latest edition of following standards:
   1. American National Standards Institute and Institute of Electrical and Electronic Engineers:
      a. ANSI/IEEE-C62.41.1 Guide on the Surge Environment in Low Voltage AC Power Circuits.
      b. ANSI/IEEE-C62.41.2 Recommended Practice on Characterization of Surges in Low Voltage AC Power Circuits.
      c. ANSI/IEEE-C62.45 Recommended Practice on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits.
   2. American National Standards Institute and Underwriters Laboratories:
      a. ANSI/UL-50 Enclosures for Electrical Equipment.
      b. ANSI/UL-67 Panelboards.
      c. ANSI/UL-845 Motor Control Centers.
      d. ANSI/UL-857 Busway.
      e. ANSI/UL-891 Dead Front Switchboards.
      f. ANSI/UL-1283 Electromagnetic Interference Filters.
      g. ANSI/UL 1449 Third Edition, Surge Protective Devices.
      h. ANSI/UL 1558 Metal Enclosed Low Voltage Power Circuit Breaker Switchgear.
   3. National Fire Protection Association:
      a. NFPA-70 National Electrical Code.
      b. NFPA-780 Lightning Protection Systems.
   4. Military Standards
      a. MIL STD 220C Method of Insertion Loss Measurement.
   5. Underwriters Laboratories:
      a. UL 96A Lightning Protection Systems.

C. Internally mounted SPD equipment shall be UL-1449 and UL-1283 Listed or shall be UL-1449 and UL-1283 component recognized as a surge protective device and electromagnetic interference filter. The protected equipment including the SPD shall be fully tested and certified to the applicable switchgear, switchboard, motor control center, busway and/or panelboard UL Standard.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Submit unit dimensions, weights, mounting provisions, connection details and layout diagrams of each SPD application.
   2. Indicate location with respect to protected bus and connection characteristics to bus including material type, length and routing.

B. Product Data:
   1. Copy of UL 1449 Certification under Category VZCA or VZCA2 with applicable model numbers highlighted and indicating following information:
      a. Model number.
      b. Product Type.
      c. Voltage.
      d. Phase.
      e. Voltage protection rating per mode.
      f. Nominal discharge current rating per mode.
      g. Maximum continuous operating voltage rating per mode.
   2. Standard catalog data sheets indicating:
      a. Modes of protection.
      b. Surge current capacity per mode.
      c. Surge current capacity per phase.
      d. Short circuit current rating.
      e. Filter attenuation.
      f. Diagnostics and monitoring features.

C. Contract Closeout Information:
   1. Operation and Maintenance Data.
      a. See Section 01 78 23.
   2. Warranty.

1.5 STORAGE AND HANDLING

A. SPD equipment shall be shipped, stored and handled in accordance with manufacturer’s instruction.

1.6 WARRANTY

A. Manufacturer’s Limited Ten-Year Warranty from date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Surge Suppression Devices:
   1. Base:
      a. Square D/Surgelogic – IMA/EMA Series
      b. Eaton/Cutler-Hammer – SPD Series.
      c. Siemens Energy & Automation/Sentron – TPS3 Series.

2.2 MATERIALS

A. Environmental Requirements:
   1. Operating temperature range shall be minus 40 DEGC to plus 50 DEGC.
   2. Relative humidity range shall be 5 PCT to 95 PCT non-condensing.
   3. Capable of operation at altitudes up to 16,000 FT above sea level.
   4. No audible noise.
   5. No appreciable emissions of EMI/RFI fields.

B. General Electrical Requirements:
   1. SPD shall be a combination of a solid state, parallel connected surge suppression device and an electromagnetic interference filter.
   2. The surge suppression elements shall be Metal Oxide Varistor (MOV).
   3. Each MOV shall be provided with individual over-current and thermal over-temperature protection.
   4. Surge current shall be equally distributed to all components to ensure equal stressing and maximum performance.
   5. Nominal operating voltage: as indicated on the drawings or panelboard schedules.
   6. Nominal operating frequency: 60 Hz.
   7. Protection modes: provide directly connected suppression elements between line and neutral (L-N), line and ground (L-G), and neutral and ground (N-G).
   8. Maximum Continuous Over Voltage (MCOV) shall equal or exceed the following:
      a. 208Y/120 volt systems:
         1) L-N: 150.
         2) L-G: 150.
         3) N-G: 150.
         4) L-L: 300.
      b. 480Y/277 volt systems:
         1) L-N: 320.
         2) L-G: 320.
         3) N-G: 320.
         4) L-L: 640.
   9. Voltage Protection Rating (VPR) shall not exceed the following:
      a. 208Y/120 volt systems:
         1) L-N: 800.
         2) L-G: 800.
         3) N-G: 800.
         4) L-L: 1200.
      b. 480Y/277 volt systems:
         1) L-N: 1200.
         2) L-G: 1200.
         3) N-G: 1200.
         4) L-L: 2000.
   10. Nominal discharge current rating: 20kA.
   11. Short circuit current rating (SCCR): 200kA.
   12. EMI/RFI filter shall provide minimum 50 dB noise attenuation at 100 kHz using MIL-STD-220A insertion loss test method.
   13. Diagnostics and monitoring:
      a. Solid state monitoring of each mode and power loss in any phase.
      b. Externally visible green/red LED operational status indicator lights for each protection mode. Absence of a green light and presence of red light shall indicate which mode(s) or phase(s) have been damaged.
      c. Audible alarm with silence switch shall sound if any fault condition occurs.
      d. Form C dry contacts (1 NO/1 NC) for remote status monitoring. Contacts shall change state if any fault condition occurs.
      e. Test switch shall test SPD's diagnostics and monitoring system.

f. Surge counter with LCD display shall indicate the quantity of transients recorded. Count shall be stored in non-volatile memory. Provide reset pushbutton with two second duration to reset.

C. Specific Electrical Requirements by Application/Location:
  1. Internally mounted within service entrance equipment:
    a. UL Labeled as Type 2, or Type 4 investigated by UL for use in Type 2 applications.
    b. Tested and suitable for use in ANSI/IEEE C62.41 Category C environments.
    c. Surge current capacity:
      1) Maximum surge current rating per phase shall be minimum 250kA.
      2) Maximum surge current rating per mode shall be minimum 125kA.
    d. Factory installed.
      1) SPD equipment shall be located within the service entrance equipment enclosure and installed in the factory by the service entrance equipment manufacturer.
      2) SPD equipment shall be connected directly to the protected equipment bus on the load side of the service disconnect. If direct bus connection is not possible, conductor leads may be provided. Conductor leads shall be kept as short and straight as possible. Leads shall be minimum #8 conductors and twisted with a minimum of three twists per foot (ten twists per meter) in the conductors to minimize impedance. Tie wrap twisted conductors at 4 IN 100 MM spacing.
      3) Provide a remote diagnostics panel mounted on the cover of the service entrance equipment enclosure and visible from outside the enclosure.
  2. Internally mounted within distribution equipment and/or panelboards serving rooftop equipment:
    a. UL Labeled as Type 2, or Type 4 investigated by UL for use in Type 2 applications.
    b. Tested and suitable for use in ANSI/IEEE C62.41 Category C or B environments.
    c. Surge current capacity:
      1) Maximum surge current rating per phase shall be minimum 160kA.
      2) Maximum surge current rating per mode shall be minimum 80kA.
    d. Factory installed.
      1) SPD equipment shall be located within the distribution equipment enclosure and installed in the factory of the distribution equipment manufacturer.
      2) SPD equipment shall be connected directly to the protected equipment bus on the load side of the main circuit breaker if provided. Neutral and ground leads shall be kept as short and straight as possible. Leads shall be minimum #8 conductors and twisted with a minimum of three twists per foot (ten twists per meter) in the conductors to minimize impedance. Tie wrap twisted conductors at 4 IN 100 MM spacing.
      3) Provide a window in the equipment to allow the diagnostics panels to be visible from outside the enclosure. If not, provide a remote diagnostics panel mounted on the cover of the distribution equipment enclosure and visible from outside the enclosure.
    e. SPD mounting shall not limit the use of through-feed lugs, sub-feed lugs or sub-feed breakers.
    f. Panelboards shall be capable of being placed back in re-energized service upon removal of the SPD.
  3. Internally mounted within branch circuit panelboards:
    a. UL Labeled as Type 2, or Type 4 investigated by UL for use in Type 2 applications.
    b. Tested and suitable for use in ANSI/IEEE C62.41 Category B environments.
    c. Surge current capacity:
      1) Maximum surge current rating per phase shall be minimum 100kA.
      2) Maximum surge current rating per mode shall be minimum 50kA.
    d. Factory installed.
      1) SPD equipment shall be located within the panelboard enclosure and installed in the factory of the panelboard manufacturer.

2) SPD equipment shall be connected directly to the protected equipment bus on the load side of the main circuit breaker if provided. Neutral and ground leads shall be kept as short and straight as possible. Leads shall be minimum #8 conductors and twisted with a minimum of three twists per foot (ten twists per meter) in the conductors to minimize impedance. Tie wrap twisted conductors at 4 IN 100 MM spacing.
3) Provide a window in the panelboard cover to allow the diagnostics panels to be visible from outside the enclosure.

e. SPD mounting shall not limit the use of through-feed lugs, sub-feed lugs or sub-feed breakers.
f. Panelboards shall be capable of being placed back in re-energized service upon removal of the SPD.

D. Factory-test SPD equipment prior to shipment, including but not be limited to:
1. Quality assurance checks.
2. MCOV and let-through voltage verification tests.
a. MCOV testing shall consist of units burned-in at applicable MCOV for a minimum of one (1) hour.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install SPD equipment per manufacturer’s recommendations.

B. Do not energize SPD’s until distribution system has been energized, stabilized and tested.

C. Disconnect SPD’s during distribution system insulation resistance testing.

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SECTION 26 51 13

BUILDING LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Building Lighting, as indicated, in accordance with provisions of Contract Documents.

B. Section includes interior luminaires and accessories, lamps, ballasts and drivers.

C. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Where groups of luminaire types on Lighting Equipment Schedule exhibit same manufacturers, final installation shall consist of same manufacturer's equipment across groupings as specified for consistency of optics, color of light, finishes, aesthetics and similarity of maintenance procedures.
   1. Mixing/matching across groups is unacceptable except where specified.
   2. Mixing/matching across multi-phased projects is unacceptable, except where products have subsequently been discontinued or significantly redesigned in size, appearance, lamping or gear.
   3. See Lighting Equipment Schedule for additional information.

B. Coordinate ballasts/drivers used with lamping/LED modules, lamp sockets, and control devices prior to submitting shop drawings.

C. Provide luminaires bearing UL labels, and tested by a nationally recognized testing facility under UL1598 and UL 8750, and manufactured in accordance with NEC.

D. Lamps and ballasts shall comply with U.S. Federal Efficiency laws and TCLP compliance Standards.

E. Materials and installations shall be in accordance with latest revision of National Electrical Code and any applicable Federal, State and local codes and regulations.

F. Luminaires shall comply with relevant and current ANSI, CBM, ESTA, FCC, IEC, IEEE, IESNA, NEMA, NFPA, and UL standards and practices.

G. American National Standards Institute (ANSI):
   1. ANSI C62.41.2 IEEE Recommended Practice on Characterization of Surges in Low Voltage (1000 V and less) AC Power Circuits
   2. ANSI C78.376: Chromaticity of Fluorescent Lamps (ANSI/NEMA C78/376-96).
   3. ANSI C78.377: Specifications for the Chromaticity of Solid State Lighting Products.
   4. ANSI C81.64: Electric Lamp Bases and Holders.
   5. ANSI C82.1: American National Standard for Lamp Ballasts - Line Frequency Fluorescent Lamp Ballasts
   6. ANSI C82.2: Fluorescent Lamp Ballasts, Methods of Measurement of (includes supplements)
   7. ANSI C82.4: American National Standard for Ballasts for High-Intensity Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
   8. ANSI C82.11: American National Standard for Lamp Ballasts--High-Frequency Fluorescent Lamp Ballasts
   9. ANSI C82.77: Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment.
   10. ANSI E1.3: Entertainment Technology Lighting Control System 0 to 10V Analog Control Specification.

11. ANSI E1.20: Remote Device Management over DMX512 Networks.
12. ANSI/IES RP-16-10: Nomenclature and Definitions for Illuminating Engineering.

H. Certified Ballast Manufacturers Association (CBM):
   1. Requirements for Ballast Certification.

I. Federal Communications Commission (FCC):
   1. Code of Federal Regulations (CFR), Title 47, Part 18, Industrial, Scientific, and Medical Equipment
   2. Code of Federal Regulations (CFR), Title 47, Part 15 Class B: Radio Frequency Devices, Commercial Rated.

J. International Electrotechnical Commission (IEC):
   1. IEC 61000-3-2: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
   2. IEC 61347-1: General and Safety Requirements for Lamp Control Gear
   3. IEC 61347-2-13: Particular Requirements for DC or AC. Supplied Electronic Controlgear for LED Modules
   4. IEC 61547: Equipment for general lighting purposes - EMC Immunity Requirements.
   5. IEC 62384: DC or AC Supplied Electronic Control Gear for LED Modules - Performance Requirements.
   6. IEC 62386-101: Digital Addressable Lighting Interface - Part 101: General Requirements - System.
   7. IEC 62386-102: Digital Addressable Lighting Interface - Part 102: General Requirements - Control Gear.
   8. IEC 62386-207: Digital Addressable Lighting Interface - Part 207: Particular Requirements for Control Gear - LED Modules (Device Type 6).

K. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE C62.41-91: Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits.

L. Illuminating Engineering Society of North America (IESNA):
   1. IES LM-9: Electrical and Photometric Measurements of Fluorescent Lamps
   2. IES LM-15: IESNA Guide for Reporting General Lighting Equipment Engineering Data for Indoor Luminaires
   3. IES LM-20: Approved Method for Photometry of Reflector-Type Lamps
   4. IES LM-28: IES Guide for the Selection, Care and Use of Electrical Instruments in the Photometric Laboratory
   5. IES LM-40: Approved Method for Life Performance Testing of Fluorescent Lamps
   6. IES LM-41: Approved Method: Photometric Testing of Indoor Fluorescent Luminaires
   7. IES LM-45: Electrical and Photometric Measurements of General Service Incandescent Filament Lamps
   8. IES LM-46: Photometric Testing of Indoor Luminaires Using High Intensity Discharge or Incandescent Filament Lamps
   9. IES LM-47: Approved Method for Life Testing of High Intensity Discharge (HID) Lamps
   10. IES LM-49: Life Testing of Filament lamps
   11. IES LM-50: Method for Photometric Measurement of Roadway and Street Lighting Installations
   12. IES LM-51: Electrical and Photometric Measurement of High Intensity Discharge Lamps.
   13. IES LM-52: Photometric Measurements of Roadway Sign Installations
   14. IES LM-54: Guide to Lamp Seasoning
   15. IES LM-61: Identifying Operating Factors Influencing Measured Vs. Predicted Performance for Installed Outdoor High Intensity Discharge (HID) Luminaires
   16. IES LM-62: Laboratory or Field Thermal Measurements of Fluorescent Lamps and Ballasts in Luminaires
   17. IES LM-63: ANSI Approved Standard File Format for Electronic Transfer of Photometric Data and Related Information

18. IES LM-64: Photometric Measurements of Parking Areas
19. IES LM-65: Life Testing of Single-Based Fluorescent Lamps
20. IES LM-66: Electrical and Photometric Measurements of Single-Based Fluorescent Lamps
21. IES LM-72: Directional Positioning of Photometric Data
22. IES LM-76: Photometric Testing of Fiber Optic Lighting Systems
23. IES LM-79: Electrical and Photometric Measurements of Solid-State Lighting Products
24. IES LM-80: Measuring Lumen Maintenance of LED Light Sources
25. IES LM-82: Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature
26. IES LM-84: Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines and Luminaires
27. IES LM-85: Electrical and Photometric Measurements of High-Powered LEDs
28. IES TM-21: Projecting Long Term Lumen Maintenance of LED Light Sources
29. IES TM-30: IES Method for Evaluating Light Source Color Rendition

M. National Electrical Manufacturer's Association (NEMA):
1. NEMA FAl: Outdoor Flood Lighting Equipment.
2. NEMA SH5: Tubular Steel, Aluminum and Prestressed Concrete Roadway Lighting Poles.
3. NEMA SSL1: Electronic Drivers for LED Devices, Arrays, or Systems.
4. NEMA SSL3: High-Power White LED Binning for General Illumination.
5. NEMA SSL7A: Phase Cut Dimming for Solid State Lighting: Basic Compatibility.
6. NEMA 410: Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts

N. National Fire Protection Association (NFPA):
1. NFPA 70: National Electrical Code (NEC)
2. NFPA 101: Life Safety Code

O. UL International (UL):
1. UL 1310 Standard for Class 2 Power Units
2. UL 8750 Standard for Light Emitting Diode (LED) Equipment for Use in Lighting Products

P. LEED Requirements:
1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Pre-Approval:
1. Substitutions not identified in contract documents as “acceptable substitutions” or “alternate manufacturers” must be identified during bidding process and submitted for pre-approval.
2. Only specified equipment or approved equals should be used to develop pricing
3. Provide a list of fixture types and quantities for information only.

B. Shop Drawings:
1. Shop drawings and product data not conforming to specification requirements will be returned rejected without review.
2. For continuous pattern luminaires, indicate layout, individual section lengths, and lamp/LED module quantities.
   a. Show details of connections, emergency ballast/driver and lamp/module placement, corners and extensions, end plates, and mounting. Include pendant or bracket locations and show remote transformers/ballasts/drivers.
   b. Provide field-measured overall dimensions in wall-to-wall and wall-to-corner applications.
3. Details of special construction, accessories, and finishes.
4. Specifier reserves right to reject submitted product(s) for any reason.

5. Allow adequate time for the sample procurement, submittal review and ordering process of all products. (Some luminaires may require 12 to 16 weeks of lead time or more to arrive at the job site after ordering.) Substitutions will not be accepted on the basis that arrival of the specified luminaires will delay the Contractor's timeline.

C. Product Data:
   1. Submit product data for fixtures indicated on Electrical Drawings, Specifications and Schedules.
   2. Identify luminaires by Lighting Equipment Schedule designation.
      a. For each luminaire, provide cutsheets indicating following information:
         1) Name of manufacturer, cutsheet, and complete catalog number.
            a) Include product data details for catalog number references to explain special construction, accessory or finish, and photometric data.
         2) Photometric Data:
            a) Collected by an independent testing laboratory.
            b) Indicate optical performance developed using methods of Illuminating Engineering Society of North America (IESNA) as follows:
               (1) Coefficients of utilization.
               (2) Candlepower data presented graphically and numerically, in maximum 10 degree increments.
               (3) Develop data for up and down quadrants that are normal, parallel, and at 45 DEG to lamp if light output is asymmetric.
               (4) Zonal lumens stated numerically in 10 degree increments as above.
               (5) Fixture efficiency.
   3. Solid state Luminaires:
      a. LED Luminaires:
         1) Total input wattage.
         2) Luminaire voltage.
         3) Delivered lumens.
         4) Color temperature, color rendering index (CRI), and individual R-values, measured in accordance with IESNA standards.
         5) Color fidelity metric (Rf) and Color Gamut Metric (Rg).
         6) Rated life, measured in accordance with IESNA standards.
         7) Total harmonic distortion (THD).
         8) Submit in tabular format the characteristics of submitted fixture per the technical information categories of the Lighting Equipment Schedule. Deviations from specified criteria shall be identified by a +/- percentage.
         9) Submit the rated lumen maintenance life of LED luminaires. Life shall be reported based upon the light source's L70 rating.
      b. LED Drivers:
         1) Driver manufacturer and model number.
         2) Driver rated life.
         3) Driver dimensions.
         4) Driver type (0-10V, constant voltage, constant current).
         5) If applicable, include lumen management protocols.
         6) Dimming range and control device compatibility list.
         7) Wiring Diagrams – as needed for special operation or interaction with other systems.
   4. Coordinate ballasts/drivers used with lamping/LED modules, lamp sockets, and control devices prior to submitting Shop Drawings.
   5. Upon request, provide calculations performed in AGi32 IN specific spaces as identified by Architect for submitted optional manufacturers or substitutions.
   6. Coordinate luminaires with ceiling construction.
      a. Confirm clearances and fixture flange compatibility with construction.

D. Project Information:
    1. Manufacturer's installation instructions.
    2. Certificate of compliance for radio frequency interference free luminaires.

E. Contract Closeout Information:
    1. Manufacturer’s Warranty shall be from date of Substantial Completion.
        a. Include labor allowance for full cost of component replacement.
        b. Provide warranties, as specified, for the following equipment:
            1) Finish.
            2) Lenses.
            3) Housings.
            4) Ballasts.
            5) Lamps.
            6) Transformers.
            7) LED Drivers.
            8) LED Luminaires.
    2. Warrant electronic fluorescent ballasts for five years from Date of Substantial Completion. Include labor allowance for full cost of ballast installation.
    3. Warrant LED drivers for five years from Date of Substantial Completion.
        a. Include labor allowance for full cost of driver installation.
    4. Warrant the luminaire and all of its components (except the ballast/transformer/driver) to be free from defect in operation or finish for five years from the date of Date of Substantial Completion.
        a. Warrant LED modules during this period for color and lumen maintenance (percent shift +/- degrees Kelvin).
        b. As long as luminaire has been operated within the rated voltage range, Contractor is responsible for cost of materials and labor necessary to repair or replace luminaire.
    5. It is the responsibility of the Contractor to manage all warranty issues that may arise.
    6. Inventory of lamp/ballast and driver/module replacement stocks.
    7. At time of Substantial Completion as defined by the Architect, submit all installation and maintenance tools received from various luminaire vendors clearly and permanently tagged with Manufacturer’s name and relevant luminaire type(s) to the Owner’s Representative.
    8. Maintenance and Operating Manuals.
        a. See Section 01 78 23.
    9. Two weeks prior to the final inspection or in accordance with commissioning requirements, submit one hard copy and one digital copy of the final updated maintenance and operating manuals to the Owner’s Representative and a digital copy to the Architect. At a minimum, this document shall include the following information for each luminaire type:
        a. Luminaire cutsheets with full catalog number identifying all provided components including but not limited to drivers, LED modules, accessories, lenses, finish, etc.
        b. Information for ordering replacement components including:
            1) Manufacturer.
            2) Catalog Number.
            3) Date of Purchase.
            4) Local Representative’s Contact Information.
        c. A recommended relamping/cleaning program.
        d. List of tools required for maintenance.
        e. List of types of cleaners to be used.
        f. Data sheets for every luminaire type that graphically identify recyclable components and recycling protocols and/or disposal information.
        g. Warranty Information.

F. Review of shop drawings and product data does not waive the Contractor of their obligations.

G. As-build model and drawings shall show all lighting fixtures with solid line work.

1.4 DELIVERY, STORAGE AND HANDLING

A. Protect fixtures from damage using appropriate material, cartons, plastic wrapping and protective means

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Luminaires:
   1. Base:
      a. As indicated on Lighting Equipment Schedule.
   2. Optional:
      a. As indicated on Lighting Equipment Schedule.
   3. Use catalog numbers listed as a guide only. Follow modifications and other requirements shown or specified.

B. Lamps/LED Modules:
   1. GE Lighting.
   2. Osram Sylvania.
   3. Philips Lighting.
   4. Cree (LED only).
   5. Soraa (LED only)
   6. Xicato (LED only).

C. Drivers:
   1. Osram Sylvania.
   2. Philips Advance.
   3. Mean Well.
   4. eldoLED.
   5. Hatch.
   6. Lutron.

2.2 MATERIALS

A. Luminaires:
   1. Resistant to corrosion and thermal and mechanical stresses encountered in normal application. Provide accessory equipment such as starters, sockets and lampholders, approved by UL and ETL, unless otherwise noted.
   2. Electrical components of recessed luminaires shall be accessible and removable through luminaire without having to remove luminaire from ceiling.
   3. Housings:
      a. Troffer luminaires: Minimum 22 GA 0.76 MM sheet steel; integral end plates and trim flanges to suit ceiling construction. Provide wire way covers with captive retainers to allow access to electrical components without use of tools.
      b. Downlight luminaires: Minimum 22 GA 0.76 MM sheet steel, or minimum 0.0508 IN sheet aluminum, unless noted otherwise. Provide auxiliary junction box secured to mounting frame.
      c. Extruded aluminum housings, where scheduled, shall be at least 1/8 IN thick.
      d. Punch and form housings prior to finishing (post-paint).
      e. Ballast/driver surface shall be in complete contact with housing, having the mounting method designed for efficient conduction of ballast heat.
   4. Trim:
      a. For square and rectangular luminaires, miter and continuously weld corners. Miter perimeter inverted T-Bar angles at corners. Do not butt or overlap squared ends. Finish joints smooth.

5. Castings:
    a. Uniform quality, free from imperfections affecting strength and appearance. Exterior surfaces, if not receiving a finish coat, shall be smooth and match adjacent surfaces. At least one coat of clear methacrylate lacquer shall be applied unless a painted finish is specified.
6. Fasteners:
    a. For aluminum or steel luminaires, fastening hardware shall be cadmium-plated or an equivalent. For stainless steel luminaires stainless steel fasteners shall be used. For bronze luminaires, the fastening hardware shall be bronze or stainless steel.
7. Finishes: As selected from manufacturer's standards unless scheduled otherwise.
    a. Painted surfaces, except as scheduled otherwise:
        1) Manufacturer's standard metal pretreatment and baked or air-dried, light-stabilized enamel finish; acrylic, alkyd, epoxy, polyester or polyurethane.
        2) White finishes shall have minimum 85 PCT reflectance.
    b. Unpainted aluminum surfaces:
        1) Interior luminaires: Clear anodic coating, satin finish, except as scheduled otherwise.
        2) Exterior luminaires: Clear anodic coating.
8. Lens/Louver Frames:
    a. Extruded aluminum with mitered corners unless scheduled otherwise.
    b. Hinging or other normal motion shall not cause lens or louver to drop out.
    c. When installed, any exposed fixture housing surface, trim frame, door frame and lens frame shall be free of light leaks; lens doors shall close in a light tight manner.
9. Lenses:
    a. Utilize 100 PCT virgin, UV stabilized acrylic.
    b. For troffer luminaires, utilize extruded 100 PCT virgin acrylic male conical prismatic, minimum thickness 0.150 IN, size as required. ICI Acrylics Inc. Type K19; or ALP Inc. Type ALP 19.
    c. The lenses shall be held securely in place but must also be removable to clean and service the luminaire.
        1) Luminaires with a spread lens shall also include a lens orientation device to ensure that it is not affected during cleaning or relamping.
    d. There shall be no light leaks between the lens and the luminaire.
    e. Acrylic lenses and diffusers shall be properly cast, molded or extruded as necessary to meet the intent of the specified optics, and shall remain free of any dimensional instability, discoloration, embrittlement, or loss of light transmittance at least for the period of the Manufacturer’s warranty.
10. Reflectors:
    a. High-purity No. 12 aluminum reflector sheet, 0.047 IN or heavier if specified, free from fabrication or assembly damages. No exposed rivets, springs or other hardware after installation. Shape reflectors in modified elliptical or parabolic contour to produce no apparent brightness.
    b. Downlights: Any direct image of the light source shall not be visible in 45 degree zone from nadir.
    c. Downlight reflector and baffle finishes: First-quality Alzak anodized specular or semi-specular finish of color as specified, unless otherwise noted in Lighting Fixture Schedule.
        1) Downlight reflectors shall be securely fastened but also removable for cleaning and relamping.
    d. Troffer reflector finish: integral reflectors shall be painted white after fabrication and shall have a minimum reflectance value of 90 PCT.
11. Gaskets: Provide gaskets at face plates or frames of recessed luminaires which serve as ceiling trim and which allow interior access. Provide moisture seal gaskets at exterior locations and in other areas designated. Secure frames to luminaire bodies with screws or other means, to result in tight installation, without light leaks. See Lighting Equipment Schedule for other types of seals and gaskets.

