Argonne NATIONAL LABORATORY

SPECIFICATIONS

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Issued for Proposal
Building No. 241

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HDR

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SECTION 20 05 00

GENERAL MECHANICAL REQUIREMENTS (Revised AD-1, AD-4)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Products:
      a. Access doors, panels, and frames.
      b. Equipment guards.

AD-4: Section 20 05 00: Add paragraph 1.1.A.1.c and renumber subsequent paragraphs.

      c. Heat tracing cable.
      d. Motors and controls.
      e. Rain hoods and counter flashings.
      f. Penetrations.
      g. Structural steel for supports.

B. 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.

C. Installation of systems and equipment:
   1. Installation is subject to clarification as indicated in reviewed Shop 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 corridors and aisle ways, 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).

D. Description of systems: 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 and standards:
   1. International Mechanical Code - 2006.
   2. International Energy Conservation Code - 2006.
   3. Illinois Plumbing Code - 2004.
   4. American Gas Association.

5. National Electrical Code 2008 Edition.
6. National Fire Protection Association.
7. Authorities having jurisdiction.

AD-4: Section 20 05 00: Add article 1.3 in its entirety and renumber subsequent articles.

1.3 SUBMITTALS

A. Product data:
   1. Heat tracing cable.

1.4 PROTECTION

A. Provide covering and shielding for all stored on-site or installed equipment 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. 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, 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. 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 1.

H. Operation and maintenance data: See Division 1.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:

AD-4: Section 20 05 00: Add paragraphs 2.1.A.1 through 2.1.A.1.b.1) and renumber subsequent paragraph.

1. Heat tracing cable:
   a. Base:
      1) Thermon Manufacturing.

b. Optional:
1) Raychem.

2. Motors:
a. Base:
1) Reliance Electric.
b. Optional:
1) Baldor.
2) Century Electronics; E-Plus.
3) General Electric; Energy Saver.
4) Westinghouse Motor.

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

2.2 ACCESS DOORS, PANELS, AND FRAMES

A. 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.

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. End of shaft shall be protected from accidental contact.
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.

AD-4: Section 20 05 00: Add article 2.4 in its entirety and renumber subsequent articles.

2.4 HEAT TRACING CABLE

A. Heat tracing cable shall consist of flat, flexible, low heat density strip of parallel circuit construction.
1. 16 AWG bus bars and a continuous inner core of self-regulating conductive material.
2. Insulate core with a radiation crosslinked polyolefin jacket.

B. Design system to maintain minimum water temperature of 40 degF at an ambient of 0.0 degF.
1. Interlock electrical power to operate whenever circuit breaker is energized and temperature is below 40 degF.

C. Cable shall be self-regulating.
1. Cable shall respond to varying localized temperature conditions along the pipe by self-regulating its heat output at each point along its length.

D. Provide power connection kit, splices, end seal kits, glass cloth adhesive tape, and other components required for a complete installation.

E. Provide adjustable high limit thermostat for outdoor mounting to prevent pipe temperature from exceeding 50 degF.

F. Power: 120/60/1.

2.5 MOTORS AND CONTROLS

A. Motors:
   1. Provide motors indicated in Division 23.
   2. Motors shall be ball or roller bearing type, high efficiency type, and have starting and running characteristics consistent with torque and speed requirements of driven machine:
      a. All motors 25 HP and larger shall have greasable bearings.
   3. Motor efficiency:
      a. NEMA Standard MG1-12.53a.
      b. Indicate full load efficiency on each nameplate.
      c. Minimum motor efficiency to comply with ASHRAE 90.1-2001, Table 10.2.
   4. Use motors 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.
   5. Motor powers as scheduled.
   6. Do not allow power requirements of driven machine to exceed nominal nameplate rating of motor furnished.
   7. Do not include service factor when selecting motor power.
   8. Motors 1/2 HP and over: 460/3/60.
   9. Motors less than 1/2 HP: 115/1/60.
   10. Provide for items which require electric drive.
   11. Motors for certain pieces of equipment will be controlled by adjustable frequency drives (AFD's). These motors shall be designed for inverter-duty, have 1600 volt insulation for 460 V motors and double shielded bearings:
      a. Meet NEMA MG1-31.
      b. Provide grounding system for protection from static and AFD induced currents.
   12. Where equipment with motors will be driven by adjustable frequency drives (AFD's), provide motors that are compatible with AFD's.

B. Motor controls and wiring for controls:
   1. Provide complete installation of controls and wiring for controls for Division 20 through 25 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 Division 20 through 25 shall comply with applicable Division 26 specifications.
   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.

2.6 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 counterflashings exposed to view:
   1. Material specified in Section 07 62 00.

2.7 PENETRATIONS

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

2.8 STRUCTURAL STEEL FOR SUPPORTS

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

PART 3 - EXECUTION

3.1 GENERAL

A. When changes in location of work are required, obtain approval of Owner 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 Owner.

E. Electrical equipment:

AD-1: Section 20 05 00: Revise paragraph 3.1.E.1.

   1. Install no ductwork or piping in or above communication equipment rooms, electrical equipment rooms and closets, except for ductwork and piping serving fan coil units.
   2. Install no ductwork or piping above panelboards, switchboards, motor control centers, or motor control panels.
   3. Floor drains may be installed in floor of electrical equipment rooms.

AD-1: Section 20 05 00: Revise paragraph 3.1.F.

F. In elevator machine rooms, install no piping except floor drains and fire protection piping and fan coil unit ducts and 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, service, or maintenance in normally accessible locations, or provide flush-mounted access doors:
   1. Such devices include but are not limited to equipment, valves, filters, motors, drives, air terminal units, compressors, unions, traps, strainers, thermometers, gauges, switches, measurement devices, coils, detectors, dampers, sensors, monitors, backflow prevention devices, water-hammer arresters, drains, floor sinks, cleanouts, test stations, signal devices, sprinkler, 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. Perform or pay for cutting, fitting, repairing, patching and finishing of work of other sections where it is necessary to disturb such work to permit installation of mechanical work.

B. Avoid cutting, where possible, by setting sleeves or frames, and by requesting openings in advance:
   1. Coordinate locations with work of other sections.

C. Before cutting of structural elements, obtain written approval of Owner:
   1. Use only approved methods.
   2. Neatly cut holes as small as possible to admit work.
   3. Do not weaken walls or floors; locate holes in concrete to miss structural sections.

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

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 or weld to building structural members.
   4. Provide equipment supports even though not detailed on architectural and structural drawings.

C. Verify that equipment will fit support 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 openings, 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 3-1/2 IN high concrete housekeeping pads. Outside dimension of pad shall be at least 4 IN larger in all directions than base of equipment.
   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, with 6 IN minimum penetration into floor.
   4. Chamfer top edges 3/4 IN.
   5. Make faces smooth.
   6. Set anchor bolts for equipment.

G. Provide concrete curbs for air handling units. See mechanical and structural drawings.

3.6 PAINTING

A. See Section 09 91 23.

3.7 FIELD QUALITY CONTROL

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

3.8 INDOOR AIR QUALITY

A. Develop and implement an Indoor Air Quality Management plan for the construction and pre-occupancy phases of the building as follows:
   1. If air handlers must be used during construction, filtration media with a Minimum Efficiency Reporting Value of 8 in accordance with ASHRAE 52.2-1999 must be provided at each return register.
   2. Replace all filtration media immediately prior to occupancy. Filtration media shall have a Minimum Efficiency Reporting Value of 13 in accordance with ASHRAE 52.2-1999.
   3. After construction ends and prior to occupancy, conduct a minimum of two-week building flush-out utilizing 100% outside air.
   4. After the flush-out, replace all AHU filter media in accordance with the requirements of Section 23 73 29.

3.9 ADJUST AND CLEAN

A. Inspect equipment and put in satisfactory working order.

B. Clean exposed and concealed items: See Cleaning (Section 01 74 23):
   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 traps and strainers and equipment surfaces such as pumps, motors, boilers, chillers, etc.
   4. Clean finned elements of fin tube radiation with compressed air.
   5. Clean piping of tags, debris and other construction materials before insulating or painting.
   6. Wipe all ducts and air plenums clean inside.

3.10 COMMISSIONING

A. See Section 23 90 00.

END OF SECTION

SECTION 20 05 19
PIPING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Products:
      a. Pressure gauges.
      b. System drains.
      c. Thermometer wells and test gauge connections.
      d. Thermometers (non mercury type).
      e. Wye strainers for steam and hydronic systems.

1.2 QUALITY ASSURANCE

A. Comply with UL, ANSI, ASME or ASTM Standards.

1.3 SUBMITTALS

A. Product data:
   1. Pressure gauges.
   2. Thermometers.
   3. Wye strainers.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Pressure gauges:
      a. Base:
         1) Trerice.
      b. Optional:
         1) Weiss Instruments.
         2) Marsh Instrument.
         3) US Gauge.
         4) Weksler Instruments.
         5) Weston and Ernst.
         6) Orange Research, Inc.
   2. Thermometers:
      a. Base:
         1) Weiss Instruments.
      b. Optional:
         1) Trend Instruments.
   3. Wye strainers:
      a. Base:
         1) Armstrong International.
      b. Optional:
         1) Spirax Sarco.
         2) Keckley, OC.
         3) Metraflex.
         4) Mueller Steam Specialty.

5) Spence Engineering.
6) Victaulic of America.