12. Ventilation: Provide ventilation openings of adequate size and quantity to permit operation of lamps/LED modules and ballast/driver without affecting rated output or life expectancy.
13. Lamp Holders:
    a. Position sockets so that lamps are in optically correct relation to luminaire components.
    b. Secure sockets by screws to luminaire enclosure. Spring mounted sockets are not approved. Do not use plastic or sheet metal sockets unless specified otherwise.
    c. Fluorescent: White urea plastic body; silver plated phosphor bronze or beryllium copper contacts.
    d. Light Emitting Diode (LED): Unless otherwise specified, a dedicated means of connecting light source to power shall be used in luminaires purposely made for use with LEDs unless otherwise specified. LED modules shall be field replaceable.
14. Wiring:
    a. Factory wire luminaire to be compatible with project electrical and controls systems.
    b. Ballasted luminaires shall comply with NEC requirements and be supplied with a disconnecting means accessible to qualified persons before servicing or maintaining ballast.
    c. Thermally protect incandescent and HID luminaires.
    d. Power supplies, unless otherwise specified, shall be field replaceable and shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers unless so specified.
15. Mounting Accessories:
    a. Provide appropriate mounting accessories for each luminaire, compatible with various structural conditions encountered. Provide fastening clips (seismic clips) for luminaires supported from framing members of suspended ceilings.
    b. Luminaires with adjustable beam angles shall have a locking device to ensure that the beam distribution is not effected during relamping or cleaning.
    c. Recessed Luminaires:
        1) Plaster frames: Provide frames for luminaires installed in gypsum board and concealed suspension system ceiling tile. Make frames of non-ferrous metal or suitably rustproof after fabrication.
        2) Baffles and gaskets: As required to prevent light leakage.
        3) Flanged luminaires are required in all ceiling systems except exposed grid lay-in panel type.
    d. Luminaire Suspension Material:
        1) Unfinished spaces: 1/2 IN minimum diameter pendant, unless otherwise noted.
        2) Finished spaces: Unless otherwise noted, provide manufactured cable or stem and outlet box canopy; contemporary design with swivel self-aligning features; size canopy to cover outlet box; finished to match luminaire. Coordinate pendant location with ceiling tiles/ceiling grid, and submit coordinated mounting accessories as part of Product Data submission.
            a) Provide luminaires mounted on suspended ceiling grids with outlet box designed for grid mounting with direct cord entry.
    e. Mechanical Safety: Unless otherwise specified, retain luminaire closures (lens doors, trim frame, hinged housings, etc.) in secure manner by captive screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
    f. Luminaires in Hazardous Areas: Luminaires shall be suitable for installation in flammable atmospheres (Class and Group) as defined in NFPA 70 and shall comply with UL 844.
    g. LED luminaires shall be manufactured specifically for their respective light source with dedicated electrical connections and with power supplies integral to the fixture, except where remote devices are specified. Luminaires shall be designed for lamps as specified.
    h. The Contractor shall assure that all trims and canopies and escutcheons fit snugly and securely to the ceiling and/or wall so that no light leaks occur and so that no gaps or uneven waves are evident.

B. Lamps:
  1. LED's:
     a. Color temperature specified shall be uniform for all LED modules within like luminaire types. Color temperature measurement shall have a maximum MacAdam Ellipse boundary of 3 SDCM unless otherwise specified in the Lighting Equipment Schedule.
     b. Color temperature specified shall be uniform for all LED modules within like luminaire types. Color temperature measurement shall have a maximum MacAdam Ellipse boundary of 3 SDCM unless otherwise specified in the Lighting Equipment Schedule at the end of rated life.
        1) Correlated color temperature shall be as defined in the Lighting Equipment Schedule.
     c. Minimum Ra value or color rendering index (CRI) of 85.
     d. Minimum R9 value of 50
     e. Minimum R9 value defined in the Lighting Equipment Schedule.
     f. LED light output and efficacy shall be measured in accordance with IES LM-79 standards.
     g. LED life and lumen maintenance shall be measured in accordance with IES LM-80 and TM-21 standards.
        1) Rated minimum L70 life of 50,000 HRS.
     h. The individual LED's shall be connected such that a catastrophic loss or the failure of one LED will not result in a light output loss of the entire luminaire.

C. Drivers:
  1. General:
     a. Comply with UL and ANSI specifications. Enclosure shall display approval label for compliance with UL standards.
     b. Contractor shall verify required voltage, frequency and power factors.
     c. Comply with US Federal Efficiency Laws.
     d. Manufacturing facilities shall maintain ISO 9001 certification.
     e. Equipment shall not contain PCBs.
     f. Manufacturer shall have a twenty year history of producing electronic ballasts for the North American market.
  2. LED Drivers:
     a. LED Dimming Driver.
        1) Driver as specified on the Lighting Equipment Schedule.
     b. General.
        1) LED dimming shall be equal in range and quality to a commercial grade incandescent dimmer. Quality of dimming to be defined by dimming range, freedom from perceived flicker or visible stroboscopic flicker, smooth and continuous change in level (no visible steps in transitions), natural square law response to control input, and stable when input voltage conditions fluctuate over what is typically experience in a commercial environment. Demonstration of this compliance to dimming performance will be necessary for substitutions or prior approval.
        2) Driver shall operate from 60 Hz input source of 120V through 277V with sustained variations of +/- 10 PCT (voltage and frequency) with no visible change in light output.
        3) Total Harmonic Distortion less than 20 PCT and meet ANSI C82.11 maximum allowable THD requirements at full output. THD shall at no point in the dimming curve allow imbalance current to exceed full output THD.
        4) Driver shall have a Power Factor greater than 0.90.
        5) Driver output shall be regulated to +/- 5 PCT across published load range.
        6) Driver shall have a Class A sound rating.
        7) Driver shall have a minimum operating temperature of -4 DEGF.
        8) Driver shall tolerate sustained open circuit and short circuit output conditions without fail and auto-resetting without need for external fuses or trip devices.

9) Driver output ripple current shall be less than 15 PCT measured peak-to-average, with ripple frequency greater than 100 Hz.
10) Driver must limit inrush current and meet or exceed NEMA 410 driver inrush standard of 430 Amps per 10 Amps load with a maximum of 370 Amps2 – seconds.
11) Driver shall withstand up to a 1,000 volt surge without impairment of performance as defined by ANSI C62.41 Category A for Transient protection.
12) Driver shall comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 18, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).
13) Driver must support automatic adaptation, allowing for future luminaire upgrades and enhancements and deliver improved performance:
    a) Adjustment of forward LED voltage, supporting 3V through 55V.
    b) Adjustment of LED current from 200 mA to 1.05A at the 100 PCT control input point in increments of 1 mA.
    c) Adjustment for operating hours to maintain constant lumens (within 5 PCT) over the 50,000 HR design life of the system, and deliver up to 20 PCT energy savings early in the life cycle.
14) Driver: UL Recognized under the component program and shall be modular for simple field replacement. Drivers that are not UL Recognized or not suited for field replacement will not be considered.
15) Driver shall include ability to provide no light output when the analog control signal drops below 0.5 V, or the DALI/DMX digital signal calls for light to be extinguished and shall consume 0.5 watts or less in this standby mode. Control deadband between 0.5V and 0.65V shall be included to allow for voltage variation of incoming signal without causing noticeable variation in fixture to fixture output.
16) Drivers shall have a rated life greater than or equal to the stated life of luminaire they control.
17) LED engine must be compatible with type of driver, and coordinated prior to submission of shop drawings.
18) Coordinate if lighting controls utilize source or sync dimming. Luminaire manufacturer shall provide converter pathway device(s) as required for luminaires to dim and function as specified.
19) Fixture shall be properly heat-sinked to assure LED junction temperature ratings are not exceeded. Manufacturer shall provide ambient operating temperature range for which product is warranted.
20) If driver is remote-mounted, provide maximum allowable distances for secondary wire runs to luminaires. Driver shall be housed in NEMA enclosures so rated for the power supply and located in code-compliant, sound-isolated, well-ventilated, easily accessible areas. Size wire according to run length and LED Manufacturer's size and distance-of-run requirements and in accordance with code requirements.
21) All LED power supplies shall be suitably sized to accommodate the LED array consistent with industry standards, including IEC standard 60929 Annex E.
22) Driver shall be available in an all metal-can construction for optimal thermal performance.
23) Driver shall be provided with integral color-coded connectors.
24) Provide with mounting hardware as required.

c. Light Quality.
1) Over the entire range of available drive currents, driver shall provide step-free, continuous dimming. Driver shall respond similarly when raising.
    a) The luminaire shall be capable of continuous dimming over a range of 100 PCT to 10 PCT of rated lumen output.
        (1) Driver must be capable of 20 bit dimming resolution for white light LED drivers or 15 bit resolution for RGBW LED drivers.
2) Driver must be capable of configuring a linear or logarithmic dimming curve, allowing fine grained resolution at low light levels.

3) Drivers to track evenly across multiple fixtures at all light levels, and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.
4) Driver and luminaire electronics shall deliver illumination that is free from objectionable flicker as measured by flicker index (ANSI/IES RP-16-10). At all points within the dimming range from 100-0.1 PCT luminaire shall have:
   a) LED dimming driver shall provide continuous step-free, flicker-free dimming similar to incandescent source.
   b) Flicker index shall be less than 5 PCT at all frequencies below 800 Hz.

d. Control Input.
   1) 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers.
      a) Must meet IEC 60929 Annex E for General White Lighting LED drivers.
      b) Connect to devices compatible with 0 to 10V Analog Control Protocol, Class 2, capable of sinking 0.6 ma per driver at a low end of 0.3V. Limit the number of drivers on each 0-10V control output based on voltage drop and control capacity.
      c) Must meet ESTA E1.3 for RGBW LED drivers.
      d) Driver shall utilize fully isolated 0-10V control inputs. 0-10V input shall be protected from line voltage miswire, and shall be immune and output-unresponsive to induced AC voltage on the control leads.

3. LED emergency back-up driver:
   a. Confirm compatibility with LED lamps utilized.
   b. Transfer devices permits emergency lights to be switched under normal conditions and automatically transfers to unswitched emergency circuit upon power interruption.
   c. Backup driver shall consist of a high temperature, maintenance-free nickel cadmium battery, charger and electronic circuitry.
   d. A solid state charging indicator light to monitor the charger and battery, a single-pole test switch, and installation hardware shall be provided.
   e. UL component listed.
   f. The following product family shall be selected based on coordination with LED lamp type:
      1) Bodine BSL23C: can operate up to 4.5W at 410mA.
      2) Bodine BSL26C: can operate up to 5.1W at 265mA.
      3) Bodine BSL722: can operate up to 23W at 770mA.
   g. Bodine BSL23C: can operate up to 23W at 770mA in operating conditions ranging from -4 DEGF to 140 DEGF.
   h. Alternate manufacturer: Iota.

D. Emergency Battery Wall Pack Luminaires:
   1. Transfer Circuit:
      a. Automatically energize lamps upon failure of normal source; de-energize lamps and activate high-rate charge upon restoration of normal source.
   2. Battery Charger:
      a. Automatic two-rate or acceptable solid-state pulse type capable of replacing maximum charge taken out in 1-1/2 HR emergency discharge period within 12 HRS; manual two-rate charger will not be accepted.
   3. Provide visual signal to indicate state of charge.
   4. Provide integrally mounted, adjustable emergency lights and status lights.
   5. Provide luminaire with self-diagnostics and self-testing.
   6. Where shown or specified provide remote sealed beam adjustable lights.
   7. Provide white UV stabilized thermoplastic housing in finished areas.
   8. Acceptable Manufacturers:
      a. Dual-Lite.
      b. EmergiLite.
      c. Lithonia.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate luminaire mounting and trim type with architectural reflected ceiling plans, suspended ceiling grid and ceiling tile specification, and room finish schedules prior to submission of shop drawings.
   1. Advise Architect of any discrepancies.

B. Coordinate required above-ceiling clearances of recessed luminaires with ductwork and piping.
   1. In exposed ceiling areas, coordinate luminaire locations, mounting heights, and supports with other trades.

C. Coordinate, review and approve fixture locations shown on acoustical ceiling shop drawings prior to submission.
   1. Notify Architect of any discrepancies with lighting plans and review coordinated ceiling shop drawing review comments.

D. Coordinate lighting control devices with fixture ballasts and drivers. Advise Architect of discrepancies prior to submission of shop drawings.

3.2 INSTALLATION

A. Strictly follow the manufacturer's directions for installation of all lighting equipment. Assemble and wire luminaires, with lamps, in such a manner to ensure correct operation.

B. Locate luminaires in accordance with architectural reflected ceiling plans.
   1. Where luminaires are installed in acoustical tile ceilings, locate in exact center of tile unless indicated otherwise. Relocate misplaced luminaires and replace damaged ceiling materials.
   2. Where field conflicts exist, coordinate relocation of equipment with Architect.

C. Mount luminaires at heights indicated in Section 26 00 10 and as indicated on drawings. Where field conflicts exist, or mounting height is not stated, coordinate with Architect.

D. Verify structural support is adequate to ensure luminaires are supported to maintain level and alignment.

E. Add two 12 GA steel wire safety hangers for luminaires weighing less than 56 LBS connected from opposite, diagonal ends of fixture housing to structure above in addition to support requirements specified and recommended by manufacturer.
   1. These wires may be slack.

F. Support luminaires weighing 56 LBS or more directly from structure with approved hangers.

G. Provide hangers with enclosure rating, NEMA 1, 4, 4x or 7, equal to enclosure requirements of area in which they are installed.

H. Ground luminaires per NEC Article 410.

I. Provide exit sign at exit locations, with mounting type, number of single or double faces, and directional arrows (chevrons) as required for exiting.
   1. Where exit signs are pendant mounted, provide manufacturers pendant mount stem kit.
   2. Do not mount sign housing to junction box suspended by conduit.

J. Orient horizontally positioned fluorescent lamps or LED circuit boards of luminaires within a single room in same direction unless indicated otherwise.

K. Seal luminaires for wet locations (i.e. knock-outs, pipe and wire entrances) to prevent water wicking.

L. Luminaire finishes which are disturbed in any way during construction shall be touched up or refinished in a manner satisfactory to the Architect and which does not void warranty.

M. Install reflector cones, louvers, baffles, lenses, trims and other decorative elements after completion of ceiling tile installation, plastering, painting and general cleanup.

N. Recessed Luminaires:
   1. Verify mounting details for each space; provide correct luminaire flange mounting accessories for each condition.
   2. Fasten luminaires supported by suspended ceiling systems to ceiling framing system with hold-down clips and to building structure with two No. 12 GA steel hanger wires connected to opposite corners of the luminaire.
      a. Each hanger shall have the capacity of 100 PCT of luminaire weight acting in any direction.
   3. Support downlights and exit signs with rails spanning between runners of suspension system.
   4. Coordinate to ascertain luminaires are furnished in sizes, with flange details, and installed with the devices (hangers, clips, trim frames, flanges), to match ceiling system being installed.
   5. Support troffers in gypsum board ceilings from structural framed openings with adjustable lugs on side of luminaire or yoke mounting as recommended by luminaire manufacturer.
      a. Where structural framed openings are not provided, fixtures must be independently supported from structure.
      b. Suspended grid systems for gypsum board ceilings are not approved structural support systems for luminaires.
   6. Support downlights and troffers in metal pan and gypsum board ceilings from plaster frames.
   7. Use unwired or pre-wired luminaires as required.
      a. Do not use pre-wired luminaires for through-wiring unless UL approved for the purpose.
   8. Provide access panels for recessed luminaires that require access for maintenance when such access is not provided for in design of luminaire.
      a. See Section 26 00 10.
   9. Wherever recessed luminaires are installed in insulated ceiling systems, it is responsibility of the Contractor to construct above-ceiling enclosures around non-insulation-contact-rated equipment to provide at least 3 IN or airspace on each side of the luminaire.
   10. Trims shall fit plumb and flush with ceiling or wall surface.
   11. There shall be no light leak around interface between lens door or holder trim flanges and ceiling or wall.
   12. Coordinate trimless or flangeless luminaires with other trades to achieve a trimless/ flangeless installation.
      a. Provide a level 5 finish at drywall or plaster ceilings/walls unless otherwise directed by Architect.
      b. In drywall, plaster, wood, or stone, special luminaire collars and exacting coordination are required.

O. Surface Mounted and Pendant-Hung Luminaires:
   1. Attach surface mounted lighting luminaires to ceiling system with positive clamping devices that completely surround supporting members.
      a. Attach safety wires between clamping device and adjacent ceiling hanger or to structure above.
      b. Do not exceed design carrying capacity of supporting member for luminaire load.
   2. Support pendant hung lighting luminaires directly from structure above, using 9 GA steel wire, without relying on ceiling suspension system for support.
   3. Pierce ceiling material for hangers and outlet boxes as required.
   4. Do not remove ceiling material above surface mounted luminaires.
   5. Hang luminaires plumb with continuous rows in alignment.
   6. Unless otherwise noted, suspend luminaires in each room or area at same height regardless of varying clear height conditions.
      a. Provide stem lengths as required.
   7. Cord of pendant fixtures must enter directly into approved wiring box without passing through plenum, in accordance with NEC.

8. Provide suspended luminaires with flexible cord.
   a. Flexible cord shall connect to a junction box located directly above luminaire feed point.
   b. Flexible metal conduit and luminaire whips are not allowed for suspended luminaires.
   c. Trim cords to length, and attach to suspension cable at regular intervals.
   d. Do not coil flexible connections.
9. Surface or pendant luminaires mounted end to end shall have flat end caps to assure flush alignment and shall be UL listed for through wiring.
10. Provide pendant cylinder luminaires with swivel hangers which allow luminaire to swing in any direction but not permit stem to rotate.
11. In mechanical, electrical and storage spaces, pendant mounted, open industrial luminaires, not in continuous rows, shall be supported by conduit or metal channel, similar to Unistrut, and All Thread.
   a. Pendant mounted luminaires in continuous rows shall be fastened to each other or mounted on continuous metal channel.
   b. Provide reflector alignment clips on industrial luminaires mounted in continuous rows.
12. Contractor shall provide and/or coordinate additional bracing in wall or above ceiling as required to support fixture in accordance with manufacturer's recommendations.

P. Continuous Luminaire Patterns:
1. Fasten sections together for continuously aligned appearance, with no dimpling or light leakage.
   a. Provide end extensions where required.
2. Where luminaires run continuously around inside or outside corners, provide prefabricated illuminated corner pieces.
   a. Run luminaire lenses, baffles or louvers continuously with luminaire.
   b. Miter and/or fan at corners as directed.
3. Where lenses are used, open gaps shall not be visible.
   a. Solid-state luminaires shall utilize mitered or rabbited lenses to prevent direct view of modules.
   b. Maximum visible gap between the edge of lens and the end of luminaire trim is 1/16 IN, and not allow direct view of solid state modules.
4. Only where continuous runs do not end at a wall or fascia, provide a finished end plate, with no visible holes and concealed fasteners.
5. Provide a continuous light appearance over total length of assembly.
   a. The luminaire shall run continuously wall to wall or wall to corner without a gap at either end of the fixture when located adjacent to a wall or corner. The maximum permitted non-illuminated length at either end shall not exceed 6 IN.
   b. For fluorescent fixtures, utilize 3 FT and 4 FT linear lamps wherever possible.
      1) Where required, provide a 2 FT lamp in spaces less than 3 FT in length.
   c. For continuous direct fluorescent fixtures, overlap sockets to prevent socket shadows.
6. Cove luminaires in architectural coves shall be installed continuously with no gaps between luminaires.
7. Coordinate installation and requirements of undercabinet luminaires with casework installation.
   a. Provide separate segments of luminaires if luminaires cannot run continuously beneath cabinet.
   b. Conceal wiring and conduit to luminaires.

3.3 COMMISSIONING

A. Coordinate lighting operations, including support from Luminaire and Controls Manufacturers, with commissioning and controls.

B. Synchronize fully functional lighting and lighting controls systems to address lighting operation in complete and code compliant manner.

C. Provide documentation related to commissioning, including record drawings identifying luminaire control loops and addresses with respect to specific luminaire types and Initial Preset Schedule Spreadsheet.

3.4 ADJUSTABLE FIXTURES

A. Aiming shall occur upon Substantial Completion of project including, but not limited to, installation of artwork, millwork, furniture, and plantings.

B. Aim adjustable fixtures as directed.

C. Perform this work at night, outside of normal working hours, with no light from stray sources.

D. Use light meter to obtain as even a distribution as possible.

E. Coordinate a time with Architect and Owner, to make final adjustments to aiming.

F. Provide ladders, scaffolding, lifts and tools required for accessing and aiming fixtures, and coordinate this activity based on site availability of Lighting Designer.

3.5 RELAMPING AND CLEANING

A. Replace inoperable lamps, fluorescent lamps with unevenly illuminated tubes, or lamps with darkened end caps prior to final acceptance.

B. Replace noisy and malfunctioning ballasts prior to final acceptance.

C. Replace lamps and/or ballasts where necessary to eliminate strobing.

D. Align luminaires and remove paint splatters, dirt and debris.

E. Touch up any visible damages to luminaire finish.

F. Wipe clean luminaire reflectors, lenses, lamps and trims, after installation.

G. Install luminaires with caution to avoid fingerprints or smudges on surfaces of parabolic louvers and downlight reflectors.
   1. Use cleaning materials and methods that will not damage finish.
   2. Where fingerprints or smudges cannot be adequately removed, replace affected luminaire.

H. Install architectural cove luminaires after cove has been painted.
   1. Vacuum construction debris from cove to ensure a dust-free reflector surface prior to date of Substantial Completion.

3.6 SPECIAL PROTECTION

A. Remove protective covers immediately prior to date of Substantial Completion.

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DIVISION 31

EARTHWORK

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SECTION 31 10 00
SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Howard County Department of Public Works Standards and Specifications latest edition and amendments unless otherwise noted herein referred to as Standard Specifications.

1.2 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, and removing site utilities, abandoning site utilities in place.
   7. Temporary erosion- and sedimentation-control measures.

1.3 DEFINITIONS

A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 IN in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.

E. Tree-Protection Zone/Forest Retention Area: Area surrounding individual trees, groups of trees or forest to be protected during construction, and indicated on Drawings.

F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

G. Remove and Salvage: Items indicated to be removed and salvaged remain the Owner's property. Remove, clean, and pack or crate items to protect against damage. Identify contents of containers and deliver to Owner's designated storage area.

1.4 SALVAGED SITE FURNISHINGS AND MATERIALS

A. Contact Construction Manager to coordinate locations for storing and stockpiling salvaged materials.

1.5 MATERIAL OWNERSHIP

A. Except for stripped topsoil, soil spoils 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.

1.6 SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
   1. Use sufficiently detailed photographs or videotape.
   2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.7 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at Project site.

1.8 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   1. See drawings for further maintenance of traffic notes and details.
   2. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   3. 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 by Owner.

C. Utility Locator Service: Notify Owner's utility locating service where Project is located before site clearing, as indicated on Drawings.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control and tree protection measures are in place and authorities having jurisdiction have been notified as indicated on Drawings.

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.

F. Do not direct vehicle or equipment exhaust towards protection zones.

G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

H. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material:
   1. See Geotechnical Report for soils information and recommendations.
   2. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.
   3. See 31 20 00 “Earth Moving” for definition of satisfactory soils.

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, to be removed or to be relocated per direction from the Project Landscape Architect. Flag each tree trunk at 54 IN above the ground.

C. Protect existing site improvements to remain from damage during construction.

D. 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 measures shown on the Erosion and Sediment Control drawings.

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 the Landscape Architect. Tree repairs/replacement shall be approved by a MD Licensed Tree Expert.

3.4 EXISTING UTILITIES

A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
   1. Verify that utilities have been disconnected and capped before proceeding with site clearing.

B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
   1. Arrange with Owner and utility companies to shut off indicated utilities.
   2. Owner will arrange to shut off indicated utilities when requested by Contractor.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Bypass services/systems which are required to be removed, relocated, or abandoned before cutting service to prevent interruption to occupied areas.
   2. Do not proceed with utility interruptions without Owner's Representative written permission.

E. Excavate for and remove underground utilities indicated to be removed.

3.5 UTILITY ABANDONMENT

A. Existing utility system encountered to be abandoned/removed shall have all "open ends" bulkheaded. Cut/trim ends of piping to be bulkheaded in a neat manner. No guarantee is made in regard to the absence of ground or potable water flows in lines to be cut. Bulkheads are to be 8" minimum thickness mortared masonry, courses laid level, full mortar joints, and finished "outside" faces approximately plumb. Construct bulkheading each side of trench on excavation, when applicable.

B. If the existing system to be removed has been backfilled with flowable fill, bulkheading is not required.

C. Backfill all abandoned pipe below building structures with flowable fill.

D. Existing utility lines/manholes in conflict with proposed work to be removed/abandoned as necessary and backfilled and compacted to specified density.

3.6 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 IN below exposed subgrade.
   3. Chip removed tree branches and spread over areas identified by the Landscape Architect.

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 IN, and compact each layer to a density equal to adjacent original ground.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
   2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

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

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SECTION 31 20 00
EARTH MOVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Excavating and filling for rough grading the Site.
   2. Preparing subgrades for slabs on grade, walks, pavements, turf and grasses, and plants.
   3. Excavating and backfilling for buildings and structures.
   4. Drainage course for concrete slabs-on-grade.
   5. Subbase course for concrete walks and pavements.
   6. Subbase course for asphalt paving.
   7. Subsurface drainage backfill for walls and trenches.
   8. Excavating and backfilling trenches for utilities and pits for buried utility structures.

B. Related Requirements:
   1. Retain subparagraphs below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.
   2. Section 03 30 53 "Miscellaneous Cast-in-Place Concrete" for granular course if placed over vapor retarder and beneath the slab-on-grade.
   3. Section 31 10 00 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
   4. Section 32 92 00 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.
   5. Section 32 93 00 "Plants" for finish grading in planting areas and tree and shrub pit excavation and planting.

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
   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.

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. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. or more in volume that exceed a standard penetration resistance of 100 blows/2 IN when tested by a geotechnical testing agency, according to ASTM D 1586.

I. 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.

J. 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.

K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

L. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct preexcavation conference at Project site.
   1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
      a. Personnel and equipment needed to make progress and avoid delays.
      b. Coordination of Work with utility locator service.
      c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
      d. Extent of trenching by hand or with air spade.
      e. Field quality control.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following manufactured products required:
   1. Geotextiles.
   2. Controlled low-strength material, including design mixture.
   3. Warning tapes.

B. Samples for Verification: For the following products, in sizes indicated below:
   1. Geotextile: 12 by 12 IN.
   2. Warning Tape: 12 IN long; of each color.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
   1. Classification according to ASTM D 2487.
   2. Laboratory compaction curve according to ASTM D 698.

C. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

1.7 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

1.8 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Utility Locator Service: Notify Owner's utility locating service for area where Project is located before beginning earth-moving operations.

C. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 01 50 00 “Temporary Facilities & Controls” are in place.

D. 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.

E. Do not direct vehicle or equipment exhaust towards protection zones.

F. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, GC, SW, SP, SM, SC, CL, and ML according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 3 IN in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter, with a minimum maximum dry density of 105 pounds per cubic foot according to ASTM D 698.

C. Unsatisfactory Soils: Soil Classification Groups OL, CH, MH, OH, and PT according to ASTM D 2487, 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/D 2940M; with at least 90 percent passing a 1-1/2 IN sieve and not more than 12 percent passing a No. 200 sieve.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 294/D 2940M 0; with at least 95 percent passing a 1-1/2 IN sieve and not more than 8 percent passing a No. 200 sieve.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2 IN sieve and not more than 12 percent passing a No. 200 sieve.

G. Reinforced-Soil Fill: Comply with requirements in Section 32 32 23 “Segmental Retaining Walls” for satisfactory installation materials.

H. Select Borrow: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with no more than 30 percent passing a No. 200 sieve, a Liquid Limit not more than 34; ASTM D 4318;, and a Plasticity Index not more than 7; ASTM D 4318.

I. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 1 IN sieve and not more than 8 percent passing a No. 200 sieve.

J. 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 IN sieve and zero to 5 percent passing a No. 8 sieve.

K. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1 IN sieve and zero to 5 percent passing a No. 4 sieve.

L. Sand: ASTM C 33/C 33M; fine aggregate.

M. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   1. Survivability: Class 2; AASHTO M 288.
   2. Survivability: As follows:
      a. Grab Tensile Strength: 157 lbf.
      b. Sewn Seam Strength: 142 lbf.
      c. Tear Strength: 56 lbf.
      d. Puncture Strength: 56 lbf.
   3. Apparent Opening Size: No. 70 sieve, maximum; ASTM D 4751.
   4. Permittivity: 0.1 per second, minimum; ASTM D 4491.
   5. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
   1. Survivability: Class 2; AASHTO M 288.
   2. Survivability: As follows:
      a. Grab Tensile Strength: 247 lbf; ASTM D 4632.
      b. Sewn Seam Strength: 222 lbf ; ASTM D 4632.
      c. Tear Strength: 90 lbf; ASTM D 4533.
      d. Puncture Strength: 90 lbf; ASTM D 4833.
   3. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
   4. Permittivity: 0.02 per second, minimum; ASTM D 4491.
   5. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

2.3 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 IN wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 IN deep; colored as follows:
   1. Red: Electric.
   2. Yellow: Gas, oil, steam, and dangerous materials.
   3. Orange: Telephone and other communications.
   4. Blue: Water systems.
   5. Green: Sewer systems.

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 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
   1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

3.4 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.

B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.
   1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; and soil, boulders, and other materials not classified as rock or unauthorized excavation.
      a. Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 IN. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
   1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
   2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 IN. Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:
   1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, 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 01 56 39 "Temporary Tree and Plant Protection."

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.
   1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

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 IN higher than top of pipe or conduit unless otherwise indicated.
   1. Clearance: 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. For pipes and conduit less than 6 IN in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
   2. For pipes and conduit 6 IN or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
   3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
   4. Excavate trenches 6 IN deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trench Bottoms: Excavate trenches 4 IN deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.

E. 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 01 56 39 "Temporary Tree and Plant Protection."

3.8 SUBGRADE INSPECTION

A. Notify Construction Manager when excavations have reached required subgrade.

B. If Construction Manager determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade with a 35-ton pneumatic-tired roller or dump truck to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
   1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
   2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

D. Authorized additional excavation and replacement material will be paid for according to Contract provisions.

E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.9 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, may be used when approved by Architect.
   1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.10 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.