2.2 PRESSURE GAUGES

A. Pressure gauges:
1. Steam systems and 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.
   h. Siphon and gauge cock (low pressure steam): chrome plated brass.
   i. Siphon and needle valve (medium and high pressure steam): chrome plated brass.
   j. Accuracy: 1.0% full scale, ASME B40.1 Grade 1A.
   k. Range: Operating pressure to occur in middle half (25 % to 75%) of the full scale range of the fluid being measured.
   l. Connections: 1/4 IN or 1/2 IN NPT.
2. Compressed air systems and water systems operating below 150 degF:
   a. Case and Ring: 4-1/2 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% full scale, ASME B40.1 Grade 1A.
   k. Range: Refer to pressure range schedule except as follows:
      1) Pump suction gauges for open piping systems where elevation difference between pump center line and liquid level of open system is less than 50 feet: Compound type, indicating at least -100 kPa to 210 kPa 30 IN Hg to 30 PSIG.
      2) Fuel oil pump suction: Compound type, indicating .
   l. Connections: 1/4 IN or 1/2 IN NPT.
3. Deionized water system:
   a. Features similar to above, except all wetted parts (tube and socket) to be 316 stainless steel.

4. Pressure gauge range schedule:

	Range PSIG	Fig. Interval PSIG	Inter. Graduations PSIG
Chilled Water	0-150	10	1
Glycol water	0-100	10	1
Heating hot water	0-100	10	1
Fire	0-400	50	5
Cond. pump discharge	0-100	10	1
LP Steam	0-60	5	1
MP Steam	0-100	5	1
HP Steam	0-300	25	5
Flash tank	0-60	5	1
Domestic hot water	0-100	10	1
Domestic cold water	0-100	10	1
Process cooling and secondary chilled water	0-150	10	1
RO or Deionized Water	0-150	10	1

B. Trerice 600. Trerice 700 for deionized water (4-in dial).

C. Differential Pressure Gauges:
1. 4-1/2 IN dial, surface or flush type, whiteface, black numerals, black pointers, brass body, teflon seals, shatterproof glass.
2. Minimum 150 psig static pressure.
3. Piston sensor.
4. ± 2-1/2 % accurate over entire range.
5. Select range such that differential operating point is approximately 50% of full range.
6. Ashcroft 1092 gauge cock and 1106 pulsation damper.
7. Orange Research, Inc.

2.3 SYSTEM DRAINS

A. Valved drains (nonpotable water):
1. Piping 2 IN and smaller:
   a. 1/2 IN V-13 with male hose-thread outlet and brass cap.
   b. Hose bibb 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.
3. RO or Deionized water piping:
   a. Piping 3 IN and smaller:
      1) 1/2 IN V-67 with SS hose-thread outlet and cap.
   b. Piping 3-1/2 IN and larger:
      1) 1-1/2 IN V-67 with SS hose-thread outlet and cap.

B. Valved drains (potable water):
1. 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% of scale range.

B. Thermometers range schedule:

	Range degC	Division degC
Domestic hot water	32-180	1
Domestic cold water	32-100	1
Heating hot water	50-300	1
Condensate pump disc	50-300	1
Compressed air	50-300	1
LP steam	50-300	1
Blow down	50-400	2
Chilled water at coils	32-130	1
Chilled water at pumps	32-100	1

2.6 WYE STRAINERS FOR STEAM AND 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.
      c. Deionized water:
         1) Stainless steel body and screens, flanged or butt welded connections.
   3. Working pressure, non shock: 150 PSIG.
   4. Strainers in high pressure steam lines shall be 300 psig flange rating.
   5. 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.
      b. Steam: Stainless steel or brass.
         1) 3/64 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.

B. Install siphons on steam gauges.

C. Install brass tee handle cock, or needle valve, and 1/4 IN hard tempered tubing from gauge to pipe connection. Deionized water system shall be constructed from 304 or 316 stainless steel.

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

E. 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.

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

SECTION 20 05 23
MANUAL VALVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. 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.

1.2 QUALITY ASSURANCE

A. Boiler system valves: ASME Boiler Code Specifications.

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

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

D. Valves cleaned for oxygen service: CGA Pamphlet G-4.1, Cleaning Equipment for Oxygen Service.

E. 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.

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

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

H. 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.

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

J. 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 01 30 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 GENERAL

A. Acceptable manufacturers:
   1. Angle valves:
      a. Base:
         1) Nibco.
         2) Stockham .
      b. Optional:
         1) Crane Valves.
         2) Hammond Valve.
         3) Jenkins Valves.
         4) Lunken.
         5) Milwaukee Valve.
         6) Powell.
         7) Walworth.
   2. Ball valves:
      a. Base:
         1) Milwaukee Valve.
         2) Nibco.
      b. Optional:
         1) Apollo.
         2) Crane Valves.
         3) Hammond Valve.
         4) Jamesbury.
         5) Jenkins Valves.
         6) Stockham.
   3. Butterfly valves:
      a. Base:
         1) CenterLine Inds.
         2) Milwaukee Valve.
         3) Stockham.
         4) Victaulic of America.
      b. Optional:
         1) Crane Valves.
         2) Jamesbury.
         3) Hammond Valve.
         4) Keystone Valve.
         5) Lunken.
         6) Mueller Steam Specialty.
         7) Nibco.
         8) Powell.

9) Walworth.

4. Check valves:
   a. Base:
      1) Apco Valve & Primer.
      2) Nibco.
      3) Stockham Valves & Fittings.
   b. Optional:
      1) Crane Valves.
      2) Hammond Valve.
      3) Kennedy Valve.
      4) Milwaukee Valve.
      5) Mueller Steam Specialty.
      6) Powell.
      7) Victaulic of America.
      8) Viking.
      9) Walworth.
      10) Waterous.
5. Gate Valves:
   a. Base:
      1) Mueller Steam Specialty.
      2) Nibco.
      3) Stockham.
   b. Optional:
      1) Crane Valves.
      2) Hammond Valve.
      3) Jenkins Valves.
      4) Kennedy Valve.
      5) Milwaukee Valve.
      6) Mueller Steam Specialty.
      7) Powell.
      8) Walworth.
6. Globe valves:
   a. Base:
      1) Stockham.
   b. Optional:
      1) Crane Valves.
      2) Hammond Valve.
      3) Jenkins Valves.
      4) Lunken.
      5) Milwaukee Valve.
      6) Nibco.
      7) Powell.
      8) Walworth.
7. Plug valves:
   a. Base:
      1) Resun Valves.
   b. Optional:
      1) Milliken.
      2) Mueller Steam Specialty.
      3) Rockwell International.
      4) Victaulic of America.
8. Valve boxes and stop boxes:
   a. Base:
      1) Tyler Pipe.
      2) Western.
   b. Optional:

        1) Neenah Foundry.
        2) Vulcan.
        3) Local foundry.
    9. Balancing valves (globe style):
        a. Base:
            1) Armstrong (Model CBU, min. 4 turn, drip tight shutoff, flow and pressure measurement points).
        b. Optional:
            1) Wheatley.
            2) Mepco.
            3) Tour and Anderson.

B. Ball valves:
    1. Port size: Standard.
    2. Ball and stem: 316 Stainless Steel.
    3. Blow-out proof stems.
    4. Reinforced Teflon seats.
    5. Teflon seals.
    6. Adjustable packing.
    7. 3-piece valves:
        a. May be standard port.
        b. Repairable in line.

C. Butterfly valves:
    1. Ninety degree operation.
    2. Bi-directional, bubble-tight shut off at full pressure rating (at full differential pressure).
    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. Iron body:
        a. Seals shall be replaceable without removing valve from line or removing parts other than operator.
    7. Bronze:
        a. Blow-out proof stem.
        b. Viton seals.
        c. Pressure rating: 175 PSI WWP, 350 PSI WOG.

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. Electric Valve Operators:
    1. Quarter-turn for use with butterfly valves.
    2. Permanently lubricated self-locking gear train.
    3. Manual over-ride allows operation of valve with motor rotor locked.
    4. Mechanical and electrical travel stops:
        a. Travel stops adjustable without disassembly.
    5. Drip-proof enclosure:
        a. Epoxy-coated finish to resist corrosion.
        b. Where operator is located out-of-doors, enclosure shall be weather-proof.
        c. Where operator is located in unconditioned environment, provide internal heater to protect operator from low temperature or condensation.
    6. Factory Mutual or UL approval.
    7. Visual position indicator.

8. Temperature limit: -20 degF to 140 degF.
9. Output torque: Up to 15,000 lb in.
10. Control box:
    a. For wall or pedestal mounting.
    b. Robust, industrial construction. Enclosure, buttons, and pilot lights shall be NEMA rated drip-proof construction.
    c. Open, Close, and Stop buttons.
    d. Open and Closed pilot lights.
    e. Control box to be mounted in a convenient location not more than 48 IN above finished floor.

F. 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.

G. 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.

H. Packing shall not contain asbestos.

I. 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.

2.2 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.

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 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 BA-350S.

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

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

O. V-14: Ball valve, same as V-13 except threaded. Example: Milwaukee BA-100S.

P. V-15: Ball valve, 150 PSI SWP, 400 PSI WOG, 29 IN Hg vacuum service, bronze body, 3-piece construction, cleaned and capped for oxygen service, lockable in either the open or closed position, color coded handle to match gas service, braze. Example: Milwaukee BA-350S.

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 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-B.

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

AA. V-26: Check valve, in-line pattern, spring-operated disc, Class 125, bronze body, renewable Teflon 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 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.

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.

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

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 degrees, 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.
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, bronze body, ductile iron disk with EPDM coating, extended neck, grooved. Example: Victaulic 600.

HHH. V-63: Butterfly valve, Class 150, carbon steel body, RTFE seat, stainless steel shaft, stainless steel disc, TFE packing, wafer. Example: Campbell 1W.

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.

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.