3.11 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:
   1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
   2. Surveying locations of underground utilities for Record Documents.
   3. Testing and inspecting underground utilities.
   4. Removing concrete formwork.
   5. Removing trash and debris.
   6. Removing temporary shoring, bracing, and sheeting.
   7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 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 Roadways: Provide 4 IN thick, concrete-base slab support for piping or conduit less than 30 IN below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 IN of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

D. Backfill voids with satisfactory soil while removing shoring and bracing.

E. Initial Backfill:
   1. Soil Backfill: Place and compact initial backfill of satisfactory soil, free of particles larger than 1 IN in any dimension, to a height of 12 IN over the pipe or conduit.
      a. 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. Final Backfill:
   1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.

G. Warning Tape: Install warning tape directly above utilities, 12 IN below finished grade, except 6 IN below subgrade under pavements and slabs.

3.13 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.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 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.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 IN in loose depth for material compacted by heavy compaction equipment and not more than 4 IN 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 698:
   1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 IN of existing subgrade and each layer of backfill or fill soil material at 95 percent.
   2. Under walkways, scarify and recompact top 6 IN below subgrade and compact each layer of backfill or fill soil material at 92 percent.

3. Under turf or unpaved areas, scarify and recompact top 6 IN 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.

3.16 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
   1. Provide a smooth transition between adjacent existing grades and new grades.
   2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:
   1. Turf or Unpaved Areas: Plus or minus 1 IN.
   2. Walks: Plus or minus 1 IN.
   3. Pavements: Plus or minus 1/2 IN.

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 IN when tested with a 10 FT straightedge.

3.17 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Section 33 46 00 "Subdrainage."

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6 IN course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 IN of filter material, placed in compacted layers 6 IN thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 IN.
   1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.

C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 IN of final subgrade, in compacted layers 6 IN thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 IN.
   1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
   2. Place and compact impervious fill over drainage backfill in 6 IN thick compacted layers to final subgrade.

3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place base course under pavements and walks as follows:
   1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
   2. Shape base course to required crown elevations and cross-slope grades.
   3. Place base course 6 IN or less in compacted thickness in a single layer.
   4. Place base course that exceeds 6 IN in compacted thickness in layers of equal thickness, with no compacted layer more than 6 IN thick or less than 3 IN thick.
   5. Compact 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 698.

C. Pavement Shoulders: Place shoulders along edges of base course to prevent lateral movement. Construct shoulders, at least 12 IN wide, of satisfactory soil materials and compact simultaneously with each base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.19 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. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
   2. Place drainage course 6 IN or less in compacted thickness in a single layer.
   3. Place drainage course that exceeds 6 IN in compacted thickness in layers of equal thickness, with no compacted layer more than 6 IN thick or less than 3 IN thick.
   4. 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.

3.20 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
   1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
   2. Determine that fill material classification and maximum lift thickness comply with requirements.
   3. Determine, during placement and compaction,that in-place density of compacted fill complies with requirements.

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. 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.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
   1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab but in no case fewer than three tests.
   2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 FT or less of wall length but no fewer than two tests.
   3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 FT or less of trench length but no fewer than two tests.
   4. Reinforced Backfill: In accordance with Section 32 32 23, Segmental Retaining Walls.

F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.21 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
   1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.22 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.

B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.
   1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

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SECTION 31 23 00
BUILDING EXCAVATION, FILLING, AND BACKFILLING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Building Excavation, Filling, and Backfilling, as indicated, in accordance with provisions of Contract Documents.

B. Definitions:
   1. Unsuitable material:
      a. Debris and/or soil material judged unsuitable by Geotech for support of slabs and foundations or for use as a fill or backfill material.
   2. Maximum density:
      a. As determined using ASTM D698, Standard Proctor.
   3. Geotech:
      a. Geotechnical Engineer or Representative of Foundation Consultant employed by Owner to inspect foundation work.
   4. Rock excavation:
      a. Excavation of rock material which is sufficiently solid and of such strength that it cannot be loosened or broken down in a single pass with following equipment:
         1) Single tooth ripper mounted onto a Caterpillar D-8K crawler tractor (or equivalent) or Caterpillar 977 front end loader (or equivalent) with a minimum draw bar pull rated at not less than 56,000 pounds.
         2) This classification does not include loose rock, concrete, or other materials that can be removed by means other than hoe ramming or ripping, but which for reasons of economy in excavating, the contractor chooses to remove by hoe ramming or ripping.
   5. Competent person:
      a. Employed by the contractor to daily inspect all excavations, adjacent areas and protective systems to ensure all aspects of site excavation safety in accordance with OSHA Part 1926 Subpart P.

C. Completely coordinate with work of other trades.

1.2 EXTRA WORK

A. Removal and replacement of unsuitable material will be paid as extra work.
   1. Notify (Owner's agent) in time to estimate and record quantity removed.
   2. If Contractor is unwilling to accept estimate, notify Architect or Construction Manager prior to backfilling and a surveyor will be hired at Contractor's expense to measure and determine excavated volumes.
   3. Recorded quantity will be basis for payment.
   4. Include unit price on Bid Form.

B. Rock excavation will be paid for as extra work.
   1. Notify (Owner's agent) in time to estimate and record quantity removed.
   2. Recorded quantity will be basis for payment.
   3. Include unit price on Bid Form.

1.3 QUALITY ASSURANCE

A. Subsurface Soils Investigations:
   1. Soils information was obtained at project site for use in preparing foundation design.
   2. Availability of soils report information is indicated in specifications.
   3. Examine site and soils report and independently determine character of materials to be encountered.

B. Inspection and Compaction Density Tests:
   1. Owner will hire the Geotech to inspect earthwork and to conduct in-place compaction moisture-density tests.
   2. Initial test at each location will be paid by Owner.
   3. If initial test fails, Contractor pays for retesting.

C. Subgrade Tolerance:
   1. +0.00 FT/-0.10 FT from required elevations.

D. Base Tolerance:
   1. +0 IN/-0.75 IN from required elevations.

1.4 SUBMITTALS

A. Product Data:
   1. Maximum Density curves for fill and backfill material.
   2. Sieve analysis for granular fill.

1.5 JOB CONDITIONS

A. Ensure daily inspection of site excavations by competent person.

B. Determine safe slopes of excavations for the earth materials encountered.

C. Shoring and bracing excavations as required to protect personnel, utilities, existing construction and new work.

D. Removing bracing when safe.

E. Protecting from damage (or replacing as directed) sidewalks, pavements and other facilities resulting from settlement, lateral movement, undermining erosion or other hazards created by earthwork operations.

F. Complying with rules and regulations governing earthwork and respective utilities.

G. Providing adequate barricades and warning lights as required to protect persons and property and to satisfy applicable regulations.

H. Maintaining bench marks, movements and other reference points and replacing any disturbed or destroyed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fill and backfill material:
   1. Clean selected materials, approved by Geotech, from site excavation or from off site borrow areas.
   2. Materials should consist of soils classifying GW, GP, GM, SW, SP, SM, SC or ML per the Unified Soil Classification System (ASTM D2487).
   3. Liquid limit shall be less than 45. Plasticity Index shall be less than 20.
   4. Free of boulders, organic matter, debris or other deleterious materials. Maximum particle size shall be no greater than 3 IN.
   5. Maximum dry density per ASTM D698 shall be greater or equal to 100 pcf.
   6. Submit Maximum Density curves for each source of fill or backfill material.

B. Granular fill:
   1. Clean, uncrushed, natural rounded gravel; without broken faces, sharp edges, or points.
   2. Submit sieve analysis verifying granular fill adheres to AASHTO #57 stone or equivalent.

PART 3 - EXECUTION

3.1 EXCAVATION - GENERAL

A. Do not perform blasting.

B. Excavate to dimensions and elevations indicated regardless of materials encountered.
   1. Allow additional space as required for construction operations and inspection of foundations.

C. Remove old foundations, building construction, and other materials concealed beneath present grade, as required to execute work, and as indicated.

D. Remove and replace unsuitable material with compacted backfill as directed by Geotech.

E. If rock is encountered, remove and replace with suitable material as directed by Geotech.

F. Properly level off bottoms of excavations.

G. Where cuts are required to bring floor slabs to proper elevations, excavate to level below slabs allowing for required granular fill.
   1. Remove rocks, lumps, vegetation and other foreign material.
   2. Scarify top 8 IN of earth below granular fill and recompact to 95 PCT of maximum density.
   3. Where compacted subgrade is disturbed by frost, moisture, or construction operations, re-scarify and recompact as directed by Geotech.

H. Control grading around building.
   1. Pitch surface to prevent water from running into excavated areas or damaging structure.
   2. Maintain pits and trenches where footings will be placed free of water.
   3. Provide pumping required to keep excavated spaces clear of water during construction.
   4. When springs or running water are encountered, notify Architect. Provide free discharge of water by trenches or pumps, and drain to appropriate point of disposal as directed.

3.2 FOOTINGS

A. Provide undisturbed, level, dry, unfrozen surfaces free of foreign or loose material for placement of footings.

B. Obtain Geotech's approval of footing subgrade before placing any concrete and/or reinforcing steel.

C. Do not carry excavations lower than indicated, except when directed by Geotech.

D. If excavations are made below indicated level as directed by Geotech, fill with concrete of same strength as foundation concrete at no extra cost.

E. When excavations become soft and wet, remove soft material and replace with concrete of same strength as foundation concrete, at no extra cost.

F. When freezing temperatures are expected, do not excavate to full depth unless footings can be placed immediately. Protect bottoms of excavations from freezing if placement is delayed.

3.3 SUBGRADE PREPARATION, FILLING, AND BACKFILLING

A. Remove rocks, lumps, frozen ground, soft or wet material, vegetation, and other foreign material upon which fill or backfill is to be placed.

B. Before scarifying subgrade, obtain approval of Geotech. Proof-roll subgrade and base as required by Geotech.

C. Scarify top 8 IN of excavation surface or subgrade and compact to 95 PCT of maximum density.

D. Place fill material in 6 IN lifts and compact each lift to 95 PCT maximum density. Reduce to 3 IN lifts in confined areas.

E. Maintain moisture between +1.5 PCT/-1.5 PCT of the optimum moisture content during compaction.

F. Compact fill and backfill using suitable mechanical tamping equipment to obtain specified density.
   1. Use mechanical hand tampers for filling and backfilling next to walls.
   2. Compact granular fill using vibratory methods.

G. Where existing ground surface is steeper than one vertical to four horizontal, step surface with steps not exceeding 12 IN or slope surface not exceeding one vertical to 50 horizontal.

H. Correct and recompact compacted material not meeting specified compaction requirements. Continue corrective measures until required compaction has been attained.

I. Do not backfill against part of walls, piers, or columns until each part has reached design strength.
   1. Do not place fills against walls until floor slabs at top and bottom of walls are in place.
   2. Bring backfill up uniformly around building and individual wall units.

J. Do not backfill against foundations, walls, curbs, footings, and areaways until concrete forms have been removed, masonry work has been pointed, and concrete finishing, dampproofing, and waterproofing have been completed.

K. Heavy equipment shall not operate within 5 FT of below grade walls or walls to be backfilled.

3.4 GRADING NEXT TO BUILDING

A. To provide drainage evenly slope finished grade away from building walls at slopes not less than one (1) vertical to fifty (50) horizontal.

3.5 GRANULAR FILL UNDER SLABS ON GRADE

A. Place minimum 6 IN granular fill below vapor retarder under slabs on grade.
   1. Vapor retarder: See Section 03 31 10.

3.6 ACCEPTANCE OF WORK

A. Obtain Architect's and Geotech's approval of each earthwork operation before next operation.

B. Notify Architect and Geotech in sufficient time for inspection.

3.7 DISPOSAL OF EXCESS AND WASTE MATERIAL

A. Remove waste and excess materials including excess earth, unsuitable materials, trash and debris and legally dispose of it off Owner's property.

END OF SECTION

SECTION 31 23 19
DEWATERING

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 construction dewatering.

B. Related Requirements:
1. Section 01 32 33 "Photographic Documentation" for recording preexisting conditions and dewatering system progress.
2. Section 31 20 00 "Earth Moving" for excavating, backfilling, site grading, and controlling surface-water runoff and ponding.

1.3 ALLOWANCES

A. Dewatering observation wells are part of dewatering allowance.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at project site, JHU Applied Physics Laboratory, Building 14.
1. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
2. Review condition of site to be dewatered including coordination with temporary erosion-control measures and temporary controls and protections.
3. Review geotechnical report.
4. Review proposed site clearing and excavations.
5. Review existing utilities and subsurface conditions.
6. Review observation and monitoring of dewatering system.

1.5 ACTION SUBMITTALS

A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.
1. Include plans, elevations, sections, and details.
2. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
3. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
4. Include written plan for dewatering operations including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, land surveyor, and professional engineer.

B. Field quality-control reports.

C. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by dewatering operations. Submit before Work begins.

D. Record Drawings: Identify locations and depths of capped wells and well points and other abandoned-in-place dewatering equipment.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.

1.8 FIELD CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.
   1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.
   2. The geotechnical report is included referenced elsewhere in Project Manual.

B. 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.
   1. Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer.
   2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
   3. Prevent surface water from entering excavations by grading, dikes, or other means.
   4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
   5. Remove dewatering system when no longer required for construction.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water- and debris-disposal regulations 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 dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.
2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 01 50 00 "Temporary Facilities and Controls, Section 31 10 00 "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 sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

D. 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 IN below bottom of excavation.

C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others and meets all governmental regulatory requirements.

D. 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 IN below overlying construction.

3.4 FIELD QUALITY CONTROL

A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.

1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

B. 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.

C. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

D. Prepare reports of observations.

3.5 PROTECTION

A. Protect and maintain dewatering system during dewatering operations.

B. Promptly repair damages to adjacent facilities caused by dewatering.

END OF SECTION

DIVISION 32

EXTERIOR IMPROVEMENTS

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SECTION 32 12 16

ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Latest edition of the Maryland State Highway Administration 2017 Standard Specifications for Construction and Materials.

C. Latest edition of the Howard County Standard Specifications and Details for Construction.

1.2 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.
5. Asphalt curbs.
6. Asphalt traffic-calming devices.
7. Asphalt surface treatments.

B. Related Requirements:
1. Section 02 41 19 "Selective Demolition" for demolition and removal of existing asphalt pavement.
2. Section 31 20 00 "Earth Moving" for subgrade preparation, fill material, separation geotextiles, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
3. Section 32 13 13 "Concrete Paving" for concrete pavement and for separate concrete curbs, gutters, and driveway aprons.
4. Section 32 13 73 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.
5. Section 32 14 00 "Unit Paving" for bituminous setting bed for pavers and for stone and precast concrete curbs.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project Site.
1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
   a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
   b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include technical data and tested physical and performance properties.
2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
3. Job-Mix Designs: For each job mix proposed for the Work.

B. Samples for Verification: For the following product, in manufacturer's standard sizes unless otherwise indicated:
   1. Paving Fabric: 12 by 12 IN minimum.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer and testing agency.

B. Material Certificates: For each paving material. Include statement that mixes containing recycled materials will perform equal to mixes produced from all new materials.

C. Material Test Reports: For each paving material, by a qualified testing agency.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the Maryland SHA.

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of Howard County, Maryland, Department of Public Works for asphalt paving work.
   1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
   1. Prime Coat: Minimum surface temperature of 60 DEGF.
   2. Tack Coat: Minimum surface temperature of 60 DEGF.
   3. Slurry Coat: Comply with weather limitations in ASTM D 3910.
   4. Asphalt Base Course: Minimum surface temperature of 40 DEGF and rising at time of placement.
   5. Asphalt Surface Course: Minimum surface temperature of 60 DEGF at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: ASTM D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

C. 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.
   1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

D. Mineral Filler: ASTM D 242/D 242M, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: In compliance with the latest edition of Maryland State Highway Administration 2017 Standard Specifications for Construction and Materials, Category 900.

B. Asphalt Cement: In compliance with the latest edition of Maryland State Highway Administration 2017 Standard Specifications for Construction and Materials, Category 900.

C. Emulsified Asphalt Prime Coat: In compliance with the latest edition of Maryland State Highway Administration 2017 Standard Specifications for Construction and Materials, Category 900.

D. Tack Coat: In compliance with the latest edition of Maryland State Highway Administration 2017 Standard Specifications for Construction and Materials, Category 900.

E. Fog Seal: In compliance with the latest edition of Maryland State Highway Administration 2017 Standard Specifications for Construction and Materials, Category 900.

F. Water: Potable.

G. Undersealing Asphalt: ASTM D 3141/D 3141M; pumping consistency.

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.

C. Sand: ASTM D 1073 or AASHTO M 29, Grade No. 2 or No. 3.

D. Paving Geotextile: AASHTO M 288 paving fabric; nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.

E. Joint Sealant: In compliance with the latest edition of Maryland State Highway Administration 2017 Standard Specifications for Construction and Materials, Category 900.

2.4 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by Howard County and/or the Maryland State Highway Administration and complying with the following requirements:
   1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
   2. Base Course: Howard County Detail R-2.01, Pavement P-3.
   3. Surface Course: Howard County Detail R-2.01, Pavement P-3.

2.5 CHIP SEAL SURFACE TREATMENT

A. All walkway areas where indicated on the plans shall consist of hot mix asphalt base course, “Thin Lift Mix”, 19.0mm. Coarse Graded, over the compacted aggregate base. The hot mix asphalt surface course shall be overlaid with a double surface of Chip Seal, in accordance with 503, “Chip Seal Surface Treatment” of the Maryland Department of Transportation State Highway Administration Standard Specifications for Construction and Materials. Roads shall be installed to the sizes, dimensions, grades, slopes and elevations as shown on the contract drawings.

B. The Contractor shall submit in writing at least three weeks in advance of the paving operation the following information for the Engineer.
   1. Source of each aggregate component.
   2. Source of asphalt and anti-stripping agent.
   3. Complete gradation.
   4. Plant from which materials will be ordered.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protection: Provide protective materials, procedures, and worker training to prevent asphalt materials from spilling, coating, or building up on curbs, driveway aprons, manholes, and other surfaces adjacent to the Work.

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.
   1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
   2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
   3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

3.3 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 2 IN.
   2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
   3. Control rate of milling to prevent tearing of existing asphalt course.
   4. Repair or replace curbs, driveway aprons, manholes, and other construction damaged during cold milling.
   5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
   6. Patch surface depressions deeper than 1 IN after milling, before wearing course is laid.
   7. Handle milled asphalt material according to approved waste management plan required in Section 01 74 19 "Construction Waste Management and Disposal."
   8. Keep milled pavement surface free of loose material and dust.
   9. Do not allow milled materials to accumulate on-site.

3.4 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 IN 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. Undersealing: Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.

2. 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/SQYD.
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.

E. Placing Patch Material: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.5 REPAIRS

A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 IN in existing pavements.
1. Install leveling wedges in compacted lifts not exceeding 3 IN thick.

B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 IN.
1. Clean cracks and joints in existing hot-mix asphalt pavement.
2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 IN wide. Fill flush with surface of existing pavement and remove excess.
3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 IN wide. Fill flush with surface of existing pavement and remove excess.

3.6 SURFACE PREPARATION

A. Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. 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.
1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.

C. Cutback Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 GAL/SQYD. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

D. Emulsified Asphalt Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.10 to 0.30 GAL/SQYD per IN depth. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.
1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

E. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 GAL/SQYD.
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.

3.7 PAVING GEOTEXTILE INSTALLATION

A. Apply tack coat uniformly to existing pavement surfaces at a rate of 0.20 to 0.30 GAL/SQYD.

B. Place paving geotextile promptly according to manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints 4 IN and transverse joints 6 IN.

C. Protect paving geotextile from traffic and other damage, and place hot-mix asphalt overlay the same day.

3.8 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. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
   2. Place hot-mix asphalt surface course in single lift.
   3. Spread mix at a minimum temperature of 250 DEGF.
   4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
   5. 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 FT wide unless infill edge strips of a lesser width are required.
   1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 IN from strip to strip to ensure proper compaction of mix along longitudinal joints.
   2. Complete a section of asphalt base course before placing asphalt surface course.

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.

3.9 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 IN.
   3. Offset transverse joints, in successive courses, a minimum of 24 IN.
   4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
   5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
   6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.10 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 DEGF.

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: 96 percent of reference laboratory density according to AASHTO T 245, but not less than 94 percent or greater than 100 percent.
   2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041/D 2041M, 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. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549/D 3549M.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. Asphalt Traffic-Calming Devices: Finished height of traffic-calming devices above pavement will be measured for compliance with tolerances.

E. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to AASHTO T 168.
   1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041/D 2041M, and compacted according to job-mix specifications.
   2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726/D 2726M.
      a. One core sample will be taken for every 1000 SQYD or less of installed pavement, with no fewer than three cores taken.
      b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726/D 2726M.

F. Replace and compact hot-mix asphalt where core tests were taken.

G. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

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SECTION 32 13 13
CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes Concrete Paving
   1. Driveways.
   2. Roadways.
   3. Parking lots.
   4. Curbs and gutters.
   5. Walks.

B. Related Requirements:
   1. Section 03 30 53 "Miscellaneous Cast-in-Place Concrete"
   2. Section 32 14 00 "Unit Paving"

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference:
   1. Review methods and procedures related to concrete paving, including but not limited to, the following:
      a. Concrete mixture design.
      b. Quality control of concrete materials and concrete paving construction practices.
   2. Require representatives of each entity directly concerned with concrete paving to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.
      c. Ready-mix concrete manufacturer.
      d. Concrete paving Subcontractor.
      e. Manufacturer's representative of stamped concrete paving system used for stamped detectable warnings.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Initial Selection: For each type of product, ingredient, or admixture requiring color selection.

C. Samples for Verification: For each type of product or exposed finish, prepared as Samples of size indicated below:
   1. Exposed Aggregate: 10-lb Sample of each mix.

D. 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.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer of stamped detectable warnings ready-mix concrete manufacturer and testing agency.

B. Material Certificates: For the following, from manufacturer:
1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

C. Material Test Reports: For each of the following:
1. Aggregates.

D. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Stamped Detectable Warning Installer Qualifications: An employer of workers trained and approved by manufacturer of stamped concrete paving systems.

B. 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.
1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

C. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

D. 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 concrete paving to demonstrate typical joints; surface finish, texture, and color; curing; and standard of workmanship.
2. Build mockups of concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than 96 IN by 96 IN.
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. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

1.9 FIELD CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete 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 DEGF, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 DEGF and not more than 80 DEGF 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.

C. Hot-Weather Concrete Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:
   1. Cool ingredients before mixing to maintain concrete temperature below 90 DEGF at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
   2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
   3. Fog-spray forms steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

2.2 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 with a radius of 100 feet or less

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

A. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from as-drawn galvanized-steel wire into flat sheets.

B. Deformed-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, flat sheet.

C. Epoxy-Coated Welded-Wire Reinforcement: ASTM A 884/A 884M, Class A, plain steel.

D. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

E. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

F. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

G. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars; assembled with clips.

H. Plain-Steel Wire: ASTM A 1064/A 1064M, galvanized.

I. Deformed-Steel Wire: ASTM A 1064/A 1064M.

J. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A; coated, deformed.

K. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars; zinc coated after fabrication according to ASTM A 767/A 767M, Class I coating. Cut bars true to length with ends square and free of burrs.

L. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars.

M. Tie Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

N. Hook Bolts: ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

O. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
   1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
   2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

P. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.

Q. Zinc Repair Material: ASTM A 780/A 780M.

2.4 CONCRETE MATERIALS

A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:
   1. Portland Cement: ASTM C 150/C 150M, portland cement Type I/Type II.
   2. Fly Ash: ASTM C 618, Class F.
   3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.

B. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 4S or Class 4M, 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 Coarse-Aggregate Size: 1 IN nominal.
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Air-Entraining Admixture: ASTM C 260/C 260M.

D. 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.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

E. Color Pigment: ASTM C 979/C 979M, 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 indicated by Architect.

F. Water: Potable and complying with ASTM C 94/C 94M.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 OZ./SQYD 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.

2.6 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.

C. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

D. Epoxy-Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:
   1. Types I and II, nonload bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

E. Chemical Surface Retarder: Water-soluble, liquid, set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 1/8 to 1/4 IN.

F. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.
   1. Color: As selected by Architect from manufacturer's full range.

G. Rock Salt: Sodium chloride crystals, kiln dried, coarse gradation with 100 percent passing 3/8 IN sieve and 85 percent retained on a No. 8 (2.36 MM) sieve.

2.7 STAMPED DETECTABLE WARNING MATERIALS

A. Detectable Warning Stamp: Semirigid polyurethane mats with formed underside capable of imprinting detectable warning pattern on plastic concrete; perforated with a vent hole at each dome.
   1. Size of Stamp: One piece, matching detectable warning area shown on Drawings.

B. Liquid Release Agent: Manufacturer's standard, clear, evaporating formulation designed to facilitate release of stamp mats.

2.8 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), 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.

2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
   1. Fly Ash or Pozzolan: 25 percent.
   2. Slag Cement: 50 percent.
   3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.

D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
   1. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.

E. 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.

F. Concrete Mixtures: Normal-weight concrete.
   1. Compressive Strength (28 Days): Per Plans.
   2. Maximum W/C Ratio at Point of Placement: 0.45.
   3. Slump Limit: Per Plan Mix Design.

2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
   1. When air temperature is between 85 and 90 DEGF, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 DEGF, reduce mixing and delivery time to 60 minutes.

B. 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 CUYD 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 CUYD, increase mixing time by 15 seconds for each additional 1 CUYD.
   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 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 (13.6 tonnes).
   3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 IN according to requirements in Section 31 20 00 "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.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT INSTALLATION

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

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

E. Zinc-Coated Reinforcement: Use galvanized-steel wire ties to fasten zinc-coated reinforcement. Repair cut and damaged zinc coatings with zinc repair material.

F. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M.

G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2 IN overlap of adjacent mats.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
   1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
   1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
   2. Provide tie bars at sides of paving strips where indicated.
   3. Butt Joints: Use epoxy-bonding adhesive at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
   4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 IN into concrete.
   5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate 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 IN or more than 1 IN 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.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 (ACI 301M) 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 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
   1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels and joint devices.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.

K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
   1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

3.7 DETECTABLE WARNING INSTALLATION

A. Blockouts: Form blockouts in concrete for installation of detectable paving units specified in Section 32 17 26 "Tactile Warning Surfacing."
   1. Tolerance for Opening Size: Plus 1/4 IN, no minus.

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/SQFT 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 as follows:
   1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
      a. Water.
      b. Continuous water-fog spray.
      c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12 IN lap over adjacent absorptive covers.
   2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover, placed in widest practicable width, with sides and ends lapped at least 12 IN, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears occurring during installation or curing period, using cover material and waterproof tape.
   3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 (ACI 117M) and as follows:
   1. Elevation: 1/4 IN
   2. Thickness: Plus 3/8 IN, minus 1/4 IN.
   3. Surface: Gap below 10 FT long; unleveled straightedge not to exceed 1/2 IN.
   4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 IN per 12 IN of tie bar.
   5. Lateral Alignment and Spacing of Dowels: 1 IN.
   6. Vertical Alignment of Dowels: 1/4 IN.
   7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 IN per 12 IN of dowel.
   8. Joint Spacing: 3 IN.
   9. Contraction Joint Depth: Plus 1/4 IN, no minus.
   10. Joint Width: Plus 1/8 IN, 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 and inspecting of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:
   1. Testing Frequency: Obtain at least one composite sample for each 100 CUYD or 5000 SQFT 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/C 231M, 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 DEGF and below and when it is 80 DEGF 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 (3.4 MPa).

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. 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 REPAIR 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. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

SECTION 32 14 00
UNIT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Unit pavers set in bituminous setting beds.
2. Stone pavers set in mortar setting beds.
3. Aluminum edge restraints.

B. Related Requirements:
1. Section 32 12 16 ‘’Asphalt Paving” for asphalt base under unit pavers.
2. Section 03 05 00 "Concrete" for concrete base under unit pavers and for cast-in-place concrete curbs and gutters serving as edge restraints for unit pavers.
3. Section 32 14 43 "Porous Unit Paving" for unit paving using pavers with openings between them.
4. Section 32 17 26 “Tactile Warning Surface” for detectable warning unit pavers.

1.2 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

B. Include paver distributor or manufacturer’s representative.

1.3 ACTION SUBMITTALS

A. Product Data: For materials other than water and aggregates.

B. Product Data: For the following:
1. Pavers (for each type, color and finish).
2. Bituminous setting materials.
3. Mortar and grout materials.
4. Edge restraints.
5. Polymeric sand for joints.
6. Decorative aggregate.

C. LEED Submittals:
1. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

D. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C 136.

E. Samples for Initial Selection: For each type of unit paver indicated and the following:
1. Joint materials involving color selection.
2. Edge restraints involving color selection.

F. Samples for Verification: For full-size units of each type of unit paver indicated. Include Samples of the following:
1. Joint materials involving color selection (include polymeric sand).
2. Edge restraints involving color selection.

1.4 INFORMATIONAL SUBMITTALS

A. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.
   1. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C 67.