KKK. V-66: High performance butterfly valve, Class 150, 316 stainless steel body, RTFE seat, stainless steel shaft, stainless steel disc, TFE packing, wafer.

LLL. V-67: Ball valve, 150 PSI SWP, 1000 PSI WOG 316 stainless steel body, locking handle, 3-piece construction, NPT or socket weld. All wetted parts to be stainless steel. Example: Milwaukee 30SSOF.

MMM. V-68: Plug valve, non-lubricated, 316 stainless steel construction. ANSI 150 LB flanged connections. Pressure rating; 250 PSIG minimum. Bearings shall be sleeve type metal bearings of 316 stainless steel ASTM A743 grade CF8M. Shaft seals shall be multiple v-ring type. Example: Sartell, Series 100.

NNN. V-69: Check valve, stainless steel ASTM A351 CF8M body, cover, disc and hinge arm. 150 LB pressure class, flanged end connections. Gasket and plug seal: PTFE hinge pin, disc nut and plug: Type 304 or 316 stainless steel. Example: Aloyco/Crane, Figure 377.

OOO. V-70: Check valve, in-line pattern spring-operated double doors, Class 150 316 stainless steel body, EPDM seat, 316 stainless steel doors and spring; threaded lug type. Example APCO S-9000L (stainless steel).

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.

END OF SECTION

SECTION 20 05 29
PENETRATIONS AND SUPPORTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Penetrations.
   2. Pipe hangers and supports.
   3. Pipe and equipment anchors.
   4. Pipe supports at plumbing fixtures.

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

1.2 QUALITY ASSURANCE

A. Pipe hanger standards:
   1. Manufacturers Standardization Society (MSS) SP-58, SP-89 and SP-69, as referenced.
   2. ASME/ANSI B31.1.
   3. Coordinate with Section 20 05 50.

1.3 SUBMITTALS

A. Shop drawings:
   1. For pipe larger than 6 IN, show layout of hanger locations and method of support from structure.
   2. Provide coordinated layout drawing for all slab and wall penetrations prior to concrete placement.

B. Product data:
   1. Pipe hangers:
      a. Identify each hanger according to systems, pipe sizes, and orientations on which it will be used.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Pipe hangers:
      a. Base:
         1) B-Line Systems.
      b. Optional:
         1) Grinnell.
         2) Elcen.
   2. Concrete inserts, pre-pour:
      a. Base:
         1) B-Line Systems.
      b. Optional:
         1) Grinnell.
         2) Ackerman - Johnson.
         3) Hilti.

3. Concrete inserts, post-pour:
    a. Base:
        1) Phillips Drill Co.
    b. Optional:
        1) Hilti.
        2) Ackerman - Johnson.
4. Factory-fabricated supports for insulated pipe:
    a. Base:
        1) Pipe Shields.
    b. Optional:
        1) B-Line Systems.
        2) Power Piping.
5. Pipe and equipment anchors:
    a. Base:
        1) Shop fabricated.
    b. Optional:
        1) Field fabricated.
6. Factory-fabricated pipe supports at plumbing fixtures:
    a. Base:
        1) Sioux Chief Manufacturing.
    b. Optional:
        1) B-Line Systems.
        2) Holdrite.
        3) Sumner.
7. Universal channel strut system:
    a. Base:
        1) Unistrut.
    b. Optional:
        1) B-Line Systems.
        2) Grinnell.

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.
        a. See Structural drawings for limitation on sleeve placement.
    3. Core drilling or cutting will not be permitted without prior written approval by Structural Engineer.
        a. Prior to submitting a request for coring the contractor shall locate wall and/or slab reinforcing by x-ray, ground penetrating radar, ultrasonic or other reliable means and shall adjust core locations to avoid reinforcing.
        b. In no instance shall a column or beam be cored.
    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 for this work.

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. Sealants:
1. Seal annular space around piping.
2. For fire and smoke rated floors and walls, see Section 07 84 00.
3. For non-rated floors and walls, use mineral or glass fiber insulation.
4. For exterior and foundation walls: Use synthetic rubber seals, "Link-Seal" water proof material or system.

2.3 PIPE HANGERS

A. Pipe hangers - General:
1. Materials, design and manufacture: MSS SP-58.
2. Fabrication and installation: MSS SP-89.
3. Selection and application: MSS SP-69.
4. Hangers and channels, angles, and supporting steel: Galvanized unless indicated otherwise.
5. Pipes running parallel may be supported on trapezes.
6. Hanger rods of continuous thread type: Galvanize after threads are cut.
7. Galvanize structural steel, angles, rods, channels, and hardware located in boiler, mechanical, and fan rooms and on roofs.
8. Where grooved couplings are used, place hanger within 2 FT each side of fittings or refer to manufacturer's pipe support and anchorage guide.
9. Screw threads on hangers and fittings: Conform to Class 2A and 2B of ANSI/ASME-B1.1.

B. Structural and vibration 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 to bottom of concrete filled floor deck.
5. Attach hangers to beams or brackets mounted on building columns, or racks mounted on steel columns mounted on levels one and two.
6. Coordinate with Section 20 05 50.

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

	Standard Steel		Copper	
Pipe Diameter	Fluid	Vapor	Fluid	Vapor
1/2 – 1-1/4 IN	12 FT	12 FT	6 FT	6 FT
1-1/2 - 2 IN	12 FT	12 FT	10 FT	10 FT
2-1/2 - 3 IN	12 FT	12 FT	10 FT	10 FT
3-1/2 - 4 IN	12 FT	12FT	10 FT	10 FT
5 - 6 IN	12 FT	12 FT	10 FT	10 FT
8 - 14 IN	12 FT	12 FT	10 FT	10 FT
16 IN	12 FT	12 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	610 LB
1/2 IN	1130 LB
5/8 IN	1810 LB
3/4 IN	2710 LB

2. Provide the minimum hanger rod diameters:

Pipe Size (IN)	Diameter (IN)
1/2 to 1-1/4	3/8
1-1/2 to 2	3/8
2-1/2 to 3	1/2
4 to 6	5/8
8 to 12	7/8
14 and over	1
PVC to 3	3/8
PVC over 3	1/2

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

E. Pipe hangers for uninsulated pipe:
1. Independent hangers: MSS SP-69 type 1, 3, 4, 5, 7, 9, 10, 11, 12, 24, 41, 43, 44, 45, or 46.
   a. Use types 7 and 10 only on pipe sizes 6 IN and smaller.
2. Hangers used with trapezes:
   a. MSS SP-69 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-69 type 1, 3, 7, 9, 10, 41, 43, 44, 45, or 46:
   a. Use types 7 and 10 only on pipe sizes 6 IN and smaller.
3. Hangers used with trapezes:
   a. Pipe sizes 2 IN and smaller: MSS SP-69 type 26.
   b. Pipe sizes 2-1/2 IN and larger:
      1) MSS SP-69 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-69 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 refrigerant and chilled water lines.

c. For steam piping 8 IN and larger, provide supports with slide bases.

6. Steam pipe sizes 8 IN and larger: Use MSS SP-69 hanger type 41, 43, 44, 45, or 46 with support indicated for pipe sizes 2-1/2 IN and larger.

7. Provide rigid insulation inserts at all hangers and points of support for insulated piping 1-1/2 IN and larger. Inserts shall be fire retardant treated wood blocks, calcium silicate or other high density insulating material. Insert shall be same thickness as adjoining pipe insulation and shall be provided with vapor barrier jacket. Insulation inserts shall not be less than the following lengths:

Pipe Size (IN)	Insert Length (IN)
1-1/2 to 2-1/2	10
3 to 6	12
8 to 10	16
12 and larger	22

8. A 180 degree galvanized sheet metal shield shall be provided between hangers or supports and the insulation inserts. Shields shall be 16 gauge for pipe sizes up to (but not including) 6 IN and shall be 12 gauge for pipe sizes 6 IN and larger. Shield length shall be as follows:

Pipe Size (IN)	Shield Length (IN)
1/2 to 2-1/2	6
3 to 6	8
8 to 10	12
12 and larger	18

G. Pipe hangers in other situations: See MSS-SP-69.

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. Hard-metal, self-drilling wedging anchors tapped for threaded rods and designed not to depend on lead or wood for holding power.

K. Beam clamps:

1. Pipe size 3 IN and smaller:
   a. MSS SP-69 types 19 or 23.
2. Pipe sizes larger than 3 IN but smaller than 8 IN:
   a. Malleable-iron beam clamp: MSS SP-69 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-69 type 28 or type 29.
   b. Steel Beam clamps: B-Line B3291 through B3298 or equal.

2.4 PIPE AND EQUIPMENT ANCHORS

A. Pipe anchors:
   1. Provide as indicated and required to permit complete installation of system.
   2. Do not anchor piping to plaster or gypsum wallboard partition walls.
   3. Provide anchoring devices at locations indicated.

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

C. Anchors for ductwork, equipment and piping hanger rods:
   1. Post-pour concrete inserts: Hard-metal, self-drilling wedging anchors tapped for threaded rods and designed not to depend on lead or wood for holding power.

D. Anchors for steam piping:
   1. Two-part epoxy adhesive system with 304 stainless steel all treaded fasteners. Performance equal to Hilti HVA or better.
   2. Maximum depth of fastener drilling: 4-1/2 IN.
   3. Size all thread fasteners that 1-1/2 IN protrudes after the baseplate, washers, and nuts are installed.
   4. Provide disc spring washers (Belleville type) at all anchor, expansion joint, guide, and support locations.

E. Size anchors in steam pipes 15 psig and less for 475 degF, above 15 psig 650 degF.

2.5 PIPE SUPPORTS AT PLUMBING FIXTURES

A. Pipe supports at plumbing fixtures:
   1. Fire-treated dimensional lumber.
   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.