1.5 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
   1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
   2. Work shall not start until the mock up is approved by the Architect.
   3. Installer Qualifications: A qualified paving installer who has three years experience with at least 75,000 to 100,000 square feet installed. Successful completion of five similar unit paver installations similar in design which are to be documented. Installer has included the specified product(s) in their bid and they have read and understand the contents of ASTM C 902 and/or C 1272 as applicable.
   4. For Pedestrian Unit Paving, the contractor may elect to use a sand setting bed for initial review of allowable cuts then another early review during the bituminous setting bed installation.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

C. Store asphalt cement and other bituminous materials in tightly closed containers.

1.7 FIELD CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

B. Weather Limitations for Bituminous Setting Bed:
   1. Install bituminous setting bed only when ambient temperature is above 40 DEGF and when base is dry.
   2. Apply asphalt adhesive only when ambient temperature is above 50 DEGF and when temperature has not been below 35 DEGF for 12 hours immediately before application. Do not apply when setting bed is wet or contains excess moisture.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 UNIT PAVERS

A. Regional Materials: Brick pavers shall be manufactured within 500 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

B. Unit Pavers: Light-traffic paving brick (P2b); ASTM C 902, Class SX, Type I, Application PS. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
   1. Manufacturer: Whitacre Greer
      1400 S. Mahoning Avenue
      Alliance, OH 44601
      (800) 947-2837
   2. Thickness: 2-1/4 IN.
   3. Face Size: 4 by 8 IN, square/ straight edge, with lugs.
   4. Color: A random blend of three colors for paver field.
      a. Field - Color A: Cimmerean (53) – 45%
      b. Field - Color B: Majestic (52) – 45%
      c. Field - Color C: Chocolate (54) – 10%

C. Unit Pavers: Heavy vehicular paving brick (P2a); ASTM C 1272, Type R, Application PS. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
   1. Thickness: 2-3/4 IN.
   2. Face Size: 4 by 8 IN, edges with lugs.
   3. Color: A random blend of three colors for paver field.
      a. Field - Color A: Cimmerean (53) – 40%
      b. Field - Color B: Majestic (52) – 40%
      c. Field - Color C: Chocolate (54) – 10%

D. Efflorescence: Brick shall be rated "not effloresced" when tested according to ASTM C 67.

2.3 STONE PAVERS (P5)

A. Cobblestone Module: Square module slabs made from porphyry complying with ASTM C 170-50.
   1. Manufacturer: Eurocobble (www.eurocobble.com)
   2. System: Milano Grande
   3. Thickness: 5.5cm to 6.5cm"
   4. Size: 50cm by 50 cm. Each module to be comprised of 25 individual cobblestones each approximately 8cm by 10cm.
   5. Color: Grey Mix
   6. Modulus of Rupture: ASTM C 99-52.
   7. Abrasion Resistance: ASTM C241-51.
   8. Surface Friction: ASTM E303-74.
   9. Water Absorption: ASTM C 97-47.

2.4 CURBS AND EDGE RESTRAINTS

A. Aluminum Edge Restraints at Unit Paving: Manufacturer's standard L-shaped, 3/16 IN-thick by 2-1/4 IN high extruded-aluminum edging tabs to receive ram-set masonry nails at 12 IN o.c.
   1. Basis of Design Products: Permaloc Structure Edge or approved equal.

B. Aluminum Edge Restraints at Decorative Aggregate: Manufacturer's CleanLine XL with XLR adaptor, 3/16 IN thick by 12 IN high extruded-aluminum edging. Edging to receive 18 IN aluminum stakes to lcok into XLR adaptor.
   1. Basis of Design Products: Permaloc Structure Edge or approved equal.

2.5 ACCESSORIES

A. Compressible Foam Filler: Preformed strips complying with ASTM D 1056, Grade 2A1.

2.6 BITUMINOUS SETTING-BED MATERIALS

A. Primer for Base: ASTM D 2028/D 2028M, cutback asphalt, grade as recommended by unit paver manufacturer.

B. Fine Aggregate for Setting Bed: ASTM D 1073, No. 2 or No. 3.

C. Asphalt Cement: ASTM D 3381/D 3381M, Viscosity Grade AC-10 or Grade AC-20.

D. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.

2.7 MORTAR SETTING-BED MATERIALS

A. Portland Cement: ASTM C 150/C 150M, Type I or Type II.

B. Sand: ASTM C 144.

C. Latex Additive: Manufacturer's standard water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed, and not containing a retarder.
   1. Provide product that is approved by manufacturer for application thickness of 1 IN to 1-1/2 IN.

D. Water: Potable.

2.8 GROUT MATERIALS

A. High-Performance Cement Grout: ANSI A118.7, sanded.

B. Grout Colors: As indicated by manufacturer's designations.

2.9 BITUMINOUS SETTING-BED MIX

A. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate unless otherwise indicated. Heat mixture to 300 DEGF.

2.10 SAND FOR JOINTS

A. Sand for joints of Unit and Truncated Dome Pavers: Polymeric Paver Sand: ANSI A118.7.
   1. Manufacturer: Subject to compliance with requirements, provide polymer-modified joint sand by one of the following four locally supplied products:
      a. Joint-Lock Polymeric Paver Finishing Sand, or approved equal.
      b. Alliance Gator XP Sand.
      c. Techniseal RG+ Polymeric Sand.
      d. SRW Pavermate Polymeric Sand.
   2. Provide color from Manufacturer’s range of colors for approval by Architect.

2.11 MORTAR AND GROUT MIXES

A. General: Comply with referenced standards and with manufacturers' written instructions for mix proportions, mixing equipment, mixer speeds, mixing containers, mixing times, and other procedures needed to produce setting-bed and joint materials of uniform quality and with optimal performance characteristics. Discard mortars and grout if they have reached their initial set before being used.

B. Mortar-Bed Bond Coat: Mix neat cement and latex additive to a creamy consistency.

C. Portland Cement-Lime Setting-Bed Mortar: Type M complying with ASTM C 270, Proportion Specification.

D. Latex-Modified, Portland Cement Setting-Bed Mortar: Proportion and mix portland cement, sand, and latex additive for setting bed to comply with written instructions of latex-additive manufacturer and as necessary to produce stiff mixture with a moist surface when bed is ready to receive pavers.

E. Latex-Modified, Portland Cement Bond Coat: Proportion and mix portland cement, aggregate, and liquid latex for bond coat to comply with written instructions of liquid-latex manufacturer.

F. Packaged Grout: Proportion and mix according to grout manufacturer's written instructions.

2.12 DECORATIVE AGGREGATE (P7)

A. Beach Pebbles (P7):
   1. Manufacturer: Subject to compliance with requirements, provide beach pebbles by one of the following:
      a. Stone Center: www.stonecenter-va.com
      b. The Stone Store: www.thestonestore.com
      c. Or an approved equal.
   2. Size: 1/2 IN to 1 IN in diameter.
   3. Color: Charcoal Gray to Black.

B. Provide sample from manufacturer for approval by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Ensure proper drainage is provided per the contract document details and plans from both the Civil Engineer and Landscape Architect and appropriate drainage measures are in place prior to installing unit paving.

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

3.2 PREPARATION

A. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.

3.3 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

B. String or chalk lines must be used to keep paver bond lines straight and true. The straight and true bond lines shall not deviate more than +/- 1/2 IN over 50 FT. (The correct way to install is to establish a baseline indicated on the plan and work from there in the direction indicated, and continuously check and adjust paver bond lines.) See unit paving layout plans for sequence of construction.

C. Complete Baseline 'A' paver field before completing Baseline B, C and D paver fields.

D. Surface flatness not to exceed +/- 3/8 IN over 10 FT.

E. No work is to be done when any materials are wet or frozen.

F. Mix pavers from a minimum of three pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

G. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated on L-113 and L-114 and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
   1. Cut pavers shall not be cut to less than 2/3 the original paver size in length and 1/2 the original size in width. Two pavers shall be cut to accommodate spaces that are less than 2/3 the dimension of the original paver length leaving a minimum 2 IN between joints.

H. Joint Pattern:
   1. Running bond and as otherwise indicated.
   2. Joints shall remain staggered along radii and shall be a minimum of 2 IN apart.

I. Tolerances: Do not exceed 1/16 IN unit-to-unit offset from flush (lippage), or 1/8 IN in 24 IN and 1/4 IN in 10 FT from level, or indicated slope, for finished surface of paving.

J. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 07 92 00 "Joint Sealants."

K. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
   1. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.

3.4 BITUMINOUS SETTING-BED APPLICATIONS

A. Apply primer to concrete slab or binder course immediately before placing setting bed.

B. Prepare for setting-bed placement by locating 3/4 IN deep control bars approximately 11 FT apart and parallel to one another, to serve as guides for striking board. Adjust bars to subgrades required for accurate setting of paving units to finished grades indicated.

C. Place bituminous setting bed where indicated, in panels, by spreading bituminous material between control bars. Spread mix at a minimum temperature of 250 DEGF. Strike setting bed smooth, firm, even, and not less than 3/4 IN thick. Add fresh bituminous material to low, porous spots after each pass of striking board. After each panel is completed, advance first control bar to next position in readiness for striking adjacent panels. Carefully fill depressions that remain after removing depth-control bars.
   1. Roll setting bed with power roller to a nomical depth of 3/4 IN. Adjust thickness as necessary to allow accurate setting of unit pavers to finished grade indicated. Complete rolling before mix temperature cools to 185 DEGF.

D. Apply neoprene-modified asphalt adhesive to cold setting bed by squeegeeing or troweling to a uniform thickness of 1/16 IN. Proceed with setting of paving units only after adhesive is tacky and surface is dry to touch.

E. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface. Protect newly laid pavers with plywood panels on which workers can stand. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of pavers. If additional leveling of paving is required, and before treating joints, roll paving with power roller after sufficient heat has built up in the surface from several days of hot weather.
   1. Pavers shall be rolled or compacted to achieve full bond with the setting bed, reduce lippage and improve the overall flatness of the surface. See Brick Industry Association Note 14B (page 11) and Flexible Vehicular Brick Paving Guide (page 36). Protect pavers by using a rubber roller or a 4-5,000 LBF plate tamper with a protective mat attached.

F. Joint Treatment: Place unit pavers with 1/16 IN to 3/16 IN joints or as indicated by unit paver manufacturer. Fill joints by sweeping polymeric sand over paved surface until joints are filled. Remove excess sand after joints are filled. Contractor shall comply with manufacturers recommendations for laying polymeric sand between joints.

3.5 MORTAR SETTING-BED APPLICATIONS

A. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.

B. Apply mortar-bed bond coat over surface of concrete subbase about 15 minutes before placing mortar bed. Do not exceed 1/16 IN thickness for bond coat. Limit area of bond coat to avoid its drying out before placing setting bed.

C. Apply mortar bed over bond coat; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.

D. Place pavers before initial set of cement occurs. Immediately before placing pavers on mortar bed, apply uniform 1/16 IN thick bond coat to mortar bed or to back of each paver with a flat trowel.

E. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.

F. Spaced Joint Widths: As recommended by the manufacturer.

G. Grouted Joints: Grout paver joints complying with ANSI A108.10.

H. Grout joints as soon as possible after initial set of setting bed.
   1. Force grout into joints, taking care not to smear grout on adjoining surfaces.
   2. Clean pavers as grouting progresses by dry brushing or rubbing with dry burlap to remove smears before tooling joints.
   3. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.
   4. If tooling squeezes grout from joints, remove excess grout and smears by dry brushing or rubbing with dry burlap and tool joints again to produce a uniform appearance.

I. Cure grout by maintaining in a damp condition for seven days unless otherwise recommended by grout or liquid-latex manufacturer.

3.6 REPAIRING, POINTING, AND CLEANING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

END OF SECTION

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SECTION 32 14 13

PERMEABLE INTERLOCKING CONCRETE UNIT PAVEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Permeable Articulating Concrete Block (P-ACB)
   2. Open-Graded Aggregate Sub-Base
   3. Transition and Edge Restraints
   4. Geosynthetics

B. Related Sections:
   1. Section 31 20 00 – Earth Moving

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM)
   1. ASTM C33 – Standard Specification for Concrete Aggregates
   2. ASTM D75 – Standard Practice for Sampling Aggregates
   3. ASTM C136 – Standard Test Method for Sieve Analysis for Fine and Coarse Aggregate
   4. ASTM C140 – Methods of Sampling and Testing Concrete Masonry and Related Units
   5. ASTM C150 – Standard Specification for Portland Cement
   6. ASTM D448 – Standard Classification for Sizes of Aggregate for Road and Bridge Construction
   7. ASTM C618 – Standard Specification for Coal Fly Ash for Use in Concrete
   8. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
   9. ASTM C1781 – Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement System
   10. ASTM D6684 – Standard Specification for Materials and Manufacture of Articulating Concrete Block (ACB)

B. American Association of State Highway and Transportation Office (AASHTO) H-20, HS-20, HS-25 – Highway Truck Load Rating

C. PaveDrain Installation Manual

D. PaveDrain Maintenance Manual

1.3 SCOPE OF WORK

A. The Contractor shall furnish all labor, materials, equipment, and incidentals required per Manufacturers' Installation Manual.

B. The Contractor shall perform all operations in connection with the installation of the P- ACB's in accordance with the aggregates, grades, design and dimensions shown on the Contract Documents, manufacturers' installation manual and specified herein.

1.4 SUBMITTALS

A. Refer to Section 01 33 00 – Submittal Procedures

B. Shop Drawings: Submit design details, unit details, cross-sections and layouts as per Contract Documents to Engineer of Record (EOR).

C. Samples:
   1. Natural Gray: Submit one (1) full-sized P-ACB sample.

2. Color: Submit 4 IN x 4 IN samples representative of color(s) selected within this specification or noted on Contract Documents
3. Minimum 3 LB samples of proposed subbase &/or base aggregate materials.

D. Geosynthetic: Submit product data sheet(s) and test reports for geosynthetic(s) proposed for use by EOR within this specification or on Contract Documents.

E. Submit to the EOR manufacturers' printed installation manual, literature, layout drawings, and product specifications.

F. Certification of Compliance
1. Test Reports – Indicate compliance with requirements of Contract Documents including:
   a. P-ACB unit compressive strength, moisture content and density on like units, tested in accordance to ASTM C140 by independent laboratory per unit requirements of ASTM D6684, Table 1.
   b. Sieve analysis of all aggregate grades indicated in Contract Documents, sampled according to ASTM D75 and tested in accordance to ASTM C136.
   c. Specified standard sizes of coarse aggregates shall comply with sizes given in accordance to ASTM D448, Table 1.
2. Performance Compliance – Indicate compliance with requirements of Contract Documents including:
   a. Infiltration Performance – Submit independent laboratory test report indicating in-place infiltration performance of: Average of three (3) tests of one thousand (1,000) inches per hour (in/hr.). Test shall be performed in accordance to ASTM C1781 or C1701 and based on an outdoor working surface with typical base material and installation.
   b. Structural Performance - Design of the P-ACB shall be capable of supporting AASHTO H-20, HS-20 and HS-25 truck loading with proper subgrade and base installation. The P-ACB's shall be analyzed as unreinforced concrete arches supporting a uniform truck tire load with impact per AASHTO standards as tested by an independent laboratory.
   c. Maintainability – Provide maintenance study based on at least 24 months by an independent or third party representative which includes pre and post infiltration testing documentation in multiple locations in accordance with ASTM C1781 or C1701. The study shall show that after manufacturers' recommended maintenance that the original infiltration performance of the permeable system can effectively be restored to 80 percent +/- 10 percent of initial infiltration rates.

G. Substitutions
1. No material shall be considered as an equivalent to the P-ACB specified herein unless it meets all areas of this specification without exception.
2. Manufacturer's requesting to submit materials as equivalent must provide records, data, independent laboratory test results, samples, certifications, and documentation meeting all areas of this specification without exception. Any requests must be submitted to Architect.

1.5 SCHEDULING

A. Contractor shall contact P-ACB manufacturer to determine necessary lead time to produce unit material order.

B. Schedule manufacture and delivery of P-ACB's to coincide with construction schedule to prevent storage for extended periods.

C. Approximately two (2) weeks prior to the start of the installation, a preconstruction meeting shall occur with representative(s) from the design team, general contractor, site contractor, installation contractor and manufacturers' representative.

1.6 DELIVERY, STORAGE AND HANDLING

A. P-ACB individual blocks must be delivered on wooden pallets and marked accordingly.

B. All P-ACB's shall be sound and free of defects that would interfere with proper placement or that would impair the strength of longevity of the installation.

C. Minor cracks incidental to the usual method of manufacture; scuffing or chipping that results from customary methods of handling in shipping, delivery and placement shall not be deemed grounds for rejection.

PART 2 - PRODUCTS

2.1 MANUFACTURED PERMEABLE ARTICULATING CONCRETE BLOCK (P-ACB)

A. PaveDrain® P-ACB
1. 1. Color(s): Provide sample of color selection by Architect.
2. Type: Closed-cell pre-manufactured individual concrete blocks with an arched storage chamber for additional stormwater runoff capacities as per shop drawings &/or Contract Documents. Blocks may be hand-placed or mechanically installed.
3. Physical and Performance Requirements: At the time of delivery to the work site, the units shall conform to the requirements prescribed in Table 1 below.

TABLE 1: PHYSICAL & PERFORMANCE CHARACTERISTICS

Item	Description	Values
Dimensional Tolerance	Length x Width x Height ASTM D6684 Section 5.3.2	12" x 12" x 5.65" (+/- 1/8")
Compressive Strength	ASTM D6684 / ASTM C140	Avg. of three units: 4,000 psi min. Individual units: 3,500 psi min.
Block Unit Weight		Arched Block: 45-50 lbs/sf Solid Block: 55-60 lbs/sf
Loading Capabilities	Truck Load Traffic Rating	AASHTO H-20,HS-20, HS-25
Joint Filler Between Blocks	Material Used	NONE Required
Percent Open Space		Surface: 7% Storage: 20%
Water Absorption (Max. %) Density (Min. lb/ft3)	ASTM D6684 Table 1/ ASTM C140	Avg. of three units: 9.1% lb/ft3 Individual units: 11.7% lb/ft3 Avg. of three units: 130 lb/ft3 Individual units: 125 lb/ft3
Storage Capacity	Above Aggregate Within Arch	0.0833 cf/block
Post-Installation, Verified Surface Infiltration Rates	ASTM C1781 Test Method	Avg. of three tests: 1,000 in/hr min.

B. Acceptable manufacturers and distribution partners:
1. Local – PaveDrain, LLC. (888) 575-5339, info@pavedrain.com www.pavedrain.com
2. National – PaveDrain, LLC. (888) 575-5339, info@pavedrain.com www.pavedrain.com
3. Manufacturer – PaveDrain, LLC. (888) 575-5339, info@pavedrain.com www.pavedrain.com

2.2 AGGREGATE MATERIALS

A. Open-Graded Coarse Aggregate: Select coarse aggregate shall be clean material free from organic materials and angular on all sides. Select coarse aggregate shall meet the gradations that are listed in Table 1 of ASTM D448 and based on sieve analysis in accordance to ASTM C136. Recycled aggregate material is NOT allowed within the top 4 - 6 IN elevation directly contacting the bottom of the PaveDrain units.

1. Base Course Aggregate: ASTM Grade #57 stone shall be used as the finish (top) 4 - 6 IN layer of stone directly underneath the PaveDrain units.
2. Secondary Sub-base Aggregate: ASTM Grade #2, #3 or #4 as determined by engineer of record, thickness as indicated by cross-sections on the shop drawings &/or Contract Documents.

2.3 TRANSITION AND EDGE RETRAINTS

A. Transition: Utilize PaveDrain end block, solid block and half block shapes to make smooth transitions with curbs and other rigid surfaces as per shop drawings &/or Contract Documents.

B. Edge Restraint: Type and dimensions shall be indicated by EOR as per shop drawings &/or Contract Documents.

2.4 GEOSYNTHETIC MATERIALS

A. Geotextile: Mirafi RS380i (or approved equal), a high strength, high water flow, woven monofilament or multifilament geotextile as specified by EOR based on native soil properties.

B. Geogrid: Tensar BX-1100 (or approved equal) as specified by EOR based on native soil properties.

PART 3 - EXECUTION

3.1 EXAMINATION AND INSPECTION

A. The contractor shall verify that the subgrade has been excavated, shaped, stabilized and compacted in accordance to the contract specifications and conforms to the lines, grades and cross-sections shown on Contract Documents.

B. Verify that native subgrade has been compacted to a maximum of 95 percent Modified Proctor in accordance to ASTM D 1557. Do not over over-compact or rut native subgrade.

C. Immediately prior to placing the PaveDrain units, the final prepared sub-base aggregate shall be inspected by the EOR and witness to a proof roll test by a fully loaded dump truck. Unsatisfactory conditions must be corrected prior to installation of the PaveDrain units.

3.2 GEOSYNTHETIC INSTALLATION

A. Geotextile: The contractor shall place Mirafi RS380i (or approved equal) woven monofilament or multifilament geotextile vertical sections of base aggregate free of wrinkles and overlapping a minimum of twelve (12) inches. No geotextile shall be placed horizontally on the subgrade or within the pave section.

B. Geogrid: Install Tensar BX-1100 (or approved equal) directly on top of properly prepared and leveled final aggregate base.

3.3 AGGREGATE SUB BASE INSTALLATION

A. The thickness of the sub-base, requirement of multiple gradations of open-graded coarse aggregate and intermediate geosynthetic shall be indicated by the EOR and detailed on the Contract Documents. The minimum thickness of open-graded coarse aggregate is six (6) inches. If more than six (6) inches of base aggregate is required, only the top four to six (4-6) inches shall be ASTM Grade #57.

B. All base aggregates shall be compacted in six to eight (6 - 8 IN) inch lifts will a roller compactor and final grade level compacted with a minimum 10,000 LB vibratory plate compactor in with at least two passes in both the perpendicular and parallel directions. Open-graded base aggregate installation shall not damage or dislodge the geotextile.
   1. When using multiple aggregate layers including ASTM #2, #3 or #4, the contractor shall compact a 2 IN layer of ASTM #57 into the ASTM #2, #3 or #4.

C. Finished grade shall be a smooth, plane surface with no sign of movement and conform to the lines, grades and cross-sections shown on Contract Documents.

3.4 PAVEDRAIN PERMEABLE ARTICULATING CONCRETE BLOCK INSTALLATION

A. Refer to: PaveDrain Installation Manual (latest edition)

3.5 HAND OR MECHANICAL PLACING PAVEDRAIN UNITS

A. The contractor shall determine the best starting point of the PaveDrain unit installation to conform to the lines, grades and elevations shown on the Contract Documents.

B. Place PaveDrain units tight together in running bond pattern such that one unit is directly in contact with one half of the two adjacent units. Place units in such a manner as to ensure that the pattern remains square to curbs, transitions or adjacent pavements.

C. Verify that each PaveDrain unit makes contact with the geogrid or open-graded aggregate sub-base and is tightly engaged with adjacent units.

D. When necessary, make partial units from saw cutting solid, arch-less PaveDrain units. Transitions against curbs and other rigid pavements should be made with maximum one-half (1/2) inch gaps utilizing solid, end and half PaveDrain units.

3.6 ADJUSTMENTS

A. Minor adjustments to properly engage PaveDrain units shall be made with a dead blow hammer or rubber mallet.

B. Once all PaveDrain units have been installed, minor differential heights between units can be corrected with a small non-vibratory single or double barrel roller compactor or vibratory plate compactor. When using plate compactor, protect units with nonwoven geotextile or mat to eliminate scuffing.

C. Inspect completed installation and replace any cracked or damaged units.

3.7 TOLERANCES

A. No individual PaveDrain unit shall protrude more than one-quarter (1/4) inch within the plane of final placed units/mats.

B. No gap between the individual PaveDrain units shall exceed one-half (1/2) inch.

3.8 FINISHING

A. The joints between the PaveDrain units DO NOT require backfilling with smaller aggregate joint material or sand in order to function properly. The joints are designed to be left open; this includes following maintenance of the PaveDrain system.

3.9 POST INSTALLATION CERTIFICATION

A. Upon completion of the PaveDrain installation, the surface infiltration rate of the permeable pavement area shall be verified in accordance with ASTM C1781 or C1701 to confirm the required infiltration rate as per Table 1 in this specification.

B. If the system fails to perform as required in Table 1 of this specification, it shall be removed and replaced at the supplier’s expense.

C. The expenses associated with this post installation infiltration verification are included in the cost of the permeable system and provided by the supplier.

3.10 INSPECTION AND MAINTENANCE OF P-ACB SYSTEM

A. Refer to: PaveDrain Maintenance Manual (latest edition)

B. Maintenance shall be required when either of the following two conditions are met:
   1. The surface infiltration rates of more than 75 percent of the total permeable surface falls below 10 percent of the rate required in Table 1.
   2. Surface ponding remains for 24 hours in an area greater than 10 square feet of the permeable surface.

END OF SECTION

SECTION 32 17 26
TACTILE WARNING SURFACING

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. Detectable warning unit pavers.

B. Related Requirements:
   1. Section 03 05 00 "Concrete" for concrete walkways serving as substrates for tactile warning surfacing.
   2. Section 32 14 00 "Unit Paving" for unit paving installations incorporating detectable warning unit pavers specified in this Section.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples for Initial Selection: For each type of exposed finish requiring color selection.

C. Samples for Verification: For each type of tactile warning surface, in manufacturer's standard sizes unless otherwise indicated, showing edge condition, truncated-dome pattern, texture, color, and cross section; with fasteners and anchors.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For tactile warning surfacing, to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
   1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference as indicated by the Owner.

1.7 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

B. Weather Limitations for Adhesive Application:
   1. Apply adhesive only when ambient temperature is above 50 DEGF and when temperature has not been below 35 DEGF for 12 hours immediately before application. Do not apply when substrate is wet or contains excess moisture.

C. Weather Limitations for Mortar and Grout:
   1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.

2. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602. Provide artificial shade and windbreaks, and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 DEGF and higher.
   a. When ambient temperature exceeds 100 DEGF, or when wind velocity exceeds 8 mph and ambient temperature exceeds 90 DEGF, set unit pavers within 1 minute of spreading setting-bed mortar.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of tactile warning surfaces that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Deterioration of finishes beyond normal weathering and wear.
      b. Separation or delamination of materials and components.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TACTILE WARNING SURFACING, GENERAL

A. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1 for tactile warning surfaces.
   1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

B. Source Limitations: Obtain each type of tactile warning surfacing, anchor, and fastener from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 DETECTABLE WARNING UNIT PAVERS

A. Detectable Warning Concrete Unit Pavers: Solid paving units, made from normal-weight concrete with a compressive strength of not less than 5000 psi, water absorption of not more than 5 percent according to ASTM C 140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67, with accessible detectable warning truncated domes on exposed surface of units.
   1. Manufacturer: Whitacre Greer
      1400 S. Mahoning Avenue
      Alliance, OH 44601
   2. Shapes and Sizes:
      a. Thickness: 2-1/4 IN at field of tile.
      b. Face Size: Nominal 4 IN by 8 IN.
   3. Dome Spacing and Configuration: Manufacturer's standard compliant spacing, in manufacturer's standard pattern.
   4. Color: As selected by Architect from manufacturer's full range.

B. Setting Bed: Comply with requirements in Section 32 14 00 "Unit Paving."

C. Aggregate Setting Bed:
   1. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D 448 for Size No. 8.
   2. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33/C 33M for fine aggregate.
   3. Sand for Joints: Polymeric Sand. Comply with requirements in Section 32 14 00 "Unit Paving.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions. Verify that installation of tactile warning surfacing will comply with accessibility requirements upon completion.

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

3.2 INSTALLATION OF TACTILE WARNING SURFACING

A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.

B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

3.3 INSTALLATION OF DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles:
1. Concrete Paving Installation: Comply with installation requirements in Section 32 13 13 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of tile.
2. Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8 IN from flush.
4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
5. Clean tiles using methods recommended in writing by manufacturer.

B. Removable Cast-in-Place Detectable Warning Tiles:
1. Concrete Paving Installation: Comply with installation requirements in Section 32 13 13 "Concrete Paving." Mix, place, and finish concrete to conditions complying with detectable warning tile manufacturer's written requirements for satisfactory embedment of removable tile.
2. Set each detectable warning tile accurately and firmly in place with embedding anchors and fasteners attached, and firmly seat tile back in wet concrete by tamping or vibrating. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
3. Set surface of tile flush with surrounding concrete and adjacent tiles, with variations between tiles and between concrete and tiles not exceeding plus or minus 1/8 IN from flush.
4. Protect exposed surfaces of installed tiles from contact with wet concrete. Complete finishing of concrete paving surrounding tiles. Remove concrete from tile surfaces.
5. Clean tiles using methods recommended in writing by manufacturer.

C. Surface-Applied Detectable Warning Tiles:
1. Lay out detectable warning tiles as indicated and mark concrete pavement.
2. Prepare existing paving surface by grinding and cleaning as recommended by manufacturer.
   a. Cut perimeter kerf in existing concrete pavement to receive metal tile flange.
3. Apply adhesive to back of tiles in amounts and pattern recommended by manufacturer, and set tiles in place. Firmly seat tiles in adhesive bed, eliminating air pockets and establishing full adhesion to pavement. If necessary, temporarily apply weight to tiles to ensure full contact with concrete.
4. Install anchor devices through face of tiles and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with top surface of mat.
5. Mask perimeter of tiles and adjacent concrete, and apply sealant in continuous bead around perimeter of tile installation.

6. Remove masking, adhesive, excess sealant, and soil from exposed surfaces of detectable warning tiles and surrounding concrete pavement using cleaning agents recommended in writing by manufacturer.
7. Protect installed tiles from traffic until adhesive has set.

3.4 INSTALLATION OF DETECTABLE WARNING MATS

A. Lay out detectable warning mats as indicated and mark concrete pavement at edges of mats.

B. Prepare existing paving surface by grinding and cleaning as recommended by manufacturer.

C. Apply adhesive to back of mat in amounts and pattern recommended by manufacturer, and set mat in place. Firmly seat mat in adhesive bed, eliminating air pockets and establishing full adhesion to pavement. If necessary, temporarily apply weight to mat to ensure full contact with adhesive.

D. Install anchor devices through face of mat and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with mat surface.

E. Mask mat perimeter and adjacent concrete, and apply sealant in continuous bead around perimeter of mat.

F. Remove masking, adhesive, excess sealant, and soil from exposed surfaces of detectable warning mat and surrounding concrete pavement using cleaning agents recommended in writing by manufacturer.

G. Protect installed mat from traffic until adhesive has set.

3.5 INSTALLATION OF DETECTABLE WARNING UNIT PAVERS

A. Unit Paver Installation, General:
1. Setting-Bed and Unit Paver Installation: Comply with installation requirements in Section 32 14 00 "Unit Paving."
2. Mix unit pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
3. Cut unit pavers with motor-driven masonry saw equipment to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible.
4. Tolerances: Do not exceed 1/4 IN in 10 FT from level, or indicated slope, for finished surface of paving.

B. Aggregate Setting-Bed Applications:
1. Place aggregate base, compact by tamping with plate vibrator, and screed to depth indicated.
2. Place leveling course and screed to a thickness of 1 to 1-1/2 IN, taking care that moisture content remains constant and density is loose and uniform until unit pavers are set and compacted.
3. Treat leveling course with herbicide to inhibit growth of grass and weeds.
4. Set unit pavers with a minimum joint width of 1/16 IN and a maximum of 1/8 IN, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines.
5. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000 LBF compaction force at 80 to 90 Hz.
6. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.

3.6 CLEANING AND PROTECTION

A. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.

B. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION

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SECTION 32 31 13
CHAIN LINK 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. Chain-link fences.
   2. Swing gates.

B. Related Requirements:
   1. Section 03 30 53 "Miscellaneous Cast-in-Place Concrete" for cast-in-place concrete.
   2. ARMY FIELD MANUAL 3-19.30 "Physical Security"
   3. OPNAVINST 5530.14C. “Navy Physical Security”
   4. FEDERAL SPECIFICATION SHEET RR-F-191K/2D, 14 May 1990, Subj: Fencing, Wire and Post Metal (Chain-Link Fence Gates)
   5. PROTECTION OF ASSETS MANUAL, Chapter 3, Part 3 “Chain Link Fencing” 2004

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project Site.
   1. Review sequence of operation for each type of gate operator.
   2. Review coordination of interlocked equipment specified in this Section and elsewhere.
   3. Review required testing, inspecting, and certifying procedures.
   4. All new fencing will require approval from the Security Office prior to construction.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
      a. Fence and gate posts, rails, and fittings.
      b. Chain-link fabric, reinforcements, and attachments.
      c. Accessories: Barbed wire.
      d. Gates and hardware.

B. Shop Drawings: For each type of fence and gate assembly.
   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include accessories, hardware, gate operation, and operational clearances.

C. Samples for Initial Selection: For each type of factory-applied finish.

D. Delegated-Design Submittal: For structural performance of chain-link fence and gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For fence installer.

B. Product Certificates: For each type of chain-link fence and gate.

C. Product Test Reports: For framework strength according to ASTM F 1043, for tests performed by qualified testing agency.

D. Field quality-control reports.

E. Sample Warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gate operators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

B. The contractor shall layout the fence lines in accordance with drawings and sketches provided by APL and their consultants.

C. The contractor shall establish the fence alignment with stakes and flags. The stakes shall be at a suitable off set from every corner post and flags installed not greater than every 50 FT along a tangent section and at every other post on a curved section.

D. The fence alignment will be marked in the field as indicated above. APL shall have one week to review the alignment prior to any construction. This requirement does not remove the responsibility from the contractor for providing an accurate alignment. The contractor shall not start construction prior to receiving specific approval from APL.

1.9 WARRANTY

A. Special Warranty: Installer to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Failure to comply with performance requirements.
      b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, to design chain-link fence and gate frameworks.

B. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to ASCE/SEI 7.

C. Lightning Protection System: Maximum resistance-to-ground value of 25 ohms at each grounding location along fence under normal dry conditions.

D. Fence shall be 84 IN high with a 12 IN barbed wire top guard angled outward at 45 degrees.

E. Barbed wire shall consist of 3 strands of 12 gauge (0.106 IN) galvanized steel wire with 4-point barbs spaced not more than 5 IN apart. One wire should be interlaced vertically midway between posts.

F. Chain link mesh must reach within 2 IN of hard ground or pavement.

G. Chain link mesh shall be twisted and barbed at top and bottom.

H. All fencing parts, (nuts, bolts, etc.) will be tack-welded as appropriate to preclude or to display evidence of any surreptitious entry attempts.

I. Any fencing adjacent to structures must be installed in such a manner that the fencing posts butt against the structure forming a secure barrier to entry.

J. The number of gates and perimeter entrances shall be the minimum required for safe and efficient operation of the Laboratory.

K. When closed, gates must provide a barrier structurally comparable to the associated fencing.

L. Temporary fencing refers to any fencing structure erected for a maximum period of 5 days or less.

M. Temporary Fencing
   1. Any temporary fencing shall meet the included technical specifications, with the exception that the concrete footing will not need to extend below finished grade.
   2. Temporary fencing will require concrete footers that stabilize the fencing and maintain the integrity of the security perimeter at all times.

N. Every fence post shall be imbedded in a concrete footing. The footing shall be 3 times the post outer diameter or 1-foot diameter whichever is greater and shall extend a minimum of 36 IN below finish grade. Each base shall be crowned at least 1/2 IN.

O. All installation procedures shall meet the manufacture's recommended standards.

P. Any nicks or mars in the fence or any of its components shall be field repaired in accordance with the manufactures recommendation.

2.2 CHAIN-LINK FENCE FABRIC

A. General: Steel chain link fence fabric:
   1. Mesh and wire size: 2 IN mesh, 0.148 IN diameter. zinc-coated fabric: ASTM A-392, with zinc coating applied to steel wire before weaving according to ASTM 817, Type A II, zinc coated (galvanized) with the following minimum coating weight: Class 2; not less than 2 OZ/SQFT.

2.3 FENCE FRAMING

A. Round steel pipe: standard weight, schedule 40, galvanized steel pipe complying with ASTM F 1083. Comply with ASTM F 1043, material design group IA, external and internal coating Type A, consisting of not less than 1.8 OZ/SQFT zinc; and the following strength and stiffness requirements:
   1. Line end, corner, and pull posts and top rail: per manufacturer's requirements for heavy industrial fence.
   2. Top rail: fabricate top rail from lengths 21 FT or longer, with swedged-end or fabricated for expansion-type coupling, forming a continuous rail along top of chain link fabric. Line post selection based on wind speed is described in CLFMI WLG 2445.

2.4 TENSION WIRE

A. General: provide horizontal tension wire extended along bottom of fence fabric. Metallic coated steel wire: coating Type II, zinc coated (galvanized) by the hot-dip process matching chain link fabric coating weight.

2.5 SWING GATES

A. General: comply with ASTM F 900 for the following swing-gate types:
   1. Single gate
   2. Double gate

B. Metallic pipe and tubing: galvanized steel. Comply with ASTM F 1083 and ASTM F-1043 for materials and protective coatings.
   1. Frames and bracing: fabricate members from round galvanized steel tubing with outside dimension and weight according to ASTM F 900 for gate fabric more than 6 FT height. Frame corner construction: welded.
   2. Gate posts: fabricate members from round galvanized steel pipe with outside dimension and weight according to ASTM F 900 for gate fabric and leaf widths as indicated.

2.6 FITTINGS

A. Provide fittings according to ASTM F 626.

B. Post Caps: Provide for each post.
   1. Provide line post caps with loop to receive tension wire or top rail.

C. Rail and Brace Ends: For each gate, corner, pull, and end post.

D. Rail Fittings: Provide the following:
   1. Top Rail Sleeves: Round-steel tubing.
   2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails to posts.

E. Tension and Brace Bands: Steel.

F. Tension Bars: Steel, length not less than 2 IN shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.

G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading, rod and turnbuckle or other means of adjustment.

H. Barbed Wire Arms: Steel, with clips, slots, or other means for attaching strands of barbed wire, integral with post cap, for each post unless otherwise indicated, and as follows:
   1. Provide line posts with arms that accommodate top rail or tension wire.
   2. Provide corner arms at fence corner posts unless extended posts are indicated.
   3. Single-Arm Type: Type I, slanted arm
   4. Double-Arm Type: V-shaped arm

I. Tie Wires, Clips, and Fasteners: According to ASTM F 626.
   1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, according to the following:
      a. Hot-Dip Galvanized Steel: 0.148 IN diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric.

2.7 BARBED WIRE

A. Three-strands, outboard zinc-coated steel barbed wire: comply with ASTM A-121, standard grade for the standard size (0.099 IN diameter line wire with 0.080 IN diameter, 4 point round barbs spaced not more than 5 IN o.c.)

2.8 ANCHORING CEMENT

A. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

B. Every fence post shall be imbedded in a concrete footing. The footing shall be 3 times the post outer diameter or 1-foot diameter whichever is greater and shall extend a minimum of 36 IN below finish grade. Each base shall be crowned at least 1/2

2.9 GROUNDING

A. Fence grounding:
1. Conductors: bare, solid wire for no. 6 awg and smaller; stranded wire for no. 4 awg and larger.
2. Material on or below finished grade: copper.
3. Bonding jumpers: braided copper tape, 1 IN wide, woven of no. 30 awg bare copper wire, terminated with copper ferrules.
4. Connectors and ground rods: listed in UL 467.
5. Connectors for below-grade use: exothermic welded type.
6. Ground rods: copper-clad steel.
7. Size: 5/8 IN by 96 IN.

B. Grounding and bonding.
1. Fence grounding: install at maximum intervals of 500 FT except as follows:
    a. Fences within 100 FT of buildings, structures, walkways, and roadways: ground at maximum intervals of 500 FT.
    b. Gates and other fence openings: ground fence on each side of opening.
    c. Bond metal gates to gate posts. Bond across openings, with gates. Use no. 2 awg wire and bury it at least 18 IN below finished grade.
    d. Protection at crossings of overhead electrical power lines: ground fence at location of crossing and at a maximum distance of 150 FT on each side of crossing
2. Grounding method: at each grounding location, drive a ground rod vertically until the top is 6 IN below finished grade. Connect rod to fence with no. 6 awg conductor. Connect conductor to each fence component at the grounding location, including the following:
    a. Each barbed wire strand. Make grounding connections to barbed wire with wire-to-wire connectors designed for this purpose.
    b. Bonding method for gates: connect bonding jumper between gate post and gate frame.
    c. 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 will be galvanically compatible.
    d. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
    e. Make connections with clean, bare metal at points of contact.
    f. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
1. Do not begin installation before final grading is completed unless otherwise permitted by Engineer.

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

3.2 PREPARATION

A. The contractor shall exercise care while working on the project. The area of the project is open to APL staff and other contractor personnel, therefore contractor shall ensure that the work site is safe for vehicle and pedestrian traffic at all times.

B. The contractor shall layout the fence lines in accordance with drawings and sketches provided by APL and their consultants.

C. The contractor shall establish the fence alignment with stakes and flags. The stakes shall be at a suitable off set from every corner post and flags installed not greater than every 50 FT along a tangent section and at every other post on a curved section.

D. The fence alignment will be marked in the field as indicated above. APL shall have one week to review the alignment prior to any construction. This requirement does not remove the responsibility from the contractor for providing an accurate alignment. The contractor shall not start construction prior to receiving specific approval from APL.

3.3 CHAIN-LINK FENCE INSTALLATION

A. Install chain-link fencing according to ASTM F 567 and more stringent requirements specified.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

C. 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 to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
      a. Concrete: Place top of concrete at grade. Each base shall be crowned at least 1/2 IN.

D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more. For runs exceeding 500 FT, space pull posts an equal distance between corner or end posts.

E. Line Posts: Space line posts uniformly at 10 FT o.c.

F. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
   1. Locate horizontal braces at midheight of fabric.

G. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fence posts. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120 IN diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 IN o.c. Install tension wire in locations indicated by manufacture before stretching fabric. Provide horizontal tension wire at the following locations:
   1. Extended along top and bottom of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within 6 IN of bottom of fabric and tie to each post with not less than same diameter and type of wire.
   2. Extended along top of barbed wire arms and top of fence fabric.

H. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

I. Intermediate and Bottom Rails: Secure to posts with fittings.

J. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave no more than 2 IN bottom clearance between finish grade or surface and bottom selvage. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

K. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts, with tension bands spaced not more than 15 IN o.c.

L. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric according to ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
   1. Maximum Spacing: Tie fabric to line posts at 12 IN o.c. and to braces at 24 IN o.c.

M. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. All fencing parts, (nuts, bolts, etc.) will be tack-welded as appropriate to preclude or to display evidence of any surreptitious entry attempts.

N. Barbed Wire: Install barbed wire uniformly spaced, angled outward. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.

3.4 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation. All fencing parts, (nuts, bolts, etc.) will be tack-welded as appropriate to preclude or to display evidence of any surreptitious entry attempts.

3.5 GROUNDING AND BONDING

A. Fence and Gate Grounding:
   1. Ground for fence and fence posts shall be a separate system from ground for gate and gate posts.
   2. Ground fence on each side of gates and other fence openings.
      a. Bond metal gates to gate posts.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a ground rod located a maximum distance of 150 FT on each side of crossing.

C. Connections:
   1. Make connections with clean, bare metal at points of contact.
   2. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
   3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   4. Make above-grade ground connections with mechanical fasteners.
   5. Make below-grade ground connections with exothermic welds.
   6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.6 FIELD QUALITY CONTROL

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

B. Prepare test reports.

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. Lubricate hardware and other moving parts.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION

SECTION 32 32 23
SEGMENTAL RETAINING WALLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes segmental retaining walls with soil reinforcement. Work shall consist of designing, furnishing and constructing a Segmental Concrete Retaining Wall System using geogrid reinforcement and modular blocks in accordance with AASHTO guidelines, these specifications and in compliance with the lines, grades, dimensions and details shown on the project plans and as directed by the Engineer.

B. Work includes preparing foundation soil, furnishing and installing leveling pad, modular blocks, unit drainage fill, geogrid soil reinforcement, backfill and required incidental materials to the lines and grades shown on the Contract Drawings.

C. Related Sections:
1. Section 03 30 53 "Miscellaneous Cast-in-Place Concrete" for segmental retaining wall leveling pads.
2. Section 31 20 00 "Earth Moving" for excavation for segmental retaining walls.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design segmental retaining walls, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Engineering design shall be based on the following loads and be in accordance with the AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014 with all Interim Revisions.
1. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
2. Superimposed loads (surcharge) equal to a minimum of 2-ft of equivalent earth fill, per AASHTO LRFD.
3. Structural loads as indicated on the plans.

C. Seismic Performance: Engineering design shall be based on the following loads and factors and be according to AASHTO LRFD.
1. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
2. Superimposed loads (surcharge) equal to a minimum of 2-ft of equivalent earth fill, per AASHTO LRFD.
3. Structural loads as indicated on the plans.
4. Horizontal Peak Ground Acceleration (A) as defined in AASHTO LRFD.

D. Design Life: All components of the segmental block retaining wall system, including modular units and geogrid reinforcement, shall be designed for a minimum service life of 75 years.

1.4 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:
1. Test soil reinforcement and backfill materials for pullout resistance according to ASTM D 6706.

2. Test soil reinforcement and backfill materials for coefficient of friction according to ASTM D 5321.

1.5 ACTION SUBMITTALS

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

B. Samples for Initial Selection: For concrete units.

C. Samples for Verification: For each color and texture of concrete unit required. Submit full-size units.
   1. Include one full-size unit for each type of concrete unit required.

D. Delegated-Design Submittal: For segmental retaining walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.

E. Contractor shall submit construction drawings and design calculations for the retaining wall system prepared and stamped by a Professional Engineer registered in the State of Maryland. The engineering designs, techniques, and material evaluations shall be in accordance with the Manufacturer's Design Manual and the AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014 with all Interim Revisions.

F. The Contractor shall submit complete working drawings and specifications for each installation of the system in accordance with the requirements of this section. Submitted shop drawings shall include, but are not limited to the following:
   1. A plan view of the walls identifying beginning and end of each wall and relevant offsets and stations for wall alignment.
   2. Elevation views of walls that depict existing and finish grade profiles both behind and in front of the wall, bottom and top of wall elevations, subfoundation and leveling pad, reinforcement type, length, and locations.
   3. Detailed sections of each wall at each design section geometry.
   4. Details of all elements and components of the wall system.
   5. Complete individual details and dimensions for all wall appurtenances, including interface with proposed pipe culverts, guardrail posts, railing posts, coping, drainage pipes, bioswales, other utilities, etc.
   6. Details for constructing walls around utilities and drainage facilities (if applicable).
   7. General notes for constructing the wall including construction sequencing, wall excavation, foundation preparation, wall erection, backfill placement and any other special construction requirements.

G. Comprehensive retaining wall design calculations shall be submitted with the working drawings and prepared in accordance with the AASHTO LRFD Bridge Design Specifications. Referenced FHWA guide documents may be used to supplement AASHTO specifications as required but AASHTO shall govern in case of conflict. To further clarify the design requirements, the following additions and/or clarifications of AASHTO shall apply:
   1. The minimum length of reinforcement shall be as specified on the contract plans or approved shop drawings, regardless of wall height. All reinforcement shall be the same length in a single section.
   2. The required minimum wall embedment is 2 FT as measured from the finished ground surface to the bottom of wall or top of leveling pad.
   3. Additional embedment will be required for sloping toes based on providing a 4-ft level bench in front of walls.
   4. The maximum vertical spacing of the soil reinforcement shall be 2.0 FT.
   5. The lowest reinforcement level shall be not more than 12 IN from the bottom of the wall.

6. Extensible reinforcement coverage shall be 100 percent (no gaps) and the facing connection shall connect a minimum of 85 percent of the reinforcement width to the facing units.
7. All connections and related components shall be evaluated strictly in accordance with the AASHTO LRFD Specifications, and long-term sustained load connection testing is required to establish the appropriate reduction factors
8. Maximum concrete water absorption per ASTM C-140 shall be ≤ 7 percent in areas where freeze-thaw testing is not required.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified professional engineer and testing agency.

B. Product Certificates: For segmental retaining wall units and soil reinforcement, from manufacturer.
   1. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.
   2. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.

C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for segmental retaining wall units and soil reinforcement.
   1. Include test data for freeze-thaw durability of segmental retaining wall units.
   2. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.
   3. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.

D. Research/Evaluation Reports.

E. Preconstruction test reports.

F. Source quality-control reports.

G. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects.
   1. Build mockup of segmental retaining wall approximately 72 IN long by not less than 36 IN high above finished grade at front of wall.
      a. Include typical soil reinforcement.
      b. Include typical base and cap or finished top construction.
      c. Include backfill to typical finished grades at both sides of wall.
      d. Include typical end construction at one end of mockup.
      e. Include 36 IN return at 1 end of mockup, with typical corner construction.
   2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

C. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to segmental retaining walls including, but not limited to, the following:
      a. Structural load limitations.
      b. Construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
      c. Field quality-control procedures.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.

B. Contractor shall check all materials upon delivery to ensure that the proper type, grade, color and certification have been received.

C. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 DEGF or below 32 DEGF, and other conditions that might damage them. Verify identification of geosynthetics before using and examine them for defects as material is placed.

PART 2 - PRODUCTS

2.1 SEGMENTAL RETAINING WALL UNITS

A. Concrete Units: ASTM C 1372, Normal Weight, except that maximum water absorption shall not exceed 7 percent by weight and units shall not differ in height more than plus or minus 1/16 IN from specified dimension.
   1. Provide units that comply with requirements for freeze-thaw durability.
   2. Provide units that interlock with courses above and below by means of integral lugs or lips, pins or clips.

B. Color: Per the contract drawings, as selected by Architect from manufacturer's full range.

C. Shape and Texture: Provide units of any basic shape and dimensions that will produce segmental retaining walls of dimensions and profiles indicated without interfering with other elements of the Work and with machine-split textured, flat exposed face.

D. Cap Units: Provide cap units of shape indicated with smooth, as-cast top surfaces without holes or lugs.

E. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces as indicated.

2.2 INSTALLATION MATERIALS

A. Pins: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.

B. Clips: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.

C. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.

D. Leveling Base: Comply with requirements in Section 31 20 00 "Earth Moving" for satisfactory soils.
   1. Leveling Course: Lean concrete with a compressive strength of not more than 500 psi.

E. Drainage Fill: Material must be well-graded compactable aggregate, 0.25 in. to 1.5 in., with no more than 10 percent passing the #200 sieve in accordance with ASTM D422. Material behind and within the segmental wall may be of the same material.

F. Reinforced-Soil Fill: AASHTO No. 57 Stone free of shale or other soft, poor durability particles OR a naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 100 percent passing a No. 4 sieve, not more than 60 percent passing a No. 40 sieve, and not more than 15 percent passing a No. 200 sieve with Plasticity Index not more than 6; AASHTO T 90. The material should exhibit an internal friction of not less than 34-degrees as determined by the standard direct shear test AASHTO T 236 on the portion finer than the No. 10 sieve, using a sample of material compacted to 92 percent of the AASHTO T 180. The materials should be substantially free of shale or other soft, poor durability particles. The material shall have a magnesium sulfate soundness loss of less than 30 percent after four cycles, measured in accordance with AASHTO T 104, or a sodium sulfate loss of less than 15 percent after five cycles determined in accordance with AASHTO T 104. Stone dust shall not be used.

G. Nonreinforced-Soil Fill: Comply with requirements in Section 31 20 00 "Earth Moving" for satisfactory soils.

H. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent.
   1. Apparent Opening Size: No. 70 to 100 sieve, maximum; ASTM D 4751.
   2. Minimum Grab Tensile Strength: 110 lb; ASTM D 4632.
   3. Minimum Weight: 4 oz./sq. yd.

I. Subdrainage Pipe: Prefabricated geocomposite with perforated corrugated core molded from HDPE complying with ASTM D3350 and wrapped in geotextile filter fabric. All fittings shall be HDPE with combination NPS 4 and NPS 6 outlet connection; couplings shall be corrugated HDPE band.

J. Filter Fabric: Polypropylene geotextile.

K. Soil Reinforcement: Product specifically manufactured for use as soil reinforcement.
   1. Geosynthetic reinforcement shall consist of geogrids manufactured specifically for soil reinforcement applications and shall be manufactured from high tenacity polyester yarn or high density polyethylene. Polyester geogrid shall be knitted from high tenacity polyester filament yarn with a molecular weight exceeding 25,000 Meg/m and a carboxyl end group values less than 30. Polyester geogrid shall be coated with an impregnated PVC coating that resists peeling, cracking, and stripping.
   2. Ta, Long Term Allowable Tensile Design Load of the geogrid material, shall be evaluated based upon a 75 year design life and shall be determined as follows:

      Ta = Tult / (RFcr*RFd*RFid*FS)

      Where:

      Tult = Short Term Ultimate Tensile Strength

      Tult is based on the minimum average roll values (MARV)

      RFcr = Reduction Factor for Long Term Tension Creep

      RFcr shall be determined from 10,000 hour creep testing performed in accordance with ASTM D5262. Reduction value = 1.60 minimum.

      RFd = Reduction Factor for Durability

      RFd shall be determined from polymer specific durability testing covering the range of expected soil environments. RFd = 1.10 minimum.

      RFid = Reduction Factor for Installation Damage

RFid shall be determined from product specific construction damage testing performed in accordance with GRI-GG4. Test results shall be provided for each product to be used with project specific or more severe soil type. RFid = 1.10 minimum.

FS = Overall Design Factor of Safety

FS shall be in accordance with AASHTO LRFD requirements.

3. The maximum design tensile load of the geogrid shall not exceed the laboratory tested ultimate strength of the geogrid/facing unit connection as limited by the "Hinge Height" divided by a factor of safety of 1.5. The connection strength testing and computation procedures shall be in accordance with NCMA SRWU-1 Test Method for Determining Connection Strength of SRW.
4. Soil Interaction Coefficient, Ci
    a. Ci values shall be determined per GRI:GG5 at a maximum 0.75 IN displacement.
5. Manufacturing Quality Control
    a. The geogrid manufacturer shall have a manufacturing quality control program that includes QC testing by an independent laboratory.
    b. The QC testing shall include:
        1) Tensile Strength Testing
        2) Melt Flow Index (HDPE)
        3) Molecular Weight (Polyester)

2.3 SOURCE QUALITY CONTROL

A. Direct manufacturer to test and inspect each roll of soil reinforcement at the factory for minimum average roll values for geosynthetic index property tests, including the following:
1. Weight.
2. Roll size.
3. Grab or single-rib strength.
4. Aperture opening.
5. Rib or yarn size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of segmental retaining walls.

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

3.2 RETAINING WALL INSTALLATION

A. Excavation: Contractor shall excavate to the lines and grades shown on the Contract Drawings. Contractor shall use caution not to over-excavate beyond the lines shown, or to disturb the base elevations beyond those shown, unless directed by the Engineer. Contractor shall verify locations of existing structures and utilities prior to excavation and ensure all surrounding structures are protected from the effects of wall excavation.

B. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
1. Lay units in running bond.
2. Form corners and ends by using special units.

C. Leveling Base and Concrete Pad: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight according to ASTM D 698. Top of concrete pad shall be located to allow bottom wall units to be buried to proper depths as per wall heights and specifications.

D. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.
   1. Tamp units into leveling base as necessary to bring tops of units into a level plane.

E. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.
   1. For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.
   2. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.
   3. For units with lips at bottom rear of units, slide units as far forward as possible for firm contact of lips with units below.
   4. For units with pins, install pins and align units.
   5. For units with clips, install clips and align units.

F. Cap Units: Place cap units and secure with cap adhesive.

3.3 FILL PLACEMENT

A. General: Comply with requirements in Section 31 20 00 "Earth Moving", NCMA's "Segmental Retaining Wall Installation Guide," and segmental retaining wall unit manufacturer's written instructions.

B. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.

C. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall and place and spread fills toward embankment.
   1. Use only hand-operated compaction equipment within 48 IN of wall, or one-half of height above bottom of wall, whichever is greater.
   2. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight according to ASTM D 698.
      a. In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight according to ASTM D 698.
      b. In areas where fill height exceeds 15 FT, compact reinforced-soil fill that will be more than 15 FT below finished grade to not less than 98 percent maximum dry unit weight according to ASTM D 698.
   3. Nonreinforced-soil placed underneath the wall footprint and within the zone of influence, defined by a line projected downward at a 45-degree angle from the edge each side of the reinforced-soil zone, shall be placed and compacted in accordance with the requirements for reinforced-soil.
   4. Compact nonreinforced-soil fill outside the zone of influence to comply with Section 31 20 00 "Earth Moving."

D. Place drainage geotextile against back of wall and place layer of drainage fill at least 12 IN wide behind drainage geotextile to within 12 IN of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.

E. Place a layer of drainage fill at least 12 IN wide behind wall to within 12 IN of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.

F. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated, sloped not less than 0.5 percent to drain.

G. Place impervious fill over top edge of drainage fill layer.

H. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at base of wall away from wall. Provide uniform slopes that will prevent ponding.

I. Place soil reinforcement in horizontal joints of retaining wall where indicated and according to soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of 8 IN into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.
   1. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
   2. Place geosynthetics with seams, if any, oriented perpendicular to segmental retaining walls.
   3. Do not dump fill material directly from trucks onto geosynthetics.
   4. Place at least 6 IN of fill over reinforcement before compacting with tracked vehicles or 4 IN before compacting with rubber-tired vehicles.
   5. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.

3.4 CONSTRUCTION TOLERANCES

A. Variation from Level: For bed-joint lines along walls, do not exceed 1-1/4 IN in 10 FT 3 IN maximum.

B. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than 1-1/4 IN in 10 FT.

3.5 FIELD QUALITY CONTROL

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

B. Comply with requirements in Section 31 20 00 "Earth Moving" for field quality control.
   1. In each compacted backfill layer, perform at least 1 field in-place compaction test for each 100 FT or less of segmental retaining wall length. Testing report shall be made available to the Howard County inspector upon completion of construction.
   2. For every 1,000 cubic yards of borrow material, and for each change in borrow source, perform at least 1 grain size distribution and classification test (AASHTO T 88), 1 Atterberg limits test (AASHTO T89 and AASHTO T 90), and one direct shear test (AASHTO T 236) on the portion finer than the No. 10 sieve, using a sample of the material compacted to 95 percent of the AASHTO T 99. No testing is required for backfills with 80 percent of the sizes greater than 3/4 IN.

3.6 ADJUSTING

A. Remove and replace segmental retaining wall construction of the following descriptions:
   1. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if Architect approves methods and results.
   2. Segmental retaining walls that do not match approved Samples and mockups.
   3. Segmental retaining walls that do not comply with other requirements indicated.

B. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

END OF SECTION

SECTION 32 33 00
SITE FURNISHINGS

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. Seating.
2. Tables.
3. Bicycle Racks.
4. Trash/Recycling Receptacles.
5. Surface Mounty and Removable Site Bollards.
6. Bench.
7. Site Handrail.