B. Obtain and follow Owner's Physical Facilities Guidelines.

3.2 PENETRATIONS

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

B. Maintain rating of fire and smoke rated construction: See Section 07 84 00.

C. Set sleeves plumb or level, in proper position, tightly fitted into work:
   1. Remove sleeves before installing piping.

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. 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.
3. Factory-fabricated PVC supports:
   a. Fasten brackets to waste piping, fixture carriers, or studs.

3.4 BASE PLATES

A. Ship all steam anchor and expansion joint base plates loose to be field fit and welded.

B. The height of the stand-off to be 1-1/2 IN higher to provide sufficient material for field alignment and adjustment.

END OF SECTION

SECTION 20 05 50

VIBRATION ISOLATION OF MECHANICAL SYSTEMS (Revised AD-1)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide vibration control devices, materials, and related items. Perform all work as indicated on drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.2 MATERIAL AND EQUIPMENT

A. All vibration isolation mounts shall be supplied by one of the following approved manufacturers:
   1. Amber/Booth Co. (Houston, TX) - A.B.
   2. Korfund Dynamics Corp. (Westbury, NY) - K.D.
   3. Mason Industries Inc. (Hauppauge, NY) - M.I.
   4. Kinetics Noise Control Inc. (Dublin, OH) - K.N.C.
   5. Vibration Mountings & Controls Inc. (Butler, NJ) - V.M.&C.

B. Unless otherwise specified, supply only new equipment, parts and materials.

C. The intent of this specification is to ensure the highest standard of vibration isolation for this project. For this reason, all vibration isolation products and materials shall be furnished by a single manufacturer, who will be responsible for the proper installation and operation of all vibration isolation equipment and systems. The only exception will be internal vibration isolation that is integral with the equipment, such as internal isolators on air handling units.

1.3 REQUESTS FOR CHANGE

A. Any requests for changes to Specifications must be submitted in writing at least ten days prior to offer closing. Approval will be given through a written addendum.

1.4 CONTRACTOR'S GENERAL RESPONSIBILITIES

A. The Contractor shall bring to Owner's attention prior to installation any conflicts which will result in unavoidable contact between the building structure and the isolated equipment, piping, etc., described herein, due to inadequate space, etc. Corrective work necessitated by conflicts after installation shall be at the expense of the responsible Contractor.

B. The Contractor shall bring to Owner's attention prior to installation any discrepancies between the requirements of this specification and field conditions, changes required due to specific equipment selection, etc. Corrective work necessitated by discrepancies after installation shall be at the expense of the responsible Contractor.

1.5 DESIGN CRITERIA

A. Equipment, ductwork, piping and conduit shall not be installed which makes rigid contact with the structure unless it is allowed by this specification.

B. Pipe Anchors and Supports: Piping supports and anchors shall not interfere with free operation of vibration isolation systems. Stiff-leg support of piping supported on Type HS, or Type FSN isolators is not acceptable.

C. Ductwork: Ductwork isolation requirements are based on duct equivalent diameters. For rectangular ductwork, the equivalent diameter is the diameter of duct having the same cross-sectional area.

D. Equipment Isolation Frames and Bases: Frames and bases used to support vibration isolated pumps shall be sized to provide support for pipe elbows.

E. Isolation/Absorption Products: The completed installation must be free of vibration and noise. Systems, equipment, or parts which vibrate or generate vibration unduly, or which generate or emit undue noise while in operation, shall: (1) be adjusted, repaired, or replaced as appropriate to obtain acceptable levels of vibration or noise, or (2) be supported on, or fitted with, suppression or absorption devices, or other means, which effectively prevent the transmission of vibration or noise beyond the offending item.

F. Resilient Wall, Ceiling, and Floor Penetrations: Provide resilient wall and ceiling penetrations for all piping, conduit, ductwork, etc., supported on Type HS or Type FSN isolators. Refer to resilient penetration details on the drawings.

1.6 QUALITY ASSURANCE

A. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.

C. Provide any incidental materials needed to meet the requirements stated herein, even if not expressly specified or indicated on drawings, without claim for additional payment.

D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

E. Should any rotating equipment cause excessive noise or vibration; rebalance, realign, or provide other remedial work required to reduce noise and vibration levels. Excessive is defined as specifications exceeding these specifications or the manufacturer's specifications for the unit in question.

F. Upon completion of the work, Owner or Owner's representative shall inspect the installation and shall inform the installing Contractor of any further work that must be completed. Make all adjustments as directed by the Architect that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

1.7 SUBMITTALS

A. Shop drawings: Prior to ordering any products, submit shop drawings of the items listed below. The shop drawings must be complete when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal:
   1. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
   2. Detailed selection data for each vibration isolator supporting equipment, including:
      a. The equipment identification mark.
      b. The isolator type.
      c. The actual load.
      d. The static deflection expected under the actual load.
      e. Specified minimum static deflection.
      f. The additional deflection-to-solid under load.
      g. The ratio of spring height under load to spring diameter.
   3. Steel rails, steel base frames, and concrete inertia bases indicating all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.
   4. Written approval of the frame design to be used shall be obtained from the equipment manufacturer.
   5. Drawings showing methods for suspension, of support, and guides.

6. Drawings showing methods for isolation of piping, at penetrations of walls, slabs, and beams.
7. Special details necessary to convey complete understanding of the work to be performed.
8. Isolated trapeze hangers within the service galleys.

B. Product data: Not required for Owner review.

C. Samples: None required for Owner review.

D. Project information: Not required for Owner review.

E. Contract closeout information: Not required for Owner review.

F. Equipment field final balance reports.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION MOUNT TYPES

A. General:
1. Metal parts of vibration-isolation units shall be as follows:
   a. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14:
      1) Housing: Hot-dipped galvanized or fusion epoxy coated.
      2) Hardware (washers, nuts, bolts, etc.): Cadmium plated.
      3) Springs shall be neoprene coated.
2. All isolators installed out-doors shall have base plates with bolt holes for fastening the isolators to the support members.
3. Isolator types are scheduled to establish minimum standards. At the Contractor's option, labor saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories shall not degrade the vibration isolation system.
4. Static deflection of isolators shall be as provided in SECTION 3 - EXECUTION and as indicated on drawings. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.
5. The use of nested springs or of multiple parallel springs within a single mount is not permitted.
6. All metal parts of vibration isolation units installed out-of-doors shall be cold-dip galvanized, cadmium plated, or neoprene coated after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards.

B. Type FN (Floor Neoprene):
1. Neoprene isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.
2. Type FN isolators shall be one of the following products:

Type RVD	A.B.
Type F	K.D.
Type ND	M.I.
Type RD	K.N.C.
Series R/RD	V.M.&C.

C. Type FSN (Floor Spring and Neoprene):
   1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Springs shall have a minimum additional travel-to-solid equal to 50 percent of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1 (one). All mounts shall have leveling bolts.
   2. Either the spring element in the isolator shall be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type DNP (Double Neoprene Pad) isolator. If the DNP isolator is used, provide a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer's recommended range.
   3. If the basic spring isolator has a neoprene friction pad on its base and a DNP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum plate shall be used between the friction pad and the DNP isolator. If the isolator is outdoors, the plate shall not be made of galvanized steel. The DNP isolator, separator plate and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.
   4. If the isolator is to be fastened to the building structure and a Type DNP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers are to be galvanized.
   5. Type FSN isolators shall be one of the following products with the appropriate neoprene pad (if used) selected from Type DNP:

Type SW	A.B.
Type WSL	K.D.
Type SLF	M.I.
Type FDS	K.N.C.
Type AC or AD	V.M.&C.

D. Type PCF (Precompressed Fiberglass):
   1. Precompressed fiberglass blocks shall be made of molded inorganic glass fiber that is individually coated and sealed with an impervious elastomeric membrane. Fiberglass shall be severely overloaded during manufacture to stabilize the material into a product that is permanent and has consistent, predictable dynamic properties.
   2. Type PCF isolators shall be one of the following products.

Type KIP	K.N.C.

E. Type HSN (Hanger Spring and Neoprene):
   1. Vibration isolation hangers shall consist of a free standing and laterally stable steel spring and a neoprene element in series, contained within a steel housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Spring elements shall have a minimum additional travel-to-solid equal to 50 percent of the rated deflection. The neoprene element shall be designed to have a 0.3 IN minimum static deflection. The deflection of both the spring element and the neoprene element shall be included in determining the overall deflection of Type HSN isolators.
   2. Type HSN isolators shall be one of the following products:

Type BSRA	A.B.
Type VSX-30	K.D.
Type 30N	M.I.
Type SPH or SFH	K.N.C.
Type RSH or RFH	V.M.&.C.

F. Type HN (Hanger Neoprene):
   1. Vibration isolation hangers shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck bushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. The diameter of the hole n the housing shall be sufficient to permit the hanger rod to swing through a 30 degree arc before contacting the hanger housing.
   2. Type HN isolators shall be one of the following products:

Type BRD-A	A.B.
Type H	K.D.
Type HD	M.I.
Type RH or FH	K.N.C.
Type RHD or RFD	V.M.&.C.

2.2 EQUIPMENT BASES

A. Type BSF (Base - Steel Frame):
   1. Steel base frames shall consist of structural steel sections sized, spaced, and connected to form a rigid base which will not twist, rack, deform, or deflect in any manner which will negatively affect the operation of the supported equipment or the vibration isolation mounts. Frames shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. The depth of steel frame bases shall be at least 0.1 times the longest dimension of the base, but not less than 6 IN nor more than 12 IN. The base footprint shall be large enough to provide stability for supported equipment.
   2. Frame bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.
   3. Type BSF bases shall be supplied by the isolator manufacturer and shall be one of the following products:

Type WX	A.B.
Type Steel Base	K.D.
Type WFSL	M.I.
Type SFB or SRB	K.N.C.
Series WFB	V.M.&C.