B. Related Requirements:
1. Section 03 30 00 "Cast-in-Place Concrete" for installing pipe sleeves cast and installing anchor bolts cast in concrete footings.
2. Section 31 20 00 "Earth Moving" for excavation for installing concrete footings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and texture specified.

C. Samples for Initial Selection: For units with factory-applied finishes.

D. Samples for Verification: For each type of exposed finish, not less than 6 IN long linear components and 4 IN square sheet components.

E. Product Schedule: For site furnishings. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Material Certificates: For site furnishings manufactured with preservative-treated wood.
1. Indicate type of preservative used and net amount of preservative retained. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For site furnishings to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Bench Replacement Slats: No fewer than two full-size units for each size indicated.
2. Trash Receptacle Inner Containers: Five full-size units for each size indicated, but no fewer than two units.
3. Anchors: Per manufactures recommendation or specified mounting type.

PART 2 - PRODUCTS

2.1 BENCH (B1)

A. Manufacturer: Modern Design & Site Furnishings, www.mdsfco.com

B. Model: Aviela (1800mm)

C. Finish/ Color: Powder Coated Galvanized Steel, RAL 7022 Umbra Grey, and wood slats.

D. Installation Method: Surface mount.

2.2 BIKE RACK (BR)

A. Manufacturer: Landscapeforms, www.landscapeforms.com

B. Model: Loop Bike Rack

C. Finish/ Color: Submit manufacturer's standard colors to match charcoal grey or RAL 7022 Umbra Grey.

D. Installation Method: Surface mounted.

2.3 LITTER/ RECYCLING RECEPTACLE (LR)

A. Manufacturer: Modern Design & Site Furnishings, www.mdsfco.com

B. Model: Prax 115

C. Finish/ Color: Powder Coated Galvanized Steel, RAL 7022 Umbra Grey, and tropical wood slats.

D. Installation Method: Surface mount.

2.4 SITE BOLLARD (BO)

A. Manufacturer: Modern Design & Site Furnishings, www.mdsfco.com

B. Model: Elias, SE100

C. Finish/ Color: RAL 7022 Umbra Grey

D. Installation Method: Embedded

2.5 SITE BOLLARD (BL)

A. Manufacturer: Modern Design & Site Furnishings, www.mdsfco.com

B. Model: Elias, SE150

C. Finish/Color: RAL 7022 Umbra Grey

D. Installation Method: Removable

2.6 TABLE (TC)

A. Manufacturer: Emu Americas, www.emuamericas.com

B. Model: Cambi, #805 48” Diameter

C. Finish/ Color: 22 A/ Iron

D. Installation Method: Free Standing

2.7 CHAIR (TC)

A. Manufacturer: Emu Americas, www.emuamericas.com

B. Model: Eclipse, #056

C. Finish/ Color: 22 A/ Iron

D. Installation Method: Free Standing

2.8 SITE HANDRAIL

A. Manufacturer: Efficient-Tec International, LLC, www.eti-s3.com

B. Model: Anda (S3-ALPC-5-EM-NR-NI)

C. Finish: 6063 Aluminum with a Powder Coat Finish, RAL 7022 Umbra Gray or approved equal.

D. Mounting: Embed Mount.

E. Contractor shall submit shop drawings for approval.

2.9 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment: Pressure-treat wood according to AWPA U1, Use Category UC3b, and the following:
   1. Use preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
   2. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

2.10 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces.

E. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

F. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.11 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.12 ALUMINUM FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.13 STEEL AND GALVANIZED-STEEL FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

B. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.14 IRON FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.15 STAINLESS-STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
   1. Run directional finishes with long dimension of each piece.
   2. Directional Satin Finish: No 4.
   3. Dull Satin Finish: No. 6.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 IN larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

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SECTION 32 91 13
SOIL PREPARATION

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 planting soils and layered soil assemblies specified according to performance requirements of the mixes.

B. Lightweight Soil

C. Planting Soil

D. Topsoil

E. Related Requirements:
  1. Section 31 10 00 "Site Clearing" for topsoil stripping and stockpiling.
  2. Section 32 92 00 "Turf and Grasses" for placing planting soil for turf and grasses.
  3. Section 32 93 00 "Plants" for placing planting soil for plantings.
  4. Section 32 96 00 "Transplanting" for placing planting soil in tree planting pits.

1.3 DEFINITIONS

A. AAPFCO: Association of American Plant Food Control Officials.

B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.

C. CEC: Cation exchange capacity.

D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.

E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

F. Imported Soil: Soil that is transported to Project site for use.

G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.

J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

M. SSSA: Soil Science Society of America.

N. 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.

O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

Q. USCC: U.S. Composting Council.

1.4 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data: Contractor to provide for each type of product.
   1. Include recommendations for application and use.
   2. Include test data substantiating that products comply with requirements.
   3. Include sieve analyses for aggregate materials.
   4. Material Certificates: For each type of imported soil and soil amendment and fertilizer before delivery to the site, according to the following:
      a. Manufacturer's qualified testing agency's certified analysis of standard products.
      b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
      c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

B. Samples: For each bulk-supplied material, 1-quart volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For each testing agency.

B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.

C. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.
   1. Laboratories: Subject to compliance with requirements, provide testing by one the following:
      a. Penn State Agricultural Analytical Services Lab
      b. Turf Diagnostics LLC – Iowa
      c. Waypoint Analytic
      d. Approved equal by landscape architect.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on existing, on-site soil.
   1. Notify Architect seven days in advance of the dates and times when laboratory samples will be taken.

1.9 TESTING REQUIREMENTS

A. General: Perform tests on soil samples according to requirements in this article.

B. Physical Testing:
   1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
      a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
      b. Hydrometer Method: Report percentages of sand, silt, and clay.
   2. Bulk Density: Analysis according to core method and clod method of SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   3. Total Porosity: Calculate using particle density and bulk density according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   4. Water Retention: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods."
   5. Saturated Hydraulic Conductivity: According to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods"; at 85% compaction according to ASTM D 698 (Standard Proctor).

C. Fertility Testing: Soil fertility analysis according to standard laboratory protocol of SSSA NAPT NCR-13, including the following:
   1. Percentage of organic matter.
   2. CEC, calcium percent of CEC, and magnesium percent of CEC.
   3. Soil reaction (acidity/alkalinity pH value).
   4. Buffered acidity or alkalinity.
   5. Nitrogen ppm.
   6. Phosphorous ppm.
   7. Potassium ppm.
   8. Manganese ppm.
   9. Manganese-availability ppm.
   10. Zinc ppm.
   11. Zinc availability ppm.
   12. Copper ppm.
   13. Sodium ppm.
   14. Soluble-salts ppm.
   15. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
   16. Other deleterious materials, including their characteristics and content of each.

D. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3-Chemical Methods."

E. Lab test results to be submitted directly from testing labs to the landscape architect

F. Soil reports to not be more than 60 days old.

G. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy, viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.
   1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 SQFT for 6 IN depth of soil.
   2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 SQFT for 6 IN depth of soil.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance 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. Do not move or handle materials when they are wet or frozen.
   4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Soil Type – Planting soil for at-grade condition and in tree pits
   1. Imported soil or manufactured soil that has been modified as specified with soil amendments to produce a soil mixture best for plant growth. Using soil analyses and materials specified in other articles of this Section.
   2. Manufacturer: Stancills Inc, www.stancills.com, 877-536-9572
   3. If there is no existing soil on site, contractor to import certified planting soil to meet requirements of plantings.
   4. Contractor to provide lab test reports and lab recommendations (if any) of the planting soil to the Landscape Architect for approval prior to installation.
      a. Particle Size Distribution by USDA Textures: Classified as sandy loam soil according to USDA textures.
      b. Percentage of Organic Matter: Minimum 6 percent by volume tested by LOI test
      c. Soil Reaction: pH of 5.5 to 7.
      d. Soluble-Salt Content: .5 to .10 dS/m measured by electrical conductivity.
   5. Amend imported soil with materials specified in other articles of this Section to become planting soil complying with the following requirements:
   6. Sources: Take imported, unamended soil from sources that are naturally well drained. Sites where topsoil occurs at least 4 IN deep, not from agricultural land, bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including. However, not limited to, those identified by the Virginia Cooperative Extension or the Virginia Department of Agriculture and Consumer Services.

7. Additional Properties of Imported Soil before Amending: Minimum of 4 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration. Clean soil to be free of the following:
    a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
    b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 4 percent by dry weight of the imported soil.
    c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 2 IN in any dimension.
8. Percentage of Organic Matter: Minimum 6 percent by volume.
9. Soil Reaction: pH of 5.5 to 7

B. Screened Topsoil for all planting areas
1. Imported topsoil or manufactured topsoil that has been modified as specified with soil amendments to produce a soil mixture best for plant growth. Using soil analyses and materials specified in other articles of this Section. Topsoil to be screened topsoil.
2. Manufacturer: Stancills Inc, www.stancills.com, 877-536-9572
3. Product - Screened topsoil
    a. Particle Size Distribution by USDA Textures: Classified as sandy loam soil according to USDA textures.
    b. Percentage of Organic Matter: Minimum 6 percent by volume tested by LOI test
    c. Soil Reaction: pH of 5.5 to 7.
    d. Clean soil to be free of the following:
        1) Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
        2) Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 4 percent by dry weight of the imported soil.
        3) Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 2 IN in any dimension.

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. Class: T, with a minimum of 99 percent passing through a No. 8 sieve and a minimum of 75 percent passing through a No. 60 sieve.
2. Class: O, with a minimum of 95 percent passing through No. 8 sieve and a minimum of 55 percent passing through a No. 60 sieve.
3. Form: Provide lime in form of ground dolomitic limestone.
4. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 sieve and a maximum of 10 percent passing through a No. 40 (0.425-mm) sieve.
5. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
6. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 sieve.
7. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C 33/C 33M.

2.3 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:
   1. Feedstock: Limited to leaves, may include animal waste.
   2. Reaction: pH of 5.5 to 8
   3. Soluble-Salt Concentration: Less than 4 dS/m
   4. Moisture Content: 35 to 55 percent by weight.
   5. Organic-Matter Content: 30 to 40 percent of dry weight.
   6. Particle Size: Minimum of 98 percent passing through a 1/2 IN sieve.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2 IN sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum 5 dS/m.

C. Manure: Well-rotted, unleached, free of antibiotics, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.4 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: 1 LB/1000 SQFT of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: 20 percent nitrogen, 5 percent phosphorous, and 10 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

D. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. 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 planting soil.

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

D. All areas that are on-structure to receive lightweight soil (planting or structural) as noted in the contract drawings for the entire depth i.e. from the finished grade condition to the top of slab as shown in the contract drawings.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area(s) to a depth of 6 IN and stockpile until amended.

B. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Cleaned soil should not contain roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a 1/2 IN sieve to remove large materials.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet. Correct subgrade conditions prior to proceeding with work.

B. Correct subgrade conditions prior to proceeding with work and confirm adequate drainage is provide with a percolation test.

C. Subgrade Preparation: Till subgrade to a minimum depth of 12 IN. Remove stones larger than 2 IN in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
   1. Apply, add soil amendments, and mix approximately half the thickness of unamended soil over prepared, loosened subgrade according to "Mixing" Paragraph below. Mix thoroughly into top 4 IN of subgrade. Spread remainder of planting soil.

D. Mixing: Spread unamended soil to total depth of 8 IN, but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet. Correct subgrade conditions prior to proceeding with work.
   1. Amendments: Apply soil amendments, except compost, and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.
      a. Mix lime and sulfur with dry soil before mixing fertilizer.
      b. Mix fertilizer with planting soil no more than seven days before planting.
   2. Lifts: Apply and mix unamended soil and amendments in lifts not exceeding 12 IN in loose depth for material compacted by compaction equipment, and not more than 6 IN in loose depth for material compacted by hand-operated tampers.

E. Compaction: Compact each blended lift of planting soil to 75-82 percent of maximum Standard Proctor density according to ASTM D 698.

F. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Till soil so that it is loose for roots to penetrate, till to a minimum depth of 8”.

3.4 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet. Ensure conditions are corrected prior to proceeding with work.

B. Subgrade Preparation: Till subgrade to a minimum depth of 12 IN. Remove stones larger than 2 IN in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
   1. Apply approximately half the thickness of planting soil over prepared, loosened subgrade. Mix thoroughly into top 4 IN of subgrade. Spread remainder of planting soil.

C. Application: Spread planting soil to total depth of 8 IN, but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.
    1. Lifts: Apply planting soil in lifts not exceeding 12 IN in loose depth for material compacted by compaction equipment, and not more than 6 IN in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.5 BLENDING PLANTING SOIL IN PLACE

A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet. Ensure conditions are corrected prior to proceeding with work.

B. Preparation: Till unamended, existing soil in planting areas to a minimum depth of 6 IN. Remove stones larger than 2 IN in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Apply soil amendments, except compost, and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.
    1. Mix lime and sulfur with dry soil before mixing fertilizer.
    2. Mix fertilizer with planting soil no more than seven days before planting.

D. Compaction: Compact blended planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D 698.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.

3.6 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

A. Application: Apply compost component of planting-soil mix 4 IN of compost to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Rake, remove ridges, and fill depressions to meet finish grades.

3.7 PROTECTION

A. Protection Zone: Identify protection zones according to Section 01 56 39 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
    1. Storage of construction materials, debris, or excavated material.
    2. Parking vehicles or equipment.
    3. Vehicle traffic.
    4. Foot traffic.
    5. Erection of sheds or structures.
    6. Impoundment of water.
    7. Excavation or other digging unless otherwise indicated.

C. If planting soil or subgrade is over compacted (more than 85%), disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Landscape Architect and replace contaminated planting soil with new planting soil.

3.8 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
   1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

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SECTION 32 92 00
TURF 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.

B. Related Requirements:
   1. Section 32 93 00 "Plants" for trees, shrubs, ground covers, and other plants as well as border edgings and mow strips.
   2. Section 33 46 00 "Subdrainage" for below-grade drainage of landscaped areas.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 15 "Soil Preparation (Performance Specification)" and drawing designations for planting soils.

E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For landscape Installer.

B. 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.
   1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.

C. Product Certificates: For fertilizers, from manufacturer.

D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.
   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 turf installation in addition to requirements in Section 01 40 00 "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 Professional Landcare Network:
      a. Landscape Industry Certified Technician - Exterior.
      b. Landscape Industry Certified Lawncare Manager.
      c. Landscape Industry Certified Lawncare Technician.
   5. Pesticide Applicator: State licensed, commercial.

1.8 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 compliance 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 materials with appropriate certificates.

1.9 FIELD 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.
   1. Spring Planting: April 1 to May 15
   2. Fall Planting: September 1 to October 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.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species:
   1. Quality: State-certified seed of grass species as listed below for solar exposure.

2. Quality: Seed of grass species as listed below for solar exposure, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:
3. Full Sun: Bermudagrass (Cynodon dactylon).
4. Full Sun: Kentucky bluegrass (Poa pratensis), a minimum of three cultivars.
5. Sun and Partial Shade: Proportioned by weight as follows:
   a. 50 percent Kentucky bluegrass (Poa pratensis).
   b. 30 percent chewings red fescue (Festuca rubra variety).
   c. 10 percent perennial ryegrass (Lolium perenne).
   d. 10 percent redtop (Agrostis alba).
6. Shade: Proportioned by weight as follows:
   a. 50 percent chewings red fescue (Festuca rubra variety).
   b. 35 percent rough bluegrass (Poa trivialis).
   c. 15 percent redtop (Agrostis alba).

2.2 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
   1. Composition: 1 LB/1000 SQFT of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
   1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
   2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.3 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.

C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1 IN sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   1. Organic Matter Content: 50 to 60 percent of dry weight.
   2. Feedstock: Agricultural, food, or industrial residuals; bio-solids; yard trimmings; or source-separated or compostable mixed solid waste.

E. 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.

F. Non asphaltic Tackifier: Colloidal Tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

G. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.4 PESTICIDES

A. General: Pesticide, registered and approved by the 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 Nonselective): 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 Nonselective): Effective for controlling weed growth that has already germinated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
  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. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  3. Uniformly moisten excessively dry soil that is not workable or which is dusty.
  4. Verify that ponding of water does not occur and adequate drainage is achieved for turf subgrade. If ponding exists, correct conditions prior to proceeding with work.

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, trees, shrubs, and plantings from damage caused by planting operations.
  1. Protect adjacent and adjoining areas from hydro seeding and hydro mulching overspray.
  2. Protect grade stakes set by others until directed to remove them.

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.

3.3 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 32 91 15 "Soil Preparation" – for planting soil.

B. Placing Planting Soil: Place manufactured planting soil over exposed subgrade.
  1. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.
   1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
   2. Do not use wet seed or seed that is moldy or otherwise damaged.
   3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate of 5 to 8 LB/1000 SQFT.

C. Rake seed lightly into top 1/8 IN of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets and 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.

E. Protect seeded areas with erosion-control mats where indicated on Drawings; install and anchor according to manufacturer's written instructions.

F. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 IN in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
   1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
   2. Bond straw mulch by spraying with asphalt emulsion at a rate of 10 to 13 gal./1000 sq. ft.. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

G. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch or peat mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 IN, and roll surface smooth.

3.5 HYDROSEEDING

A. Hydroseeding: Mix specified seed, slow-release fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
   1. Mix slurry with fiber-mulch manufacturer's recommended tackifier.
   2. Spray-apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500 LB/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.
   3. Spray-apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500 LB/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1000 LB/acre.

3.6 TURF MAINTENANCE

A. General: 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 re-mulch 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 IN.
   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 IN 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 one-third of grass height. Remove no more than one-third 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 bentgrass to a height of 1/2 IN or less.
   2. Mow bermudagrass to a height of 1/2 to 1 IN.
   3. Mow Kentucky bluegrass to a height of 1-1/2 to 2 IN.
   4. Mow turf-type tall fescue to a height of 2 to 3 IN.

D. Turf Postfertilization: Apply slow-release fertilizer after initial mowing and when grass is dry.
   1. Use fertilizer that provides actual nitrogen of at least 1 LB/1000 SQFT to turf area.

3.7 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 5 by 5 IN.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.8 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to 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 Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.9 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. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

C. 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.

D. Remove non-degradable erosion-control measures after grass establishment period.

3.10 MAINTENANCE SERVICE

A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
   1. Seeded Turf: 60 days from date of planting completion.
      a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

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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. Tree stabilization
   3. Tree-watering devices
   4. Landscape edgings

B. Related Requirements:
   1. Section 01 56 39 "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. Section 32 92 00 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.
   3. Section 32 96 00 "Transplanting" for transplanting non-nursery-grown trees.
   4. Section 31 20 00 “Earth Moving” for site grading and subbase soils.
   5. Section 33 46 00 “Subdrainage” for below-grade drainage of landscaped areas.

1.3 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.

C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required.

D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.

E. 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.

F. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.

G. Finish Grade: Elevation of finished surface of planting soil.

H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

I. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

J. Planting Area: Areas to be planted.

K. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 91 15 "Soil Preparation (Performance Specification)" for drawing designations for planting soils.

L. 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.

M. 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.

N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.

O. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.4 COORDINATION

A. 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.

1.5 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
   2. Plant Photographs: Include color photographs in digital format of each required species and size of plant material as it will be furnished to 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.

B. Samples for Verification: For each of the following:
   1. Trees and Shrubs: Three Samples of each variety and size delivered to site for review. Maintain approved Samples on-site as a standard for comparison.
   2. Organic Compost Mulch: 1-quart volume of each organic 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.
   3. Weed Control Barrier: 12 by 12 IN.
   4. Proprietary Root-Ball-Stabilization Device: One unit.
   5. Slow-Release, Tree-Watering Device: One unit of each size required.

6. Edging Materials and Accessories: Manufacturer's standard size, to verify color selected.
7. Tree Grates, Frames, and Accessories: Manufacturer's standard size delivered to site for review, to verify design and color selected.
8. Root Barrier: Width of panel by 12 IN.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For 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. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
   1. Manufacturer's certified analysis of standard products.
   2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

D. Sample Warranty: For special warranty.

1.8 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required maintenance periods.

1.9 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 Section 01 40 00 "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 Professional Landcare Network:
      a. Landscape Industry Certified Technician - Exterior.
      b. Landscape Industry Certified Horticultural Technician.
   5. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
   1. Selection of plants purchased under allowances is made by Architect, who tags plants at their place of growth before they are prepared for transplanting.

C. 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 IN above the root flare for trees up to 4 IN caliper size, and 12 IN above the root flare for larger sizes.
   2. Other Plants: Measure with stems, petioles, and foliage in their normal position.

D. Plant Material Observation: Landscape Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Landscape Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
   1. Notify Landscape Architect of sources of planting materials seven days in advance of delivery to site.

1.10 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 compliance 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 materials with appropriate certificates.

C. Deliver bare-root stock plants within 24 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.

D. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, 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.

F. Store bulbs, corms, and tubers in a dry place at 60 to 65 DEGF until planting.

G. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
   1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.

H. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

I. 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.
   1. Heel-in bare-root stock. Soak roots that are in less than moist condition in water for two hours. Reject plants with dry roots.
   2. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
   3. Do not remove container-grown stock from containers before time of planting.
   4. 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.

1.11 FIELD 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. 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: April 1 to May 15
   2. Fall Planting: September 1 to October 15

C. 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.

1.12 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.
      b. Structural failures including plantings falling or blowing over.
      c. Faulty performance of tree stabilization, edgings and tree grates.
      d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   2. Warranty Periods: From date of Substantial Completion.
      a. Trees, Shrubs, Vines, and Ornamental Grasses: 24 months.
      b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
      c. Annuals: Three months.
   3. 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. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
      d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

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 List, Plant Schedule, or Plant Legend indicated 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 IN in diameter; or with stem girdling roots are unacceptable.
   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.

B. Do not use nurseries that have a different soil structure than Maryland's (e.g. do not use nurseries from the South, Tennessee and Georgia to name a few)

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. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before and after planting.

E. Labeling: Label each 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.

F. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

G. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

H. Do not install plants if they appear to be damaged during transit or on site.

I. Trees to be protected during transit so that they do not get wind burn etc.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
   1. Size: 5-gram tablets.
   2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
   1. Type: Shredded hardwood.
   2. Size Range: 3 IN maximum, 1/2 IN minimum.
   3. Color: Natural.

B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through a 1 IN sieve; soluble-salt content of 2 to 5 dS/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
   1. Organic Matter Content: 50 to 60 percent of dry weight.
   2. Feedstock: Agricultural, food, or industrial residuals; bio-solids; yard trimmings; or source-separated or compostable mixed solid waste.

2.4 WEED-CONTROL BARRIERS

A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd..

2.5 PESTICIDES

A. General: Pesticide registered and approved by the 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 Nonselective): 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 Nonselective): Effective for controlling weed growth that has already germinated.

2.6 TREE-STABILIZATION MATERIALS

A. Trunk-Stabilization Materials:
   1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2 IN nominal by length indicated, pointed at one end.
   2. Wood Deadmen: Timbers measuring 8 IN in diameter and 48 IN long, treated with specified wood pressure-preservative treatment.
   3. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or turnbuckles or compression springs.
   4. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 IN in diameter.
   5. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
   6. Guy Cables: Five-strand, 3/16 IN diameter, galvanized-steel cable, with zinc-coated turnbuckles or compression springs, a minimum of 3 IN long, with two 3/8 IN galvanized eyebolts.
   7. Rubber Hose for Guys: 1/2 IN inside diameter to wrap around tree.
   8. Flags: Standard surveyor's plastic flagging tape, white, 6 IN long.

B. Root-Ball Stabilization Materials:
   1. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, 2-by-2 IN nominal by length indicated (min. 8'-0 out of ground and 2'-0 underground); stakes pointed at one end.
   2. Wood Screws: ASME B18.6.1.

2.7 LANDSCAPE EDGINGS

A. Steel Edging: Standard commercial-steel edging, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.

B. Border Concepts Steel Edging (Border King)
   1. Edging Size: 1/4 IN thick by 5 IN deep.
   2. Stakes: Tapered steel, a minimum of 15 IN long.
   3. Accessories: Standard tapered ends, corners, and splicers.
   4. Finish: Manufacturer's standard paint.
      a. Paint Color: Contractor to submit all manufacturer colors for approval.

2.8 MISCELLANEOUS PRODUCTS

A. Wood Pressure-Preservative Treatment: AWPA U1, Use Category UC4a; acceptable to authorities having jurisdiction, and containing no arsenic or chromium.

B. Root Barrier: Black, molded, modular panels 24 IN high (deep), 85 mils thick, and with vertical root deflecting ribs protruding 3/4 IN out from panel surface; manufactured with minimum 50 percent recycled polyethylene plastic with UV inhibitors.

C. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

D. Burlap: Non-synthetic, biodegradable.

E. Planter Drainage Gravel: Washed on site after delivery with no fines #57 stone.

F. Planter Filter Fabric: Nonwoven geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.

G. Concrete Parking Stops: For anchoring trees on structure. Use minimum 3 parking stops per tree. 200 LBS+ per parking stop minimum weight

H. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per LB of vesicular-arbuscular mycorrhizal fungi and 95 million spores per LB of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
   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. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
   3. Suspend planting 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 or which is dusty.

B. 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.

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

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.

D. Lay out plants at locations directed by Landscape Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

3.3 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 32 91 15 "Soil Preparation."

B. Placing Planting Soil: Place manufactured planting soil over exposed subgrade.

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

D. Application of Mycorrhizal Fungi: At time directed by Architect, broadcast dry product uniformly over prepared soil at application rate according to manufacturer's written recommendations.

3.4 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.
   1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable and will be rejected.
   2. 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.
   3. Excavate three times as wide as ball diameter for balled and Burlapped, balled and potted, container-grown and fabric bag-grown stock.
   4. Excavate at least 12 IN wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
   5. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
   6. 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.
   7. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
   8. Maintain supervision of excavations during working hours.
   9. Keep excavations covered or otherwise protected after working hours.
   10. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.

B. Backfill Soil: Subsoil and topsoil removed from excavations may not be used as backfill soil unless otherwise indicated.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
   1. Hardpan Layer: Drill 6 IN diameter holes, 24 IN apart, into free-draining strata or to a depth of 10 FT, whichever is less, and backfill with free-draining material.

D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

E. Fill excavations with water and allow it to percolate away before positioning trees and shrubs. If pits do not drain, correct conditions prior to proceeding with work until adequate drainage is achieved.

3.5 TREE, SHRUB, AND VINE PLANTING

A. Inspection: Contractor to layout all plants prior to installation and get landscape architect's approval on the layout. Installation to occur only after landscape architect has approved the layout. Contractor to notify landscape architect minimum 7 days in advance for conducting a site visit to approve the planting layout. Layout of plants to be in accordance with contract documents.

B. At time of 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.

C. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

D. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 IN above adjacent finish grades.
   1. Backfill: Planting soil. For trees, use excavated soil for backfill.
   2. 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.
   3. 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.
   4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 IN from root tips; do not place tablets in bottom of the hole.
      a. Quantity: Two per plant.
   5. Continue backfilling process. Water again after placing and tamping final layer of soil.

E. Balled and Potted and Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 IN above Insert requirement adjacent finish grades.
   1. Backfill: Planting soil. For trees, use excavated soil for backfill.
   2. Carefully remove root ball from container without damaging root ball or plant.
   3. 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.
   4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 IN from root tips; do not place tablets in bottom of the hole.
      a. Quantity: Two per plant.
   5. Continue backfilling process. Water again after placing and tamping final layer of soil.

F. Fabric Bag-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 IN above adjacent finish grades.
   1. Backfill: Planting soil. For trees, use excavated soil for backfill.
   2. Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
   3. 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.
   4. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 IN from root tips; do not place tablets in bottom of the hole.
      a. Quantity: Two per plant.
   5. Continue backfilling process. Water again after placing and tamping final layer of soil.

G. Bare-Root Stock: Set and support each plant in center of planting pit or trench with root flare 2 IN above adjacent finish grade.
   1. Backfill: Planting soil. For trees, use excavated soil for backfill.
   2. Spread roots without tangling or turning toward surface. Plumb before backfilling, and maintain plumb while working.
   3. Carefully work backfill in layers around roots by hand. Bring roots into close contact with the soil.
   4. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
   5. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside soil-covered roots about 1 IN from root tips; do not place tablets in bottom of the hole or touching the roots.
      a. Quantity: Two per plant.
   6. Continue backfilling process. Water again after placing and tamping final layer of soil.

H. Watering Pipe: During backfilling, install watering pipe 4 FT deep into the planting pit outside the root ball with top of pipe 1 IN above the mulched surface.

I. Slopes: 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.

3.6 MECHANIZED TREE-SPADE PLANTING

A. Trees may be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.

B. Use the same tree spade to excavate the planting hole as will be used to extract and transport the tree.

C. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.

D. Cut exposed roots cleanly during transplanting operations.

E. Plant trees following procedures in "Tree, Shrub, and Vine Planting" Article.

F. Where possible, orient the tree in the same direction as in its original location.

3.7 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do not apply pruning paint to wounds.