B. Type BIB (Base - Inertia Base):
   1. Concrete inertia bases shall be formed of stone-aggregate concrete, 150 LBS/FT3 and appropriate steel reinforcing cast between welded or bolted perimeter structural steel channels. Inertia bases shall be built to form a rigid base which will not twist, rack, deform, deflect, or crack in any manner which would negatively affect the operation of the supported equipment or the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Inertia base depth shall be at least 0.083 times the longest dimension of the inertia base, but not less than 6 IN nor more that 12 IN. The base footprint shall be large enough to provide stability for supported equipment.
   2. Inertia bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.
   3. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer. Provide concrete in accordance with requirements of Division 3.
   4. Frame and reinforcement for Type BIB bases shall be one of the following products:

Type CPF	A.B.
Type RCPF	K.D.
Type KSL	M.I.
Type CIB-L or CIB-H	K.N.C.
Series WPF	V.M.&C.

2.3 RESILIENT PENETRATION SLEEVE/SEAL

A. Provide resilient wall and ceiling penetrations for all piping, conduit, ductwork supported on vibration isolators. Refer to resilient penetration details on drawings.

B. Resilient penetration sleeve/seals shall be field-fabricated from a pipe or sheet metal section that is 1 IN larger than the penetrating element in all directions around the element, and shall be used to provide a sleeve through the construction penetrated. The sleeve shall extend 1 IN beyond the penetrated construction on each side. The space between the sleeve and the penetrating element shall be packed with glass fiber or mineral wool to within 1/4 IN of the ends of the sleeve. The remaining 1/4 IN space on each end shall be filled with acoustical sealant to form an airtight seal. The penetrating element shall be able to pass through the sleeve without contacting the sleeve. Alternatively, prefabricated sleeves accomplishing the same result are acceptable.

2.4 RESILIENT LATERAL GUIDES

A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements similar to Type FN which are specifically designed to provide resilient lateral bracing of duct or pipe risers:
   1. Resilient lateral guides shall be one of the following products:

Type Custom	A.B.
Type Custom	K.D.
Type ADA	M.I.
Type RGN	K.N.C.
Type MDPA	V.M.&C.

2.5 FLEXIBLE DUCT CONNECTIONS

A. Flexible duct connections shall be made from coated fabric (or loaded vinyl if called for on drawings). The clear space between connected parts shall be a minimum of 3 IN and the connection shall have 1-1/2 IN minimum of slack material. Material width shall be 150 percent of clear dimension in addition to width required for attachment. Flexible duct connections shall result in a loose and highly compliant connection.

2.6 FLEXIBLE PIPE CONNECTIONS

A. Flexible pipe connections shall be fabricated of multiple plys of Kevlar or nylon cord, fabric, and neoprene; and shall be vulcanized so as to become inseparable and homogeneous. Flexible connections shall be formed in a double sphere shape, and shall be able to accept compressive, elongative, transverse, and angular movements:
   1. The flexible connections shall be selected and specially fitted, if necessary, to suit the system temperature, pressure, and fluid type. In addition, suitable flexible connections should be selected which do not require rods or cables to control extension of the connector.
   2. Connectors for pipe sizes 2 IN or smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings.
   3. Flexible pipe connections shall be Mason Industries Type SFDEJ; Metraflex Double Sphere (Type DS); V.M.C. Type VMT.

2.7 RESTRAINTS

A. Thrust Restraints:
   1. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection due to thrust-generated loads as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be precompressed at the factory to allow for a maximum of 1/4 IN movement during starting or stopping of the equipment. Allowable movement shall be field-adjustable.
   2. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.
   3. The thrust restraints shall be installed on the discharge of the fan so that the restraint rods are in tension. Assemblies that place the rods in compression are not acceptable.
   4. The holes in the spring restraint brackets through which the restraint rods pass must be oversized to prevent contact between the brackets and rods.
   5. Thrust restraints shall be Mason Industries Type WBI or WBD.

2.8 GROMMETS

A. Grommets shall either be custom made by combining a neoprene washer and sleeve, be Isogrommets as manufactured by MBIS, Inc. (Bedford Heights, Ohio), or be Series W by Barry Controls (Watertown, Mass.). Grommets shall be sized so that they will be loaded within the manufacturer's recommended load range. Grommets shall be specially formed to prevent bolts from directly contacting the isolator base plate.

2.9 ACOUSTICAL SEALANT

A. Sealants for acoustical purposes as described in this Specification shall be silicone or one of the nonsetting sealants indicated below:

Acoustical sealant	D.A.P.
Acoustical sealant	Pecora
Acoustical sealant	Tremco
Acoustical sealant	U.S.G.

B. Coordinate acoustical performance with fire rated assemblies and vibration isolation assemblies, when applicable.

PART 3 - EXECUTION

3.1 APPLICATION

A. General:
   1. Refer to SECTION 2 - PRODUCTS of this Specification for vibration isolation devices identified on drawings or specified herein.
   2. The static deflection of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.

B. Major Equipment (see schedule under 3.5 H):
   1. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as specified hereunder.
   2. Provide flexible duct connections at all fan unit intakes, fan unit discharges, and wherever else indicated on drawings.
   3. Provide flexible pipe connections at all pipe connections to vibration-isolated equipment and as indicated on drawings.
   4. Provide thrust restraints on all floor-mounted fans developing 4 IN WG or more of static pressure, all suspended fans, and wherever else indicated on drawings.

C. Miscellaneous Mechanical Equipment:
   1. Miscellaneous pieces of mechanical equipment such as heat exchangers, pressure reducing stations, dryers, water heaters, steam generators, strainers, storage tanks, condensate receiver tanks, flash tanks and expansion tanks which are connected to isolated piping systems shall be vibration-isolated from the building structure by Type NP or Type HN isolators (selected for 2.5 mm static deflection) unless their position in the piping system requires a higher degree of isolation as called for under Pipe Isolation.

3.2 PIPING ISOLATION

A. Pipe support isolation shall follow the guidelines established below:
   1. Spring isolators shall be selected for a static deflection, under load, of not less than 1 IN. Use FSN or HS isolators, whichever is applicable to the mounting condition.
   2. Where lateral support of pipe risers is required within the limits of isolation specified below, this shall be accomplished by use of resilient lateral supports.
   3. Pipes that penetrate the building structure within the limits of isolation specified below shall be isolated from the structure by use of resilient penetration sleeve/seals.
   4. Drain piping connected to vibration-isolated equipment shall not contact the building structure or other non-isolated system unless it is resiliently mounted as described above.
   5. Piping connected to vibration-isolated equipment shall be installed so that it does not strain or force out of alignment pipe flexes or vibration isolators supporting either the equipment or the piping.
   6. Where pipes are racked together, the most stringent isolation requirement, as defined in this specification shall take precedence.
   7. Piping, 1 IN diameter or greater, which is connected to vibration isolated equipment shall be isolated from the building structure using spring supports, resilient pipe guides, and resilient penetration sleeves (as applicable) for a distance of 25 FT or 50 pipe diameters, whichever is greater. For equipment greater than 50 HP, pipe support isolators will be selected for a deflection of not less than 2 IN.

3.3 EQUIPMENT BALANCE REQUIREMENTS

A. All rotating equipment shall operate at speeds less than 80 percent of their true critical speed. Equipment shall be balanced according to the recommendations given in the following sections.

B. Equipment components such as motors, pump rotors, fan wheels, shall be factory balanced, both statically and dynamically, to meet the balancing requirements described in Paragraph 3.4.C below.

C. Pumps, compressors, fans, and other rotating equipment not covered in paragraph D below, shall be field tested in accordance with the current edition of ANSI Standard S2.41 by an independent company after installation and under actual operating conditions. Vertical and horizontal vibration of rotating equipment shall not be greater than 0.071 IN/sec RMS, 0.1 IN/sec 0-peak velocity. The vibration shall be measured on the equipment bearing caps when the equipment is mounted on its vibration isolation mounts. If the equipment is mounted on an inertia base, or is skid-mounted, see Paragraph 3.4.F below for installed balancing requirements. A balance report shall be provided for each item of equipment.

D. Factory Balance of Fans. Fans greater than 10 HP including re circulation air fans, makeup air fans, and exhaust fans, rotors shall be whirl-tested to 125 percent operating speed and balanced to ASHRAE standards or better. Fan/motor assemblies mounted on the specified isolation springs (within their cabinets if applicable) shall be dynamically balanced to within 0.025 IN/sec RMS (0.035 IN/sec 0-peak):

1. Balance shall be achieved with the fans operating at rated airflow against the rated static pressure. Measurements shall be taken on the fan bearing caps in three orthogonal directions: parallel to the shaft in the horizontal plane and perpendicular to the shaft in the horizontal and vertical planes. For fans having inertia bases, the allowable vibration shall be reduced by the ratio given below. For fans that use adjustable frequency drives, the balance must be achieved at selected, not less than three, shaft speeds within the normal design range of operation. Balance reports shall be provided for each item of equipment prior to shipment.

E. Field Balance of Fans: The balance of the fans shall be checked following field installation. Adjustments shall be made as necessary to bring them within the specified limits. Balance reports shall be provided for each item of equipment.

F. Inertia Base or Skid-Mounted Equipment Balance: The weight of inertia bases or skids (and of any other components mounted on the same inertia base or skid) will reduce the vibration response when equipment is balanced. Therefore, the balance criteria, as specified in Paragraphs 3.5.C and 3.5.D, shall be multiplied by the following factor for such equipment:

$$\text{Factor} = \frac{W}{WT+W}$$

Where

WT = Inertia weight (base + other components)

W = Weight of the subject equipment

G. Pipes:
1. All pipes shall be isolated from the building structure as follows:
   a. Within mechanical rooms.
   b. Within 50 FT total pipe length of connected vibration-isolated equipment.
   c. All piping that is 4 IN or larger shall be isolated throughout the building.
   d. Piping serving labs mounted on isolated trapeze hangers within the service galleys.
2. Piping shall be isolated from the building structure by means of vibration isolation mounts, resilient pipe guides, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 0.4 IN, Type FSN or HSN isolators shall be used. When the required static deflection is less than or equal to 0.4 IN, Type FN or HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or HN achieving at least 0.2 IN static deflection.
4. Where lateral support of pipe risers is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections as called for under Major Equipment above and wherever indicated on drawings.

H. Ductwork:
1. All sheet metal ducts and air plenums that are within mechanical rooms or within a distance of 50 FT total duct length of connected vibration-isolated equipment (whichever is longer) shall be isolated from the building structure by Type FN or HN isolators. All isolators shall achieve 0.10 IN minimum static deflection:
   a. All ducts, air plenums, and air terminal units shall be isolated from the building structure by Type FSN or HSN isolators at 1 IN minimum static deflection.
2. Ducts within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.

3. Provide flexible duct connections as called for above under Major Equipment and wherever indicated on drawings.

3.4 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General:
1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolation Mounts:
1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
2. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.
3. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.
4. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
5. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beams and joists. Provide suitable intermediate support members as necessary.
6. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360 degrees about the rod axis without contacting any object.
7. Parallel running pipes may be hung together on a trapeze which is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and unisolated pipes on the same trapeze.
8. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
9. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
10. The installed and operating heights of equipment vibration-isolated with Type FSNTL isolators shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4 IN clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
11. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases:
1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.
2. Unless otherwise indicated, there is to be a minimum operating clearance of 1 IN between inertia bases or steel frame bases and the floor beneath the equipment. Position isolator mounting brackets and adjust isolators so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.

D. Flexible Duct Connections:
   1. Sheet metal ducts and plenum openings shall be aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so that the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

E. Flexible Pipe Connections:
   1. Provide flexible pipe connections in strict accordance with the manufacturer's instructions.

F. Restraints:
   1. Thrust restraints shall be attached on each side of the fan at the vertical centerline of thrust. The two rods of the thrust restraint shall be parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

G. Resilient Penetration Sleeve/Seals:
   1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

AD-1: Section 20 05 50: Revise Table under paragraph 3.4.H.

H. Vibration isolator schedule:

Equipment Description	Base Type	Isolator Type	Minimum Static Defl. (IN)	Restraint Type	Flexible Pipe Conn.	Note:
Air handling units, floor mounted		PCF	1/4		Yes	1
Fan, tubeaxial, floor mounted vertical		FSN	1			
Pumps, floor mounted, 10 HP and above	BIB	FSN	2		Yes	
Pumps, floor mounted, below 10 HP	BIB	FSN	1		Yes	
Pump, condensate, pressure powered, floor mounted		FN	3/8		Yes	
Tempered water circulating pumps		FSN	1		Yes	
Fan coil units, blower coil units, suspended		HN	3/8			
NOTES: 1. Place beneath base rails of AHU to completely support unit.						

END OF SECTION

SECTION 20 05 53

MECHANICAL IDENTIFICATION SYSTEMS (Revised AD-4)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of work:
   1. Piping, valve, duct and equipment identification.

1.2 QUALITY ASSURANCE

AD-4: Section 20 05 53: Revise paragraph 1.2.A.

A. All piping system identification shall meet requirements of ANSI-A13.1 "Scheme for the Identification of Piping Systems."

1.3 SUBMITTALS

A. Product data:
   1. Pipe markers.
   2. Valve tags.
   3. Duct markers.
   4. Equipment name plates.
   5. Access panel markers.

B. Contract closeout information:
   1. Letter of transmittal indicating valve charts installed and delivered.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   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 Systems.
         7) Carlton Industries.

2.2 PIPE MARKERS

A. Pipe markers: Conform to ANSI-A13.1:
   1. Pressure sensitive vinyl (self-adhesive) material.
   2. Mechanically fastened type: Snap on or strap on:
      a. For dirty greasy, oily pipe where pressure sensitive markers may not perform satisfactorily.
   3. Provide with arrows indicating direction of flow. Where flow is multidirectional, use double headed arrows.
   4. Letter sizes: In accordance with table in Part 3.

2.3 VALVE TAGS

A. Valve tags: Brass or anodized aluminum type:
   1. Brass: 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.
   2. Aluminum: 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.

B. 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 DUCT MARKERS

A. 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. See Part 3 for format.

2.5 EQUIPMENT NAME PLATES

A. Equipment name plates:
   1. 1/16 IN rigid plastic, "Setonply", "Emedolite" or bakelite with 4 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.
      c. Fasteners: Commercial quality, rust resisting nuts and bolts with backwashers, self-tapping screws or rivets.

2.6 ACCESS PANEL MARKERS

A. Access panel markers:
   1. Metal tack style: Use on acoustical tile ceilings:
      a. Seton style BCM or ECM.
   2. Engraved plastic style:
      a. 3/4 IN square with center hole for small screw.
      b. Seton style CM75.

2.7 CHART AND DIAGRAM FRAMES

A. Chart and diagram frames:
   1. Extruded aluminum with plexiglass or glass windows.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide systems having temperatures above 120 degF or pressures above 40 PSIG with legends indicating those temperatures and pressures.

3.2 VALVE IDENTIFICATION

A. Seton Name Plate Corp. Style 300-BL, 2” diameter tags on all valves installed. Include on tags respective legend as indicated below, and number as shown on Chart:
   1. HW for hot water valves.
   2. CW for cold water valves.
   3. CDA for clean dry compressed air valves.
   4. VAC for process vacuum valves.
   5. CHWS for chilled water supply valves.

6. CHWR for chilled water return valves.
7. PCWS for process cooling water supply valves.
8. PCWR for process cooling water return valves.
9. HPS/MPS/LPS for steam valves.
10. C for condensate valves.
11. HWS for heating hot water supply valves.
12. HWR for heating hot water return valves.
13. GWS for glycol water supply valves.
14. GWR for glycol water return valves.
15. EHRWS for exhaust heat recovery water supply valves.
16. EHRWR for exhaust heat recovery water return valves.
17. For control valves, i.e., V-1, V-2, etc., indicate service and control valve designation as indicated on Drawings.
18. ROS for RO water supply.
19. ROR for RO water return.
20. LCW for laboratory cold water valves.
21. LHW for laboratory hot water valves.
22. UN2 for utility nitrogen valves.
23. LN2 for liquid nitrogen valves.
24. TW for tempered water valves.
25. AR for cylinder argon valves.
26. ARHE for cylinder argon helium gas mix valves.
27. HE for cylinder helium gas valves.
28. H2 for cylinder hydrogen gas valves.
29. HPN2 for cylinder high purity nitrogen gas valves.
30. LA for cylinder laboratory compressed air valves.
31. O2 for cylinder oxygen gas valves.
32. SG for cylinder specialty gas valves.
33. SIL for cylinder silane gas valves.

B. Identify all valves, with appropriate service designation and valve number designation on valve tags:
   1. Tagging of valves at cabinet heaters, fan coil units, air terminal unit reheat coils and plumbing fixture stops are not required.

C. Secure tags to valve handles with Seton Name Plate Corp. Catalog 820 brass “S” hooks. Drill lever handle of ball valves to attach “S” hook.

D. Furnish 4 charts including valve identification number, location (room number, department) and purpose:
   1. Provide and mount as directed, in a suitably glazed frame, a typewritten chart giving valve number, whether valve is N.O. or N.C., location, and function of each valve installed.
   2. Include remaining 3 sets in "Operation and Maintenance Manuals".

3.3 PIPE IDENTIFICATION

A. Legend and Flow Arrows: Seton Name Plate Corp., Setmark System Type SNA for 5 IN and under diameter piping and covering, and Type STR for 6 IN and over diameter piping and covering. Minimum color field lengths, letter heights, field and letter colors, and legends shall be as specified below.

B. Do not identify soil, waste and vent piping.

C. Fire-protection and sprinkler piping:
   1. Painting not required in non-finished areas.
   2. Painting required in finished areas:
      a. Color: Safety Red:
         1) Paint Specification: Section 09 91 23.

D. 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.
   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. Install that it is readable from access panels and not obscured by other work.

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

Outside Diameter of Pipe or Pipe Covering IN	Length of Color Field (Markers) IN	Size of Letters and Arrows IN
1/2 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

AD-4: Section 20 05 53: Revise table under paragraph 3.3.F.