3.8 TREE STABILIZATION

A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization as follows unless otherwise indicated:
   1. Upright Staking and Tying: Stake trees of 2- through 5 IN caliper. Stake trees of less than 2 IN caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 IN below bottom of backfilled excavation and to extend one-third of trunk height above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
   2. Upright Staking and Tying: Stake trees with two stakes for trees up to 12 FT high and 2-1/2 IN or less in caliper; three stakes for trees less than 14 FT high and up to 4 IN in caliper. Space stakes equally around trees.
   3. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
   4. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

B. Trunk Stabilization by Staking and Guying: Install trunk stabilization as follows unless otherwise indicated on Drawings. Stake and guy trees more than 14 FT in height and more than 3 IN in caliper unless otherwise indicated.
   1. Site-Fabricated, Staking-and-Guying Method: Install no fewer than three guys spaced equally around tree.

a. Securely attach guys to stakes 30 IN long, driven to grade. Adjust spacing to avoid penetrating root balls or root masses. Provide turnbuckle or compression spring for each guy wire and tighten securely.
b. For trees more than 6 IN in caliper, anchor guys to wood deadmen buried at least 36 IN below grade. Provide turnbuckle or compression spring for each guy wire and tighten securely.
c. Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle or compression spring. Allow enough slack to avoid rigid restraint of tree.
d. Support trees with guy cable, connected to the brass grommets of tree-tie webbing at contact points with tree trunk and reaching to turnbuckle or compression spring. Allow enough slack to avoid rigid restraint of tree.
e. Attach flags to each guy wire, 30 IN above finish grade.
f. Paint turnbuckles or compression springs with luminescent white paint.

2. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

C. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.

1. Wood Hold-Down Method: Place vertical stakes against side of root ball and drive them into subsoil; place horizontal wood hold-down stake across top of root ball and screw at each end to one of the vertical stakes.
   a. Install stakes of length required to penetrate at least 18 IN below bottom of backfilled excavation. Saw stakes off at horizontal stake.
   b. Install screws through horizontal hold-down and penetrating at least 1 IN into stakes. Predrill holes if necessary to prevent splitting wood.
   c. Install second set of stakes on other side of root trunk for larger trees.
2. Proprietary 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.

3.9 ROOT-BARRIER INSTALLATION

A. Install root barrier where trees are planted within 60 IN of paving or other hardscape elements, such as walls, curbs, and walkways, unless otherwise indicated on Drawings.

B. Align root barrier with bottom edge angled at 20 degrees away from the paving or other hardscape element, and run it linearly along and adjacent to the paving or other hardscape elements to be protected from invasive roots.

C. Install root barrier continuously for a distance of 60 IN in each direction from the tree trunk, for a total distance of 10 FT per tree. If trees are spaced closer, use a single continuous piece of root barrier.

1. Position top of root barrier according to manufacturer's written recommendations.
2. Overlap root barrier a minimum of 12 IN at joints.
3. Do not distort or bend root barrier during construction activities.
4. Do not install root barrier surrounding the root ball of tree.

3.10 PLACING SOIL IN PLANTERS

A. Place a layer of drainage gravel at least 4 IN thick in bottom of planter. Cover bottom with filter fabric and wrap filter fabric 6 IN up on all sides. Duct tape along the entire top edge of the filter fabric, to secure the filter fabric against the sides during the soil-filling process.

B. Fill planter with planting soil. Place soil in lightly compacted layers to an elevation of 1-1/2 IN below top of planter, allowing natural settlement.

3.11 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on Drawings in even rows with triangular spacing.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to a depth not less than two nodes.

E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.12 PLANTING AREA MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 IN and secure seams with galvanized pins.

B. Mulch backfilled surfaces of planting areas and other areas indicated.
   1. Trees and Treelike Shrubs in Turf Areas: Apply organic or mineral mulch ring of 2 IN average thickness, with 36 IN radius around trunks or stems. Do not place mulch within 6 IN of trunks or stems. Mulch ‘volcanoes’ will be rejected.
   2. Organic Mulch in Planting Areas: Apply 2 IN average thickness of organic mulch extending 12 IN beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 6 IN of trunks or stems.
   3. Mineral Mulch in Planting Areas: Apply 2 IN average thickness of mineral mulch extending 12 IN beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 6 IN of trunks or stems.

3.13 EDGING INSTALLATION

A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 IN apart, driven below top elevation of edging.

B. Shovel-Cut Edging: Separate mulched areas from turf areas, curbs, and paving with a 45-degree, 4- to 6 IN deep, shovel-cut edge.

C. Mow-Strip Installation:
   1. Excavate for mow strip.
   2. Compact subgrade uniformly beneath mow strip.
   3. Apply nonselective, pre-emergent herbicide that inhibits growth of grass and weeds.
   4. Install steel edging, delineating the edge of mow strip.
   5. Install weed-control barrier before mulching, covering area of mow strip, and overlapping and pinning edges of barrier at least 6 IN and according to manufacturer's written instructions.
   6. Place indicated thickness of organic or mineral mulch, fully covering weed barrier.
   7. Rake mulch to a uniform surface level with adjacent finish grades.

3.14 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

3.15 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, and 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.

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.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

3.16 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents according to 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. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.

C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.17 REPAIR AND REPLACEMENT

A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
   1. Submit details of proposed pruning and repairs.
   2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
   3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
   1. Provide new trees of same size as those being replaced for each tree of 6 IN or smaller in caliper size.
   2. Provide two new tree(s) of 6 IN caliper size for each tree being replaced that measures more than 6 IN in caliper size.
   3. Species of Replacement Trees: Species selected by Architect.

3.18 CLEANING AND PROTECTION

A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

C. 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.

D. 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.

E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.19 MAINTENANCE SERVICE

A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. 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: 24 months from date of Substantial Completion.

B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. 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: Six months from date of Substantial Completion.

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DIVISION 33

UTILITIES

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SECTION 33 05 00
COMMON WORK RESULTS FOR UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Piping joining materials.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Sleeves.
   5. Identification devices.
   6. Grout.
   7. Flowable fill.
   8. Piped utility demolition.
   9. Piping system common requirements.
   10. Equipment installation common requirements.
   11. Painting.
   12. Concrete bases.
   13. Metal supports and anchorages.

1.3 DEFINITIONS

A. Exposed Installations: Exposed to view outdoors 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.

C. ABS: Acrylonitrile-butadiene-styrene plastic.

D. PE: Polyethylene Plastic.

E. HDPE: High Density Polyethylene.

F. PVC: Polyvinyl Chloride Plastic.

G. DI: Ductile Iron.

H. RC: Reinforced Concrete.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Dielectric fittings.
   2. Identification devices.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes 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 pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 COORDINATION

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

B. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.

C. Coordinate size and location of concrete bases. Formwork, reinforcement, and concrete requirements are specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete".

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 IN 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 IN 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. 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.

E. Solvent Cements for Joining Plastic Piping:
   1. ABS Piping: ASTM D 2235.
   2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   3. PVC to ABS Piping Transition: ASTM D 3138.

2.2 TRANSITION FITTINGS

A. Transition Fittings, General: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. AWWA Transition Couplings NPS 2 (DN 50) and Larger:
   1. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

C. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:
   1. Description: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.3 DIELECTRIC FITTINGS

A. Dielectric Fittings, General: Assembly of ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Flanges:
   1. Description: Ductile iron factory-fabricated, bolted, companion-flange assembly, NPS 8 and larger.
      a. Pressure Rating: 300 psig minimum.

C. Dielectric-Flange Kits:
   1. Description: Nonconducting materials for field assembly of companion flanges, NPS 8 and larger.
      a. Pressure Rating: 300 psig minimum.
      b. Gasket: Neoprene or phenolic.
      c. Bolt Sleeves: Phenolic or polyethylene.
      d. Washers: Phenolic with steel backing washers.

2.4 IDENTIFICATION DEVICES

A. General: Products specified are for applications referenced in other utilities Sections. If more than single type is specified for listed applications, selection is Installer's option.

B. 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.

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, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

2.6 FLOWABLE FILL

A. Description: Low-strength-concrete, flowable-slurry mix. Material in place has a minimum PH of 10 and shall be at least 7800 ohm-cm.
   1. Cement: ASTM C 150, Type I, portland.
   2. Aggregates: ASTM C 33, natural sand, fine and crushed gravel or stone, coarse.
   3. Aggregates: ASTM C 33, natural sand, fine.
   4. Admixture: ASTM C 618, fly-ash mineral.
   5. Water: Comply with ASTM C 94/C 94M.
   6. Strength: 100 to 200 PSIG at 28 days.

PART 3 - EXECUTION

3.1 PIPED UTILITY DEMOLITION

A. Refer to Section 02 41 19 "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping material. Install masonry bulkhead at ends of pipes 8 IN in diameter and larger.
   3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
   5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING INSTALLATION

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

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. 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. PVC Nonpressure Piping: Join according to ASTM D 2855.
   4. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.

H. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

I. 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.

J. 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 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.

C. Install equipment to allow right of way to piping systems installed at required slope.

3.6 PAINTING

A. Painting of piped utility systems, equipment, and components is specified in Section 09 91 13 "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Steel Shapes: Comply with ASTM A 36/ A36M.

B. Steel Bolts with Washers: ASTM A 307, Grade A, hot-dip galvanized.

C. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.

D. Field Welding: Comply with AWS D1.1/D1.1M.

3.8 GROUTING

A. Mix and install grout for utility base bearing surfaces, underground systems, 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 manhole wall voids.

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

G. Cure placed grout.

END OF SECTION

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SECTION 33 42 00
STORMWATER CONVEYANCE

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. PVC pipe and fittings.
   2. Concrete pipe and fittings.
   3. Cleanouts.
   4. Drains.
   5. Manholes.
   6. Catch basins.
   7. Stormwater inlets.
   8. Pipe outlets.

1.3 DEFINITIONS

A. None

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Manholes: Include plans, elevations, sections, details, frames, and covers.
   2. Catch basins stormwater inlets. Include plans, elevations, sections, details, frames, covers, and grates.
   3. Stormwater Management Facilities: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.

1.5 INFORMATIONAL SUBMITTALS

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

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

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

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes in accordance with manufacturer's written rigging instructions.

D. Handle catch basins and stormwater inlets in accordance with manufacturer's written rigging instructions.

1.8 FIELD 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 in accordance with requirements indicated:
   1. Notify Architect and Owner no fewer than two days in advance of proposed interruption of service.
   2. Do not proceed with interruption of service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

A. PVC Gravity Storm Sewer Piping:
   1. Pipe and Fittings: ASTM F 679, T-1 wall thickness, PVC gravity storm sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.
   2. Perforated underdrains shall have four rows of 3/8 IN holes with a hole spacing of 3.25 +-0.25 IN or a combination of hole size and spacing that provides a minimum inlet area greater than or equal to 1.76 SQIN per linear foot or be perforated with slots 0.125 IN in width that provides a minimum inlet area greater than or equal to 1.5 SQIN per linear foot of pipe.

2.2 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76.
   1. Bell-and-spigot ends and sealant joints with ASTM C 990, bitumen or butyl-rubber sealant
   2. Class IV, Wall A.

2.3 CLEANOUTS

A. PVC Cleanouts:
   1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.4 DRAINS

A. Cast-Iron Trench Drains:
   1. Description: ASME A112.6.3, 6 IN wide top surface, rectangular body with anchor flange or other anchoring device, and rectangular grate. Include units of total length indicated and quantity of bottom outlets with inside caulk or spigot connections, of sizes indicated.
   2. Top-Loading Classification(s): Extra-Heavy Duty

B. Grate Openings: In accordance with the current Howard County Design Manual Volume IV, May 2014.

2.5 MANHOLES

A. Standard Precast Concrete Manholes:
   1. Description: As shown on the contract drawings and in accordance with the current Howard County Design Manual Volume IV, May 2014.

B. Manhole Frames and Covers:
   1. Description: In accordance with the current Howard County Design Manual Volume IV, May 2014.

2.6 CONCRETE

A. General: Cast-in-place concrete in accordance with ACI 318, ACI 350, and the following:
   1. Cement: ASTM C 150/C 150M, Type II.
   2. Fine Aggregate: ASTM C 33/C 33M, sand.

3. Coarse Aggregate: ASTM C 33/C 33M, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
1. Reinforcing Fabric: ASTM A 1064/A 1064M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

2.7 CATCH BASINS

A. Standard Precast Concrete Catch Basins:
1. Description: As shown on the contract drawings and in accordance with the current Howard County Design Manual Volume IV, May 2014.

2.8 STORMWATER INLETS

A. Frames and Grates: In accordance with the current Howard County Design Manual Volume IV, May 2014.

2.9 STORMWATER DETENTION STRUCTURES

A. Precast concrete or cast in place concrete: See Section 2.4, concrete.

B. #57 or # 6 stone, per MD SHA Standards.

C. Underdrain pipe: F758, Type PS 28 or AASHTO M-278

2.10 PIPE OUTLETS

A. Head Walls: Precast concrete or cast-in-place reinforced concrete, with apron and tapered sides.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 31 20 00 "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 in accordance with 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. Install gravity-flow, nonpressure drainage piping in accordance with the following:
1. Install piping pitched down in direction of flow.
2. Install piping NPS 6 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 IN minimum cover.

4. Install PVC profile gravity sewer piping in accordance with ASTM D 2321 and ASTM F 1668.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping in accordance with the following:
   1. Join PVC profile gravity sewer piping in accordance with ASTM D 2321 for elastomeric-seal joints or ASTM F 794 for gasketed joints.
   2. 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 IN deep. Set with tops 1 IN above surrounding earth grade.

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

3.5 DRAIN INSTALLATION

A. Install type of drains in locations indicated.
   1. Use Light-Duty, top-loading classification drains in earth or unpaved foot-traffic areas.
   2. Use Medium-Duty, top-loading classification drains in paved foot-traffic areas.
   3. Use Heavy-Duty, top-loading classification drains in vehicle-traffic service areas.
   4. Use Extra-Heavy-Duty, top-loading classification drains in roads.

B. Embed drains in 4 IN minimum concrete around bottom and sides.

C. Fasten grates to drains if indicated.

D. Set drain frames and covers with tops flush with pavement surface.

E. Assemble trench sections with flanged joints.

F. Embed trench sections in 4 IN minimum concrete around bottom and sides.

3.6 MANHOLE INSTALLATION

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

B. Install precast concrete manhole sections with sealants in accordance with 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 IN above finished surface elsewhere unless otherwise indicated.

3.7 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.8 STORMWATER INLET 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.

3.9 CONCRETE PLACEMENT

A. Place cast-in-place concrete in accordance with ACI 318.

3.10 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Section 22 14 13 "Facility Storm Drainage Piping."

B. Connect force-main piping to building's storm drainage force mains specified in Section 22 14 13 "Facility Storm Drainage Piping." Terminate piping where indicated.

C. 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 IN overlap, with not less than 6 IN of concrete with 28-day compressive strength of 3000 PSI.
   2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 IN of concrete with 28-day compressive strength of 3000 psi.
   3. 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.

D. Pipe couplings, expansion joints, and deflection fittings 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.
   2. Use pressure-type pipe couplings for force-main joints.

3.11 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
   1. Close open ends of piping with at least 8 IN thick, brick masonry bulkheads.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
   1. Remove manhole or structure and close open ends of remaining piping.

C. Backfill to grade in accordance with Section 31 20 00 "Earth Moving."

3.12 IDENTIFICATION

A. Materials and their installation are specified in Section 31 20 00 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
   1. Use detectable warning tape over ferrous piping.

2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.13 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 IN 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 in accordance with 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 in accordance with 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 in accordance with ASTM F 1417.
      c. Option: Test concrete piping in accordance with ASTM C924.

3.14 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with water.

END OF SECTION

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.
   2. Drainage conduits.
   3. Drainage panels.
   4. Geotextile filter fabrics.

1.3 ACTION SUBMITTALS

A. Product Data:
   1. Drainage conduits, including rated capacities.
   2. Drainage panels, including rated capacities.
   3. Geotextile filter fabrics.

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.

B. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.

2.2 DRAINAGE CONDUITS

A. Molded-Sheet Drainage Conduits: Prefabricated geocomposite with cuspated, molded-plastic drainage core wrapped in geotextile filter fabric.
   1. Nominal Size: 12 IN high by approximately 1 IN thick.
      a. Minimum In-Plane Flow: 30 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
   2. Nominal Size: 18 IN high by approximately 1 IN thick.
      a. Minimum In-Plane Flow: 45 GPM at hydraulic gradient of 1.0when tested according to ASTM D 4716.
   3. Filter Fabric: PP geotextile.
   4. Fittings: HDPE with combination NPS 4 and NPS 6 outlet connection.

B. Multipipe Drainage Conduits: Prefabricated geocomposite with interconnected, corrugated, perforated-pipe core molded from HDPE complying with ASTM D 1248 and wrapped in geotextile filter fabric.

1. Nominal Size: 6 IN high by approximately 1-1/4 IN thick.
    a. Minimum In-Plane Flow: 15 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
2. Nominal Size: 12 IN high by approximately 1-1/4 IN thick.
    a. Minimum In-Plane Flow: 30 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
3. Nominal Size: 18 IN high by approximately 1-1/4 IN thick.
    a. Minimum In-Plane Flow: 45 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
4. Filter Fabric: Nonwoven, needle-punched geotextile.
5. Fittings: HDPE with combination NPS 4 and NPS 6 outlet connection.
6. Couplings: HDPE.

C. Single-Pipe Drainage Conduits: Prefabricated geocomposite with perforated corrugated core molded from HDPE complying with ASTM D 3350 and wrapped in geotextile filter fabric.
1. Nominal Size: 12 IN high by approximately 1 IN thick.
    a. Minimum In-Plane Flow: 30 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
2. Nominal Size: 18 IN high by approximately 1 IN thick.
    a. Minimum In-Plane Flow: 45 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
3. Filter Fabric: PP geotextile.
4. Fittings: HDPE with combination NPS 4 and NPS 6 outlet connection.
5. Couplings: Corrugated HDPE band.

D. Mesh Fabric Drainage Conduits: Prefabricated geocomposite with plastic-filament drainage core wrapped in geotextile filter fabric. Include fittings for bends and connection to drainage piping.
1. Nominal Size: 6 IN high by approximately 0.9 IN thick.
    a. Minimum In-Plane Flow: 2.4 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
2. Filter Fabric: Nonwoven geotextile made of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 GPM/SQFT when tested according to ASTM D 4491.

E. Ring Fabric Drainage Conduits: Drainage conduit with HDPE rings-in-grid pattern drainage core, for field-applied geotextile filter fabric. Include fittings for bends and connection to drainage piping.
1. Nominal Size: 18 IN high by 1 IN thick.
    a. Minimum In-Plane Flow: 82 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
2. Nominal Size: 36 IN high by 1 IN thick.
    a. Minimum In-Plane Flow: 164 GPM at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
3. Filter Fabric: Comply with requirements for flat geotextile filter fabric specified in Part 2 "Geotextile Filter Fabrics" Article.

2.3 DRAINAGE PANELS

A. Molded-Sheet Drainage Panels: Prefabricated geocomposite, 36 to 60 IN wide with drainage core faced with geotextile filter fabric.
1. Drainage Core: Three-dimensional, nonbiodegradable, molded PP.
    a. Minimum Compressive Strength: As required by the contract drawings and when tested according to ASTM D 1621.
    b. Minimum In-Plane Flow Rate: As required by the contract drawings and when tested according to ASTM D 4716.
2. Filter Fabric: Nonwoven needle-punched geotextile, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with the following properties determined according to AASHTO M 288:
    a. Survivability: As shown on the contract drawings.

b. Apparent Opening Size: As shown on the contract drawings.
c. Permittivity: As shown on the contract drawings.

3. Filter Fabric: Woven geotextile fabric, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation less than 50 percent; complying with the following properties determined according to AASHTO M 288:
   a. Survivability: As shown on the contract drawings.
   b. Apparent Opening Size: As shown on the contract drawings.
   c. Permittivity: As shown on the contract drawings.
4. Film Backing: Polymeric film bonded to drainage core surface.

2.4 SOIL MATERIALS

A. Soil materials are specified in Section 31 20 00 "Earth Moving."

2.5 WATERPROOFING FELTS

A. Material: Comply with ASTM D 226, Type I, asphalt.

2.6 GEOTEXTILE FILTER FABRICS

A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 GPM/SQFT when tested according to ASTM D 4491.

B. Structure Type: Nonwoven, needle-punched continuous filament.
   1. Survivability: AASHTO M 288 Class 2.
   2. Styles: Flat and sock.

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. Verify that drainage panels installed as part of foundation wall waterproofing is properly positioned to drain into subdrainage system.

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

3.2 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 31 20 00 "Earth Moving."

3.3 FOUNDATION DRAINAGE INSTALLATION

A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 IN deep and 12 IN wide.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 IN.

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive.

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.

F. Add drainage course to width of at least 6 IN on side away from wall and to top of pipe to perform tests.

G. After satisfactory testing, cover drainage piping to width of at least 6 IN on side away from footing and above top of pipe to within 12 IN of finish grade.

H. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

I. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 IN.

J. Install drainage panels on foundation walls as follows:
   1. Coordinate placement with other drainage materials.
   2. Lay perforated drainage pipe at base of footing. Install as indicated in Part 3 "Piping Installation" Article.
   3. Separate 4 IN of fabric at beginning of roll and cut away 4 IN of core. Wrap fabric around end of remaining core.
   4. Attach panels to wall beginning at subdrainage pipe. Place and secure molded-sheet drainage panels, with geotextile facing away from wall.

K. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 IN. Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

3.4 UNDERSLAB DRAINAGE INSTALLATION

A. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 IN between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 IN.

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive.

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for underslab subdrainage.

F. Add drainage course to width of at least 6 IN on side away from wall and to top of pipe to perform tests.

G. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.

H. Install horizontal drainage panels as follows:
   1. Coordinate placement with other drainage materials.
   2. Lay perforated drainage pipe at inside edge of footing.
   3. Place drainage panel over drainage pipe with core side up. Peel back fabric and wrap fabric around pipe. Locate top of core at bottom elevation of floor slab.
   4. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.

3.5 RETAINING-WALL DRAINAGE INSTALLATION

A. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

B. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 IN.

C. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive.

D. Install drainage piping as indicated in Part 3 "Piping Installation" Article for retaining-wall subdrainage.

E. Add drainage course to width of at least 6 IN on side away from wall and to top of pipe to perform tests.

F. After satisfactory testing, cover drainage piping to width of at least 6 IN on side away from footing and above top of pipe to within 12 IN of finish grade.

G. Place drainage course in layers not exceeding 3 IN in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.

H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 IN.

I. Install drainage panels on wall as follows:
   1. Coordinate placement with other drainage materials.
   2. Lay perforated drainage pipe at base of footing as described elsewhere in this Specification. Do not install aggregate.
   3. If weep holes are used instead of drainage pipe, cut 1/2 IN diameter holes on core side at weep-hole locations. Do not cut fabric.
   4. Mark horizontal calk line on wall at a point 6 IN less than panel width above footing bottom. Before marking wall, subtract footing width.
   5. Separate 4 IN of fabric at beginning of roll and cut away 4 IN of core. Wrap fabric around end of remaining core.
   6. Attach panel to wall at horizontal mark and at beginning of wall corner. Place core side of panel against wall. Use concrete nails with washers through product. Place nails from 2 to 6 IN below top of panel, approximately 48 IN apart. Construction adhesives, metal stick pins, or double-sided tape may be used instead of nails. Do not penetrate waterproofing. Before using adhesives, discuss with waterproofing manufacturer.
   7. If another panel is required on same row, cut away 4 IN of installed panel core and wrap fabric over new panel.
   8. If additional rows of panel are required, overlap lower panel with 4 IN of fabric.
   9. Cut panel as necessary to keep top 12 IN below finish grade.
   10. For inside corners, bend panel. For outside corners, cut core to provide 3 IN for overlap.

J. Fill to Grade: Place satisfactory soil fill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 IN. Thoroughly compact each layer. Fill to finish grade.

3.6 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. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 IN.

D. Install drainage conduits as indicated in Part 3 "Piping Installation" Article for landscaping subdrainage with horizontal distance of at least 6 IN between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with adhesive.

E. Add drainage course to top of drainage conduits.

F. After satisfactory testing, cover drainage conduit to within 12 IN of finish grade.

G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 IN.

I. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 IN. Thoroughly compact each layer. Fill to finish grade.

3.7 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. Foundation Subdrainage: Install piping level and with a minimum cover of 36 IN unless otherwise indicated.
   2. Underslab Subdrainage: Install piping level.
   3. Plaza Deck Subdrainage: Install piping level.
   4. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of 36 IN unless otherwise indicated.
   5. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 IN unless otherwise indicated.
   6. Lay perforated pipe with perforations down.
   7. 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.

3.8 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. Join perforated PVC sewer pipe and fittings according to ASTM D 3212 with loose bell-and-spigot, push-on joints.

C. 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.

3.9 BACKWATER VALVE INSTALLATION

A. Comply with requirements for backwater valves specified in Section 33 41 00 "Storm Utility Drainage Piping."

B. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.

C. Install horizontal backwater valves in piping in manholes or pits where indicated.

3.10 CLEANOUT INSTALLATION

A. Comply with requirements for cleanouts specified in Section 33 41 00 "Storm Utility Drainage Piping."

B. Cleanouts for Foundation, 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 (DN 100) 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 IN deep. Set top of cleanout flush with grade.
3. In nonvehicular-traffic areas, use NPS 4 (DN 100) 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 IN deep. Set top of cleanout 2 IN above grade.
4. Comply with requirements for concrete specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

C. Cleanouts for Underslab Subdrainage:
1. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. Use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.

3.11 CONNECTIONS

A. Comply with requirements for piping specified in Section 33 41 00 "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect low elevations of subdrainage system to inlets, manholes or as shown in the contract drawings.

3.12 IDENTIFICATION

A. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Section 31 20 00 "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.

3.13 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.

3.14 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

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SECTION 33 60 00
GAS DISTRIBUTION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Pipes,and fittings.
   2. Piping specialties.
   3. Valves.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

A. Operating-Pressure Ratings:
   1. Piping and Valves: Tested at 100 psig unless otherwise indicated.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Valves. Include pressure rating and capacity.

B. Shop Drawings: For natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe

C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Welding certificates.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

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

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

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes 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.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.10 PROJECT CONDITIONS

A. Perform site survey, and verify existing utility locations. Contact Architect for point of pipe service extension.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
   1. Notify Architect no fewer than seven calendar days in advance of proposed interruption of natural-gas service.
   2. Do not proceed with interruption of natural-gas service without Architect's written permission.
   3. Purging valve (blow-off) assemblies are for the purpose of venting or purging gas, air or nitrogen from a section of pipeline within a reasonable time interval.
   4. Service tees are to be placed on the pipe for the pressure gauge and vent testing connections. These connections are to set over the pipe as necessary to perform pipe testing requirements in accordance to NFPA 54 and authorities having jurisdiction.
   5. Natural gas piping will be considered defective if it does not past tests and inspections. The contractor shall prepare test and inspection reports.

1.11 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
   3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   a. Material Group: 1.1.
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
   e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
6. Mechanical Couplings:
   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) Dresser Piping Specialties; Division of Dresser, Inc.
      2) Smith-Blair, Inc.
   b. Steel flanges and tube with epoxy finish.
   c. Buna-nitrile seals.
   d. Steel bolts, washers, and nuts.
   e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
   f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. HDPE Pipe: ASTM D 2513, SDR 11.
   1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
   2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   3. Tracer Wire: Solid, bare, and hard drawn, ASTM B1
   4. Anodeless Service-Line Risers: Factory fabricated and leak tested.
      a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
      b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering.
      c. Aboveground Portion: PE transition fitting.
      d. Outlet shall be threaded or flanged or suitable for welded connection.
      e. Tracer wire connection.
      f. Ultraviolet shield.
      g. Stake supports with factory finish to match steel pipe casing or carrier pipe.
   5. Transition Service-Line Risers: Factory fabricated and leak tested.
      a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
      b. Outlet shall be threaded or flanged or suitable for welded connection.
      c. Bridging sleeve over mechanical coupling.
      d. Factory-connected anode.
      e. Tracer wire connection.
      f. Ultraviolet shield.
      g. Stake supports with factory finish to match steel pipe casing or carrier pipe.
   6. Mechanical Couplings, NPS2 and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

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) Lyall, R. W. & Company, Inc.
    2) Mueller Co.; Gas Products Div.
    3) Perfection Corporation; a subsidiary of American Meter Company.>.
b. Fiber-reinforced plastic body.
c. PE body tube.
d. Buna-nitrile seals.
e. Acetal collets.
f. Stainless-steel bolts, nuts, and washers.

7. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    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) Dresser Piping Specialties; Division of Dresser, Inc.
        2) Smith-Blair, Inc.
    b. Steel flanges and tube with epoxy finish.
    c. Buna-nitrile seals.
    d. Steel bolts, washers, and nuts.
    e. Factory-installed anode for steel-body couplings installed underground.

2.2 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. 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.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 DEGF complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.3 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
    1. CWP Rating: 125 psig.
    2. Threaded Ends: Comply with ASME B1.20.1.
    3. Flange Ends. Comply with ASME B16.5 for steel flanges
    4. Tamperproof Feature: Locking feature for valves located above grade.
    5. On valve body.

B. PE Ball Valves: Comply with ASME B16.40.
    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. Kerotest Manufacturing Corp.
        b. Lyall, R. W. & Company, Inc.
        c. Perfection Corporation; a subsidiary of American Meter Company.
    2. Body: PE.
    3. Ball: PE.
    4. Stem: Acetal.
    5. Seats and Seals: Nitrile.
    6. Ends: Plain or fusible to match piping.
    7. CWP Rating: 100 psig
    8. Operating Temperature: Minus 20 to plus 140 DEGF Operator: Nut or flat head for key operation.
    9. Include plastic valve extension.