F. Field and Letter Colors:

System Legends	Field Colors	Letter Colors
Chilled Water Supply, Primary, Secondary and Process	Green	White
Chilled Water Return, Primary, Secondary and Process	Green	White
Clean Dry Compressed Air*	Yellow	Black
Domestic Cold Water	Green	White
Domestic Hot Water	Yellow	Black
Domestic Hot Water Recirculating	Yellow	Black
Glycol Supply (EHRWS)	Green	White
Glycol Return (EHRWR)	Green	White
Hot Water Heating Supply	Yellow	Black
Hot Water Heating Return	Yellow	Black
Utility Nitrogen	Yellow	Black
Liquid Nitrogen	Yellow	Black
Sanitary	Green	White
Sanitary Vent	Green	White
Storm	Green	White
Sprinkler	Red	White
Standpipe	Red	White
Steam*	Yellow	Black
Steam Condensate**	Yellow	Black
Process Vacuum	Yellow	Black
RO Supply	Green	White
RO Return	Green	White
Lab Cold Water	Yellow	Black
Lab Hot Water	Yellow	Black
Lab Hot Water Return	Yellow	Black
Tempered Water	Green	White
Tempered Water Return	Green	White
Argon	Yellow	Black
Argon/Helium Mix	Yellow	Black
Helium	Yellow	Black
Hydrogen	Yellow	Black
High Purity Nitrogen	Yellow	Black
Laboratory Air	Yellow	Black
Oxygen	Yellow	Black
Specialty Gas	Yellow	Black
Silane	Yellow	Black

* Include Pressure Rating
** Include Temperature Rating

3.4 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:
   1. Mark ducts as follows:
      a. Supply Air – SA AHU - ## SA SF - ##.
      b. Return Air – RA AHU - ##.
      c. Relief Air – RELA AHU - ##.
      d. Outside Air – OA AHU - ##.

e. Make-up Air – MA AHU - ##.
f. General Exhaust – EA EF - ##.
g. Lab Exhaust – LEA EF - ##.

C. Exhaust duct labels: The duct at the fan discharge of each exhaust system must be labeled as indicated above.

3.5 EQUIPMENT IDENTIFICATION

A. Attach equipment nameplates in conspicuous location, directly on item of equipment or apparatus such as starters, AFD's, 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: Steam, radiation, 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: Type of service.
         2) A - Compressed Air.
         3) N – Nitrogen.

3.6 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

SECTION 20 07 00
PIPE, DUCT AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Pipe insulation, non-flexible and flexible.
   2. Duct insulation, non-flexible and flexible.
   3. Equipment insulation.
   4. Insulation jacketing and prefabricated fitting covers.
   5. Insulation fasteners:
      a. Adhesives, mastics, and caulking.
   6. Air ventilation duct wrap fire protection system.

B. Definitions:
   1. Concealed: Outside surfaces are isolated from room ambient air conditions by physical barrier(s):
      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) Alley ways.
         6) Ceiling spaces.
   2. Exposed: Outside surfaces are not isolated from room ambient air conditions by physical barrier(s):
      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) 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.

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:
         1) Fiberglass, phenolic, PVC: 50.
         2) Elastomeric: 150.
   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 specifications:
   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-C553, "Standard Specification for Mineral Fiber Blanket and Felt Insulation."

4. ASTM-C585, "Recommended Practice for Inner and Outer Diameters of Rigid Pipe 'Insulation for Nominal Sizes of Pipe and Tubing (NPS System)."
5. ASTM-C612, "Standard Specification for Mineral Fiber Block and Board Thermal Insulation."
6. ASTM-C1136, "Standard Specification for Flexible Low Permeance Vapor Retarders for Thermal Insulation."
7. ASTM-C795, "Thermal Insulation for Use Over Austenitic Stainless Steel."
8. Federal Specification HH-I-558B, "Mineral Fiber Boards, Blankets, Pipe Covering."

1.3 SUBMITTALS

A. Product data:
   1. Pipe insulation.
   2. Ductwork insulation.
   3. Insulation for hot equipment.
   4. Insulation for cold equipment.
   5. Jacketing and prefabricated fitting covers.
   6. Insulation fasteners.
   7. Schedule of services and insulation thickness.
   8. Air Ventilation Duct Wrap Fire Protection System.
      a. Submit reports substantiating code compliance along with manufacturer's installation instructions.

B. LEED Information:
   1. LEED Credits MR 5.1 and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   2. LEED Credit EQ 4.1, Low-Emitting Materials – Adhesives and Sealants: Manufacturer’s product data for construction sealants, including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Acceptable manufacturers:
   1. Insulation materials:
      a. Base:
         1) As indicated.
      b. Optional:
         1) Owens-Corning Fiberglass.
         2) CertainTeed Insulations.
         3) Knauf Fiber Glass.
         4) Johns-Manville.
         5) Armstrong.
   2. Air Ventilation Duct Wrap Fire Protection Systems:
      a. Base:
         1) Thermal Ceramics.
      b. Optional:
         1) Unifrax Corporation.
         2) 3M.
   3. Jacketing:
      a. Base:
         1) As indicated.
      b. Optional:
         1) Ceel Co.

2) Childers Products.
3) Johns-Manville.
4) RPR Metals.
5) Pabco.

4. Prefabricated fitting covers:
   a. Base:
      1) As indicated.
   b. Optional:
      1) Ceel.
      2) CertainTeed Insulations.
      3) Childers Products.
      4) Knauf Fiber Glass.
      5) Johns-Manville.
      6) Proto Corporation.
      7) RPR Metals.
      8) Pabco.
5. Adhesives, mastics, caulkings, and finishes:
   a. Base:
      1) As indicated.
   b. Optional:
      1) Fuller, HB.
      2) Chicago (CMC).
      3) Childers Products.
      4) Dow Corning.
      5) Johns-Manville.

B. Insulation - 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.
   4. At hangers and bracing.

2.2 PIPE INSULATION, NON-FLEXIBLE

A. Pipe insulation, non-flexible:
   1. Material: Preformed commercial-grade fiberglass or phenolic thermal insulation.
   2. Designed for application on systems operating at temperatures between 0 and 850 degF.
   3. Thermal conductivity at mean temperature:
      a. $k \leq 0.23$, 75 degF.
      b. $k \leq 0.29$, 200 degF.
      c. $k \leq 0.54$, 500 degF.
   4. Base products:
      a. Owens-Corning Fiberglas ASJ/SSL-II.
   5. Facing:
      a. All service jacket:
         1) Temperature range: -20 to 150 degF.
         2) Provide with integral vapor retarder where indicated in Part Three.
   6. Seams, longitudinal: 2 IN self-sealing facing tabs:
      a. Provide adhesive on both contacting surfaces.
      b. Designed to perform without stapling.

2.3 PIPE INSULATION, FLEXIBLE

A. Pipe insulation, flexible:
   1. Material: Commercial-grade closed-cell elastomeric thermal insulation.
   2. Designed for application on systems operating at temperatures between 40 and 200 degF.
   3. Thermal conductivity at mean temperature:

a. k ≤ 0.27, 75 degF.
b. k ≤ 0.276, 90 degF.
4. Base product: Armstrong Armaflex.
5. Seams, longitudinal: Factory-cut and self-sealing.

2.4 DUCTWORK INSULATION, NON-FLEXIBLE

A. Ductwork insulation, non-flexible:
1. Material: Commercial-grade fiberglass thermal insulation formed with a thermosetting resin into semi-rigid or rigid boards.
2. Designed for application on systems operating at temperatures between 0 and 450 degF.
3. Minimum density:
a. Semi-rigid: 3.0 PCF.
b. Rigid: 6.0 PCF.
4. Thermal conductivity at mean temperature:
a. Semi-rigid:
1) k ≤ 0.22, 75 degF.
2) k ≤ 0.27, 150 degF.
3) k ≤ 0.38, 300 degF.
b. Rigid:
1) k ≤ 0.23, 75 degF.
2) k ≤ 0.27, 150 degF.
3) k ≤ 0.37, 300 degF.
5. Base product:
a. Owens-Corning Fiberglas Type 703 and 705 industrial insulation.
6. Facing:
a. Unfaced, foiled-reinforced-kraft (FRK), or all-service-jacket (ASJ) depending on applications as specified in Part Three:
1) Temperature range: -20 to 150 degF.

B. High efficiency ductwork insulation: Non-flexible Kooltherm Insulation Products, Koolphen K phenolic foam insulation with ASJ vapor barrier jacket:
1. Thermal conductivity (k value): Not greater than 0.13.

2.5 DUCTWORK INSULATION, FLEXIBLE

A. Ductwork insulation, flexible:
1. Material: Commercial-grade fiberglass thermal insulation.
2. Designed for application on systems operating at temperatures between 40 and 250 degF.
3. Thermal conductivity at mean temperature:
a. k ≤ 0.27, 75 degF.
4. Base product:
a. Owens-Corning Fiberglas commercial-grade all-service duct wrap.
5. Facing: Foiled, reinforced-kraft vapor-retarding.
6. Seams: 2 IN facing tab.

2.6 INSULATION FOR HOT EQUIPMENT

A. Same as Pipe Insulation, Non-flexible.

2.7 INSULATION FOR COLD EQUIPMENT

A. Insulation for cold equipment:
1. Material: Commercial-grade elastomeric thermal insulation.
2. Designed for application with complete adhesive coverage on systems operating at temperatures between -40 and 180 degF.
3. Thermal conductivity at mean temperature:
a. k ≤ 0.27, 75 degF.

b. k ≤ 0.276, 90 degF.
4. Base product: Armstrong Armaflex.

2.8 VENTILATION DUCT WRAP FIRE PROTECTION SYSTEMS

A. Material:
1. High temperature inorganic foil encapsulated flexible fireproofing wrap.
2. Performance:
   a. Fire rating: 1 or 2 hour, as indicated.
3. Clearance to combustibles rating: Not applicable.
4. Thickness: 1-1/2 IN.
5. Density: 6 pcf.
6. Encapsulated maximum flame spread rating: 25.
7. Encapsulated maximum smoke developed rating: 50.
8. Standards compliance:
   a. ASTM E-814 Firestop Test F-Rating: 2 hours.
   b. ASTM E-814 Firestop Test T-Rating: 2 hours.
   c. ASTM E-119 Full Scale Engulfment test fire rating: 2 hour.