10. Include tamperproof locking feature for valves where indicated on Drawings.

C. Valve Boxes:
   1. Cast-iron, two-section box.
   2. Top section with cover with "GAS" lettering.
   3. Bottom section with base to fit over valve and barrel a minimum of 5 IN in diameter.
   4. Adjustable cast-iron extensions of length required for depth of bury.
   5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.4 DIELECTRIC FITTINGS

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

B. Dielectric Unions:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Wilkins; a Zurn company; Model DUBI or comparable product by one of the following:
      a. Capitol Manufacturing Company.
      b. Central Plastics Company.
      c. Hart Industries International, Inc.
      d. Jomar International Ltd.
      e. Matco-Norca, Inc.
      f. McDonald, A. Y. Mfg. Co.
      g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Description:
      a. Standard: ASSE 1079.
      b. Pressure Rating: 125 psig.
      c. End Connections:threaded ferrous.

C. Dielectric-Flange Insulating Kits:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.>.
   2. Description:
      a. Nonconducting materials for field assembly of companion flanges.
      b. Pressure Rating: 150 psig.
      c. Gasket: Neoprene or phenolic.
      d. Bolt Sleeves: Phenolic or polyethylene.
      e. Washers: Phenolic with steel backing washers.

2.5 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 IN wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 IN deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 30 IN below finished grade. Comply with requirements in Section 31 20 00 "Earth Moving" for excavating, trenching, and backfilling.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:
   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
   3. Replace pipe having damaged PE coating with new pipe.

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

F. Install pressure gage upstream and downstream from each service regulator.

G. "Metal Fabrications" for pipe bollards.

3.4 VALVE INSTALLATION

A. Install underground valves with valve boxes.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

C. Install anode for metallic valves in underground PE piping.

3.5 PIPING 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:
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
   5. 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. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. PE 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 Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.6 CONNECTIONS

A. Connect to Owner's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

3.7 LABELING AND IDENTIFYING

A. Install detectable warning tape directly above gas piping, 12 IN below finished grade, except 6 IN below subgrade under pavements and slabs.

3.8 PAINTING

A. Comply with requirements in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting" for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Interior latex matching topcoat.
      c. Topcoat: Interior latex flat.
      d. Color: Yellow.

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be the following:
   1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
   2. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

3.11 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

B. Underground PE valves ANSI B16.40 and ASTM D 2513.

END OF SECTION

DIVISION 41

MATERIAL PROCESSING AND HANDLING EQUIPMENT

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SECTION 41 22 00
FREE STANDING WORK STATION BRIDGE CRANES (FSBC)

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment and services for Free Standing Work Station Bridge Cranes, as indicated, in accordance with provision of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in designing and manufacturing cranes with 25 years successful experience.

B. Installer Qualifications: Company experienced in assembly and installation of cranes with 5 years successful experience and acceptable to crane manufacturer.
   1. Perform welding by certified operators in accordance with AWS D14.1.
   2. Bolted connections shall be in accordance with torque tightening procedures specified in AISC Manual, Part 5.
   3. Clearly label crane with rated load capacity. Place label at height and location easily read from floor level and loading position.

C. American Institute of Steel Construction (AISC)

D. Manual of Steel Construction, Part 5, Specification for Structural Joints Using ASTM A325 or ASTM A490 Bolts.

E. American National Standards Institute (ANSI)
   1. ANSI B30.11 - Monorails and Underhung Cranes.

F. ASTM International (ASTM):
   1. ASTM A36 - Carbon Structural Steel.
   2. ASTM A325 - Structural Bolts, Steel, Heat Treated, 120/150 ksi Minimum Tensile Strength.
   3. ASTM A490 - Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.

G. American Society for Testing and Materials (ASTM) B221
   1. Aluminum-Alloy Extruded Bar, Rod, Wire, Shape, and Tube.

H. American Welding Society (AWS)
   1. D1.1 - Structural Welding Code.

I. Occupational Safety and Health Administration (OSHA)
   1. Specification 1910.179 - Overhead and Gantry Cranes.

J. Design Responsibility:
   1. Engineering design submittal must be performed by, or under direct supervision of, a registered Engineer, licensed to practice Structural Engineering in State of Maryland.
   2. Submittal must include calculations verifying the sizing of bridge girders, end trucks and travel drivers.
      a. Indicate design live loads on submittal.
   3. Submittal to be reviewed by Architect for general conformance with design intent shown by Contract Documents.

K. Certificates: Provide overload Test Certificate stating that crane can be periodically load tested to 125 percent (plus 5 to minus 0) of rated load. Also submit the following certificates stating:
   1. No Hazardous Material is contained within system or components.
   2. System is safe to perform a Loss of Power Test.
   3. Certificate of Compliance with listed Standards.

L. LEED Requirements:
   1. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Shop drawings showing configuration, dimensions, service area, and construction and installation details.

B. Product Data: Manufacturer's data sheets on each product to be used, including:
   1. Describe capacities, performance, operation, and applied forces to foundation.
   2. Preparation instructions and recommendations.
   3. Storage and handling requirements and recommendations.
   4. Installation methods.

C. Project Information:
   1. Environmental requirements.
   2. Engineering design calculations, sealed by registered Engineer, licensed to practice Structural Engineering in state where project is located.

D. Contract Closeout Information:
   1. Maintenance data.
   2. Owner instruction report.
   3. Warranty.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

B. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.5 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1.6 WARRANTY

A. Manufacturer's Warranty: On manufacturer's standard form, in which manufacturer agrees to repair or replace assemblies and components that fail in materials and workmanship within warranty period from date of Substantial Completion.
   1. 5 years or 10,000 hours warranty for manual push-pull work station crane, jib crane, and gantry crane products to cover defects in materials and workmanship.
   2. 2 years or 4,000 hours warranty for motorized tractor products.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Free Standing Work Station Bridge Crane:
   1. Base:
      a. Gorbel Inc.

2.2 FREE STANDING WORK STATION BRIDGE CRANES

A. Performance:
   1. Crane shall provide coverage of rectangular area of size indicated on Drawings and consist of:
      a. Support structure requiring only primary structural support without longitudinal or lateral bracing.
      b. Two rigid, parallel runways. Cranes with more than two runways or with articulating runways are not acceptable.
      c. Rigid, single girder bridge moving perpendicular to runways or monorail. Double girder bridges and ones with articulating or threaded connections are not acceptable.
   2. Modular, pre-engineered design: Crane system shall be capable of expansion, disassembly and relocation, and accepting additional or multiple mixed capacity bridges.
      a. Crane shall be designed, fabricated, and installed in accordance with ANSI B30.11, and OSHA 1910.179.
   3. Productivity ratio: Crane shall be designed to manually move load with maximum force of 1/100 load weight.
   4. Runway and bridge track: Enclosed type limiting dust and dirt collection on rolling surfaces with maximum deflection of 1/450 span based on capacity plus 15 percent for lifting device weight.
   5. Crane operating temperature: 5 to 200 degrees F (-15 to 93 C).
   6. Crane shall be designed to withstand:
      a. Structural design shall include full rated load capacity plus 15 percent for hoist and trolley weight and 25 percent impact factor for speed of lifting device and weight of tooling.
      b. Crane and hoist dead load.
      c. Live load capacity equal to net rated hook load: 2000 pounds (908 kg).
      d. Inertia forces from crane and load movement.

B. Free Standing Bridge Crane: Work station, bridge crane with free standing support structure, two runways, bridge moving perpendicular to runways, and equipped with enclosed track, end trucks, hoist trolley, festooning system, bumpers, and other accessories.
   1. Model:
      a. Model GLCSLX-FS: Cranes with trussed steel runways supported at 30 FT maximum.
   2. Construction: Fabricate from ASTM A36 steel sections with finished ends and surfaces.
   3. Support structure: Support crane runways with frames consisting of two columns and horizontal header.
      a. Columns: Square tubes with bottom base plate and top header plate.
      b. Header: Fabricated from two back-to-back channels spaced apart and joined with welded end plates. Provide clamp plates, threaded rods, lock washers, and hex nuts for attaching header to column.
      c. Hanger assemblies: Provide each support frame with pair of hanger assemblies that provide a rigid connection for suspending runways. Assembly to consist of clamp angle, clamp plates, threaded rods, lock washers, and hex nuts.
   4. Runways: Vierendeel truss fabricated from square steel tubes and enclosed steel track.
      a. Track: Enclosed, cold formed, steel box track which serves as bottom cord of runway and permits end trucks and festoon carriers to ride on lower inside flanges. Fabricate lower running flanges with 2 degrees taper to center trolley within track. Flat, non-centering tracks are not acceptable.

b. Splice joint: Provide truss splice plates, channel-shaped track splice joint, bolts, lock washers, and nuts for joining runway sections. Splice joints must be located within 4 FT of a support point.
c. Runway Cantilevers: Up to 4 FT of cantilever is allowed from a hanger location to the end of the runway.
d. Festoon stack section: Provide enclosed track extension to provide for stacking festoon carriers at end of runway.

5. Bridge: Single girder, Vierendeel truss fabricated from rectangular steel tubes and enclosed steel box track; patented truss design for 2000 LB capacities.
   a. Track serves as bottom cord of bridge and permits hoist trolley and festoon carriers to ride on lower inside flanges.
   b. Fabricate lower running flanges with 2 degrees taper to center trolley within track. Flat, non-centering tracks are not acceptable.
6. Bridge: Enclosed, cold formed steel box track which permits hoist trolleys and festoon carriers to ride along track lower inside flanges. Fabricate lower running flanges with 2 degrees taper to center trolley within track. Flat, non-centering tracks are not acceptable.
7. End trucks: Rigid frame end truck designed to ride inside enclosed runway track and connect to and suspend bridge.
   a. Construction: Stamped steel fabrication with both vertical and horizontal wheels to prevent binding in runway. Designs with welds in tension are not acceptable.
   b. Wheels: Removable, self-centering wheels with sealed lifetime lubricated bearings. Vertical wheels shall be tapered 2 degrees to match track profile. Non-removable or non-tapered wheels are not acceptable. Duracomp 4 wheel material. Steel wheels are not acceptable.
   c. Drop lugs: Provide on both sides of truck to limit truck drop in the event of wheel, axle, or load bar failure.
   d. Connection to the bridge: Provide a rigid connection between bridge and end truck. Articulating connections with threaded hardware are not acceptable.
   e. Designed for easy attachment of peripherals.
8. Hoist trolley: Rigid-body trolley designed to ride inside enclosed track of bridge and to carry hoist and load. Articulating trolleys are not acceptable.
   a. Construction: Two-piece stamped steel body with two wheels each side and tapered clevis positioning hoist hook at center of trolley so load weight is evenly distributed to all four trolley wheels. Provide removable clevis pin of type and size determined by manufacturer for specified capacity. Trolleys with non-removable clevis pins are not acceptable. Holes provided in body for mechanical connections.
   b. Wheels: Removable, self-centering wheels with sealed lifetime lubricated bearings. Vertical wheels shall be tapered 2 degrees to match track profile. Non-removable or non-tapered wheels are not acceptable. Duracomp 4 wheel material. Steel wheels are not acceptable.
   c. Drop lugs: Provide on both sides of trolley to limit trolley drop in the event of wheel, axle, or load bar failure.
   d. Designed for easy attachment of peripherals.
9. End stops: Molded composite, resilient bumper installed in runway and bridge tracks to prevent end trucks, hoist trolley, and festoon carriers from rolling out of track. Bolt stops without energy absorbing bumper are not acceptable.

C. Tractor Drive:
1. Provide electric tractor drive for motorized operation of hoist trolley and end truck.
   a. Type: Variable frequency drive assembly with worm gear reducer, molded polyurethane tread, and adjustable counter-balance to ensure proper drive wheel alignment.
   b. Speed: 70 FT per minute.
   c. Motor: 1/3 HP, 1800 RPM, 3 phase, 208-460 volt, with thermal overload protection.

d. Controls: 24 volt control package with transformer, terminal strips, fusing, enclosure, and mounting brackets.
e. Controls to be factory wired to drive motor.

D. Festoon Assemblies:
1. Provide length of cable and/or air hose to supply lifting device. Supply shall be festooned along bridge and runway.
2. Festoon trolleys: Four-wheeled trolleys with pivoting saddle and applicable attachment to support service run on runway or bridge and allowing festooning as end truck or hoist trolley travels.
3. Festoon gliders: T-shaped gliders with adjustable applicable attachment to support service runs on runway or bridge and allowing festooning as end truck or hoist trolley travels.
4. Festoon clamp: Steel clamp assembly attached to track to prevent festoon trolleys and gliders from exiting track.
5. Festoon tow clamp: Steel clamp assembly attached to track to prevent festoon from binding under with end truck or trolley.

2.3 SHOP FINISHING

A. Steel: Steam wash steel crane components with iron phosphate solution and apply yellow baked enamel finish.

B. Aluminum: Mill finish.

C. Provide spray can of matching color, air-drying paint for field touch-up.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Do not begin installation until support structures have been properly prepared.

B. Design and construction of reinforced concrete footings and slabs as detailed on Drawings and specified in other sections. Verify that accurate crane applied forces and anchor bolt patterns are provided for foundation design.

3.2 INSTALLATION

A. Install units and accessories in accordance with manufacturer's instructions and approved shop drawings.

B. Do not modify crane components in any manner without advance written approval by crane manufacturer.

C. Clearances for moving crane components:
1. 3 IN minimum vertical clearance from any overhead obstruction.
2. 2 IN minimum horizontal clearance from any lateral obstruction.
3. Prior to applying proper torque to the bolts, ensure runways are:
   a. Level to within plus or minus 1/8 IN in 20 FT.
   b. Parallel with opposite runway to within plus or minus (3 mm in 6.1 m).

3.3 FIELD QUALITY CONTROL

A. Perform field quality control testing as recommended by manufacturer.

B. Move bridge and hoist trolley through entire travel to ensure crane is clear of obstructions and moves freely and smoothly.

C. Inspect installed crane. Verify all bolts are tight and lock washers fully compressed.

D. Field test crane and accessories for operating functions. Ensure crane movement is smooth and proper. Adjust as required and correct deficiencies.

E. Clean surfaces. If necessary, touch-up paint damage, scratches, and blemishes with manufacturer provided matching paint.

F. Protect crane from other construction operations.

3.4 DEMONSTRATING AND TRAINING

A. Provide demonstration and training session for Owner's representative covering operation and maintenance.

3.5 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products.

3.6 SCHEDULE OF FREE STANDING BRIDGE CRANES

A. General:
1. Acknowledge and verify that wheel load is less than maximum wheel load specified.
2. "Hook height" is minimum acceptable distance from bottom of hook in full raised position to nearest floor surface.
3. "Lifting height is distance from bottom of hook in full raised position to lowest floor from which items may be hoisted.
4. Distances listed are approximate since they will vary depending on hoist and trolley selection.

ROOM W189: AP1 PROGRAM

FREE STANDING BRIDGE CRANE (FSBC) No. 1

1. Type: Free Standing Work Station Bridge Crane.
2. Support Assembly Span: 29 FT - 0 IN long x 19 FT - 0 IN wide.
3. Bridge Span: 15 FT - 0 IN.
    a. Bridge Cantilever: 1 FT - 6 IN each side.
4. Runway Cantilever: N/A
5. Capacity: 2 tons.
6. Hook Height: 12 FT - 0 IN from top of raised access floor system.
7. Lifting Height: 12 FT - 0 IN.
8. Trolley: Motor driven.
9. Bridge Speed: 70 FPM.
10. Electrical: 208-460 volt 3 phase.
11. Special Environment: ISO 8 Class 100,000 cleanroom.
12. Maximum Support Assembly Height: 15 FT - 6 IN.

ROOM E187: GSEL

FREE STANDING BRIDGE CRANE (FSBC) No. 2

1. Type: Free Standing Work Station Bridge Crane.
2. Support Assembly Span: 30 FT - 0 IN long x 19 FT - 0 IN wide.
3. Bridge Span: 15 FT - 0 IN.
   a. Bridge Cantilever: 1 FT - 6 IN each side.
4. Runway Cantilever: N/A
5. Capacity: 2 tons.
6. Hook Height: 12 FT - 0 IN from top of raised access floor system.
7. Lifting Height: 12 FT - 0 IN.
8. Trolley: Motor driven.
9. Bridge Speed: 70 FPM.
10. Electrical: 208-460 volt 3 phase.
11. Special Environment: ISO 8 Class 100,000 cleanroom.
12. Maximum Support Assembly Height: 15 FT - 6 IN.

ROOM E112: GSEL

FREE STANDING BRIDGE CRANE (FSBC) No. 3

1. Type: Free Standing Work Station Bridge Crane.
2. Support Assembly Span: 30 FT - 0 IN long x 19 FT - 0 IN wide.
3. Bridge Span: 15 FT - 0 IN.
   b. Bridge Cantilever: 1 FT - 6 IN each side.
4. Runway Cantilever: 2 FT - 0 IN at front.
5. Capacity: 2 tons.
6. Hook Height: 12 FT - 0 IN from top of raised access floor system.
7. Lifting Height: 12 FT - 0 IN.
8. Trolley: Motor driven.
9. Bridge Speed: 70 FPM.
10. Electrical: 208-460 volt 3 phase.
11. Special Environment: ISO 8 Class 100,000 cleanroom.
12. Maximum Support Assembly Height: 15 FT - 6 IN.

END OF SECTION

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SECTION 41 22 13
BRIDGE CRANES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment and services for Bridge Cranes, as indicated, in a accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Refer to most recent editions of following standards for detailed specification requirements for materials, methods, tests and physical parameters:
   1. Crane Manufacturers Association of America; 1326 Freeport Road; Pittsburgh, Pennsylvania 15238.
      a. CMAA No.70: Specifications for Electric Overhead Traveling Cranes.
      b. Hoist Manufacturers Institute (HMI).
      c. HMI 100 Standard Specifications for Electric Wire Rope Hoists.
   2. NASA-STD-8719.9: Standard for Lifting Devices and Equipment; Section 4 – Overhead Cranes.

B. Design Responsibility:
   1. Engineering design submittal must be performed by, or under direct supervision of, a registered Engineer, licensed to practice Structural Engineering in State of Maryland.
   2. Submittal must include calculations verifying the sizing of bridge girders, end trucks and travel drivers.
      a. Indicate design live loads on submittal.
   3. Submittal to be reviewed by Architect for general conformance with design intent shown by Contract Documents.

C. Certificates: Provide overload Test Certificate stating that crane can be periodically load tested to 125 percent (plus 5 to minus 0) of rated load. Also submit the following certificates stating:
   1. No Hazardous Material is contained within system or components.
   2. System is safe to perform a Loss of Power Test.
   3. Crane Runway System conforms to the requirements as specified herein and as specified in Section 05 12 10 STRUCTURAL STEEL.
   4. Certificate of Compliance with listed Standards.

D. Furnish equipment made by a recognized reputable manufacturer.

E. Insure that all equipment selected is locally serviceable with replacement parts readily available.

F. After installation is complete, secure and pay for services of a representative of equipment supplier and provide supervision of any final adjustments.

G. Give Owner's personnel complete instructions regarding proper operation and maintenance procedures.

H. Secure from manufacturer's representative a written report stating installation has been examined and units are installed properly and in accordance with manufacturer's recommendations.

I. Submit manufacturer’s representative’s report to Architect and Owner.

J. Have all welding done by certified welders in accordance with American Welding Society Standards.

1.3 LEED REQUIREMENTS

A. Refer to Section 01 81 13, LEED v2009 Requirements, for additional performance requirements that may apply to products specified in this section.

1.4 SUBMITTALS

A. Shop drawings:
  1. Include with shop drawings structural calculations for track, supports, reports of tests verifying strength of inserts and rail, track layout including arrangement of supports, splices, and connections, and details of hoists, trolleys, etc.

B. Product data.

C. Project information:
  1. Environmental requirements.
  2. Engineering design calculations, sealed by registered Engineer, licensed to practice Structural Engineering in state where project is located.

D. Contract closeout information:
  1. Maintenance data.
  2. Owner instruction report.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Handle, unload, and store equipment in full accordance with manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Bridge Cranes
  1. Base:
    a. Dearborn Overhead Crane.
  2. Optional:
    a. Konecranes, Inc.

2.2 CRANE CONSTRUCTION - DOUBLE GIRDER TYPE

A. General:
  1. Provide top running double girder bridge crane(s) as specified, scheduled and shown on drawings.
  2. Design load carrying parts, except structural members and hoisting ropes and gearing, so that calculated stress in material, based on rated load, does not exceed 20 percent of published average ultimate strength of the material.
  3. Comply with CMAA No.70 unless noted otherwise.

B. Trolley and hoist:
  1. Provide specified and scheduled trolley and hoist compatible with scheduled bridge crane.

C. Runway rails:
  1. Type: 60# ASCE.
  2. Provide straight, parallel and level rails at same elevation.
  3. Distance C to C and elevation within a tolerance of plus or minus 1/8 IN.
  4. Design runway with sufficient strength and rigidity to prevent detrimental lateral or vertical deflection.

D. Girders:
   1. Construct crane girders of welded structural steel box sections, wide flange beams, standard "I" beams, reinforced beams, or box sections fabricated from structural shapes.
   2. Design girders to resist all vertical, lateral and torsional forces in accordance with CMAA No.70.
   3. Maximum vertical deflection of girder produced by dead load, weight of trolley and hoist and rated load not exceeding 1/800 of span.
   4. Securely fasten bridge rails to maintain center distance of rails.
   5. Provide positive stop at ends of rails to prevent creeping of bridge rails.
   6. Locate safety stops at each end of bridge girder to prevent over-travel of trolley hoist.

E. End trucks:
   1. Design end trucks to carry rated load when load is lifted at one end of crane bridge.
   2. End truck wheel base minimum of 1/7 of crane span.
   3. Construct bridge end trucks of structural steel providing a rigid structure; assure proper alignment of axles.
   4. Design truck to prevent a drop of more than one IN in case of axle or wheel failure.

F. Crane wheels:
   1. Design double flanged wheels with straight or tapered tread to carry maximum wheel load.
   2. Provide steel or heat treated ductile iron wheels with hardened tread.

G. Crane drives:
   1. Provide totally enclosed fan-cooled motors.
   2. Motors: Integral with fully enclosed oil splash lubricated gear reducers.

H. Bearings:
   1. Design bearings for minimum 5000 hours B-10 bearing life.

I. Gearing:
   1. Provide adequate and proper lubrication on all gearing.
   2. Except for final reduction at wheels, run gearing in oil or splash lubricate gearing.
   3. Comply with AGMA specifications for load ratings.
   4. Provide guards for gearing not enclosed in gear boxes.
   5. Make provision for lubrication and inspection.

J. Bridge brake:
   1. Provide bridge brake with a torque rating of at least 50 percent of bridge motor torque.

K. Bumpers, stops, and rail sweeps:
   1. Mount bridge bumpers on each end of end truck.
   2. Provide bumpers capable of stopping crane (not including lifted load) at an average rate of deceleration not to exceed 3 FT/second/second.
   3. Provide bumpers with sufficient energy absorbing capacity to stop crane when traveling at a speed of at least 40 percent of rated load speed.
   4. Provide runway stops located at limits of bridge travel.
   5. Design runway stops to resist full load speed.
   6. Runway stops shall not engage wheel tread.
   7. Provide trolley bumpers on each end of trolley.
   8. Design bumpers to stop trolley (not including lifted load) at an average rate of deceleration not to exceed 4.7 feet/second/second when traveling at 1/3 of rated load speed.
   9. Provide trolley stops at limits of trolley travel.
   10. Equip bridge end trucks with rail sweeps which extend below top of rail and project in front of crane wheels.

L. Bridge crane control:
   1. Pendant control station:
      a. Comply with NEMA Type 12.
      b. 4 FT above finish floor.

c. 3-speed control for hoist, bridge, and trolley:
   1) Infinitely variable type.
d. Provide the crane with the following rated load speeds:
   1) Hoist: Rated speed of 0 to 20 FT per minute; Stepless VFD.
   2) ESR hoist speed of 25 FT per minute.
   3) Trolley: Rated speed of 0 to 65 FT per minute; Stepless VFD.
   4) Bridge: Rated speed of 0 to 80 FT per minute; Stepless VFD.

2. Remote radio control system:
   a. Comply with NEMA ICS 8, Part 9 and FFC Part 15 (unlicensed frequencies).
   b. Control to permit complete, independent and simultaneous operation of all crane functions.

M. Electrical supply:
1. Provide disconnect switch with crane to open all ungrounded conductors.
   a. Fused.
2. Disconnect switch shall meet all requirements of Division 26.
3. Location of disconnect switch as indicated on electrical drawings.
4. Electrical supply supplied to mainline contactor and bridge control.
5. Provide using figure 8 safety conductor system.
   a. Duct-O-Bar or Insul 8.
   b. Include collectors and all other components necessary for 2 complete, operable systems.

N. Electrical controls:
1. Bridge control: Energized from mainline contactor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide installation by manufacturer or manufacturer’s authorized representative.

B. Assure all required components are properly installed.

C. Verify operation prior to substantial completion and correct all deficiencies.

3.2 OPERATIONAL TESTING

A. Perform in presence of Owner.

B. Instruct Owner's personnel in correct operation and maintenance.

3.3 FINAL CLEANUP

A. Leave unit in correct operational condition.

B. Perform final cleaning.

3.4 SCHEDULE OF CONVEYING SYSTEMS

A. General:
1. Acknowledge and verify that wheel load is less than maximum wheel load specified.
2. "Hook height" is minimum acceptable distance from bottom of hook in full raised position to nearest floor surface.
3. "Lifting height is distance from bottom of hook in full raised position to lowest floor from which items may be hoisted.
4. Distances listed are approximate since they will vary depending on hoist and trolley selection.

ROOM W182: HIGH BAY HOMELAND

BRIDGE CRANE No. 1

1. Type: CXTD Double Girder Crane/Box Grinder.
2. Span - 40 FT - 1 IN.
3. 15 ton capacity - single hoist on trolley.
4. 28 FT - 0 IN hook height.
5. Lifting height: 28 FT - 0 IN.
6. 62 FT long runway - single crane on runway.
7. CMAA Class C - Indoor Operation - Non-Hazardous. Hoist class H3.
8. Crane weight with hoist: Approximately 13,000 LBS.
9. Structural finishing: EN 5 mil, RAL1028.
10. Static wheel load: 7.4 kips.
11. Electrical: 460 volt, 3 phase, 60 Hz, 115V control.
    a. Starting/nominal current: 87.2 A/27.2 A.
12. Wire rope hoist type: 1x CXT50420080S5.
13. Duty group hoist: ISO M6.
14. Trolley type: Double girder trolley.
15. Reeving type: Center lift.
16. Provide enclosure or guarding for oil drips.
17. Requires full length service platform with safety harness rail.
18. Power supply type: Conductor bar.
19. Top of runway rail support: 30 FT - 0 IN.

ROOM W188 and E188: HIGH BAY HOMELAND

BRIDGE CRANE No. 2

1. Type: CXTD Double Girder Crane/Box Grinder.
2. Span - 42 FT - 4 IN.
3. 15 ton capacity - single hoist on trolley.
4. 28 FT - 0 IN hook height.
5. Lifting height: 28 FT - 0 IN.
6. 62 FT long runway - single crane on runway.
7. CMAA Class C - Indoor Operation - Non-Hazardous. Hoist class H3.
8. Crane weight with hoist: Approximately 13,000 LBS.
9. Structural finishing: EN 5 mil, RAL1028.
10. Static wheel load: 7.4 kips.
11. Electrical: 460 volt, 3 phase, 60 Hz, 115V control.
    a. Starting/nominal current: 87.2 A 27.2 A.
12. Wire rope hoist type: 1x CXT50420080S5.
13. Duty group hoist: ISO M6.
14. Trolley type: Double girder trolley.
15. Reeving type: Center lift.
16. Provide enclosure or guarding for oil drips.
17. Requires full length service platform with safety harness rail.
18. Power supply type: Conductor bar.
19. Top of runway rail support: 30 FT - 0 IN.

ROOM E182: HIGH BAY KMT / KMP

BRIDGE CRANE No. 3

1. Type: CXTD Double Girder Crane/Box Grinder.
2. Span - 30 FT - 0 IN.
3. 15 ton capacity - two trolleys, single hoist per trolley.
4. 28 FT - 0 IN hook height.
5. Lifting height: 28 FT - 0 IN.
6. 77 FT long runway - single crane on runway.
7. CMAA Class C - Indoor Operation - Non-Hazardous. Hoist class H4.
8. Crane weight with hoist: Approximately 13,000 LBS.
9. Structural finishing: EN 5 mil, RAL1028.
10. Static wheel load: 7.4 kips.
11. Electrical: 460 volt, 3 phase, 60 Hz, 115V control.
    a. Starting/nominal current: 87.2 A/27.2 A.
12. Wire rope hoist type: 1x CXT50420080S5.
13. Duty group hoist: ISO M6.
14. Trolley type: Double girder trolley.
15. Reeving type: Center lift.
16. Provide enclosure or guarding for oil drips.
17. Requires full length service platform with safety harness rail.
18. Power supply type: Conductor bar.
19. Top of runway rail support: 30 FT - 0 IN.

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