B. Tapes: as directed by and approved by manufacturer installation requirements.

C. Banding material:
1. Stainless steel: minimum 1/2 IN wide x 0.015 IN thick.

D. Insulation pins/washers: as directed and approved by manufacturer installation requirements.

E. Through penetration fire stop materials: as directed by and approved by the manufacturer installation requirements.

F. Access door (either of the following access door assemblies is acceptable.
1. Field assembled:
   a. Steel angle, same material and gauge as duct, welded to duct.
   b. Access cover material: minimum 16 gauge steel.
   c. Accessory devices (threaded rod, insulation pins, wing nuts, washers, etc.): per manufacturers instructions to provide a complete rated and tested assembly.
2. Pre-fabricated system supplied by insulation manufacturer with following main components:
   a. Inner door: compression seal door (Basis of Design: Ductmate F2-HT).
   b. Outer door: pre-fabricated insulated access door.
3. Accessory devices (threaded rod, insulation pins, wing nuts, washers, etc.): per manufacturers instructions to provide a complete rated and tested assembly.

2.9 JACKETING AND PREFABRICATED FITTING COVERS

A. Jacketing and fitting covers, general:
1. Fitting covers:
   a. Designed to fit over precut insulation inserts.
   b. Designed specifically for fitting being covered:
      1) 2-gore covers are not acceptable.

B. Jacketing and fitting covers, PVC:
1. High impact: Minimum 0.028 IN thick.
2. Resistant to bacterial growth, mildew, and corrosion.
3. Installations exposed to weather:
   a. Resistant to ultra-violet rays.
   b. Designed for direct exposure to weather exposure without painting.
4. Minimum 1 IN over-lap at joints.
5. Base manufacturer: Johns-Manville.

C. Jacketing and fitting covers, metal:
1. Material: As indicated in Part Three.

2. On cold systems, ducts exposed to weather, 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 Three.
   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.

D. Jacketing and fitting covers, vinyl:
1. Material: Molded closed cell vinyl.
2. Thermal conductivity at mean temperature:
   a. $k \leq 1.17$, 75 degF.
3. Attaching method:
   a. Nylon ties.
4. Factory cut longitudinal seams.
5. Base manufacturer: Truebro.

2.10 INSULATION FASTENERS

A. Insulation adhesive:
1. Childers CP-82.
2. Foster 30-36.
3. Halstead 77-198.
4. Adhesive shall have a VOC content of no greater than 80 g/L in accord with SCAQMD Rule #1198.

B. Insulation mastic:
1. Childers CP-30.
2. Foster 35-00-GPM.
3. Mastic shall have a VOC content of no greater than 80 g/L in accord with SCAQMD Rule #1198.

C. Insulation caulking:
1. Dow No.11.
2. Caulking and sealants shall have a VOC content of no greater than 250 g/L in accord with SCAQMD Rule #1198.

PART 3 - EXECUTION

3.1 APPLICATION - GENERAL

A. Apply products per manufacturer's recommendations and as specified:
1. Allow for thermal expansion and contraction.

B. Do not insulate piping until satisfactory completion of required pressure tests.

C. Do not insulate piping until heat tracing cable has been installed. Coordinate with cable installer.

D. In general, do not insulate piping below ground:
1. Specific exceptions may exist under "Pipe insulation, flexible."

E. Apply insulation to clean, dry surfaces with pipe, duct, and equipment surfaces at room temperature.

F. Butt edges of insulation firmly together, and seal joints with compatible jackets, facings and adhesives as specified.

G. On cold systems and equipment, apply insulation with a continuous, unbroken vapor retarder:

1. To prevent condensation, provide insulation and vapor seals on hangers, supports, and anchors that are secured directly to cold surfaces.

H. Continue insulation through sleeves and wall and ceiling openings.

I. Insulate fittings, valve bodies, flanges and other pipeline accessories.

J. Insulation at piping supports: Coordinate with Section 20 05 29.

K. Rectangular and flat-oval ductwork exposed to weather:
   1. 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.

L. Insulation installed in multiple layers: Stagger joints between layers.

3.2 PIPE INSULATION, NON-FLEXIBLE

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 that matches facing:
         1) Manufacturer: Same as insulation.
   2. Fittings:
      a. On non-serviceable items, use either the built-up system or prefabricated fitting covers.
      b. On serviceable items, use prefabricated fitting covers attached with bands:
         1) Exception: On systems exposed to weather, attach with method described as best by manufacturer.
      c. On exposed fittings, flanges, valves, and pipe terminations, use prefabricated fitting covers:
         1) Example: Mechanical rooms.
      d. Built-up system:
         1) 2 IN and smaller: Finish with mineral fiber cement to thickness of adjoining pipe insulation.
         2) 2-1/2 IN and larger: Insulate with mitered pipe insulation segments or preformed fiberglass fittings. Secure with vinyl faced insulation strapping tape or 20 AWG galvanized annealed wire finished with one coat of mineral fiber cement.
         3) After mineral fiber cement is dry, finish with Glass Fab embedded in 2 coats of Foster 30-36 adhesive.
      e. Prefabricated PVC fitting covers:
         1) All sizes: Install covers over mitered pipe-insulation segments or preformed fiberglass fittings.

B. Provide non-flexible insulation on following piping systems in wall thicknesses indicated:
   1. Hydronic systems:
      a. Cooling coil condensate drains:
         1) All sizes: 1 IN.
      b. Chilled water piping, primary and secondary:
         1) Runouts to 2 IN: 1/2 IN.
         2) 8 IN and smaller: 1 IN.
         3) 10 IN and larger: 1-1/2 IN.
      c. Heating water piping (to 200 degF):
         1) Runouts to 2 IN: 1/2 IN.
         2) 2 IN and smaller: 1 IN.
         3) 2-1/2 IN and larger: 1-1/2 IN.
      d. Glycol water piping including heat recovery:
         1) Runouts to 2 IN: 1/2 IN.
         2) 2 IN and smaller: 1 IN.
         3) 2-1/2 IN and larger: 1-1/2 IN.

e. Process cooling water, same as chilled water piping.

2. Plumbing systems:
   a. Domestic cold water piping, laboratory cold water piping, chilled water piping for drinking fountains:
      1) 2 IN and smaller: 1/2 IN.
      2) 2-1/2 IN and larger: 1 IN.
   b. Domestic or laboratory hot/recirculating water piping (100-130 degF):
      1) 1-1/4 IN and smaller: 1/2 IN.
      2) 1-1/2 IN and larger: 1 IN.
   c. Domestic or laboratory hot/recirculating water (140-160 degF):
      1) 2 IN and smaller: 1 IN.
      2) Over 2 IN: 1-1/2 IN.
   d. Hot water and waste lines below handicapped accessible lavatories and sinks:
      1) All sizes: 1/2 IN.
      2) Waste lines are hot systems.
   e. Horizontal above grade storm drainage and overflow storm drainage piping within the building (including 24 IN up and down from horizontal and up to underside of roof deck):
      1) All sizes: 1 IN.
      2) These are cold systems.
3. Steam systems:
   a. Steam piping (0-15 PSIG, 201-250 degF):
      1) Runouts to 1-1/2 IN: 1 IN.
      2) 1-1/2 IN and smaller: 1-1/2 IN.
      3) Over 2 IN and over: 2 IN.
   b. Steam piping (15-70 PSIG, 251-316 degF):
      1) Runouts to 2 IN: 1-1/2 IN.
      2) 1 IN and smaller: 2 IN.
      3) 1-1/4 to 4 IN: 2-1/2 IN.
      4) Over 4 IN: 3 IN.
   c. Steam piping (Over 70 PSIG, 316 degF):
      1) Runouts to 2 IN: 1-1/2 IN.
      2) 1 IN and smaller: 2-1/2 IN.
      3) 1-1/4 - 2 IN: 2-1/2 IN.
      4) 2-1/2 - 4 IN: 3 IN.
      5) Over 4 IN: 3-1/2 IN.
   d. Steam condensate, pumped condensate return, condensate vent, blowdown, and exhaust steam (all temperatures) piping:
      1) 1 IN and smaller: 1 IN.
      2) 1-1/4 to 2 IN: 1-1/2 IN.
      3) Over 2 IN: 2 IN.

3.3 PIPE INSULATION, FLEXIBLE

A. General:
   1. Install by slipping insulation 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 thicknesses indicated:
   1. Hydronic systems:
      a. Cooling coil condensate:
         1) 2 IN and smaller: 1/2 IN.

b. Chilled water runouts:
   1) 2 IN and smaller: 1/2 IN.
   2) Included are runouts to fan coil units.
c. Heating water runouts:
   1) 2 IN and smaller: 1/2 IN.
   2) Included are runouts to fan coil units, unit heaters, finned tube radiation, and terminal units.

2. Plumbing systems:
   a. Domestic cold water piping, non-potable cold water piping:
      1) 2 IN and smaller: 1/2 IN.
      2) Flexible insulation only permitted on branch piping concealed within partition or plumbing chase directly behind fixtures being served.
   b. Domestic or laboratory hot/recirculating water piping:
      1) 2 IN and smaller: 1/2 IN.
      2) Flexible insulation only permitted on branch piping concealed within partition or plumbing chase directly behind fixtures being served.
   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.

3.4 DUCTWORK INSULATION, NON-FLEXIBLE

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 that matches 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. Do not apply insulation over coil and damper access panels.
   7. Do not apply insulation over internally lined ductwork: Coordinate with Section 23 31 13.
   8. Use FRK facing on concealed ductwork.
   9. Use ASJ facing on exposed ductwork.

B. Provide non-flexible insulation on following ductwork in thicknesses indicated:
   1. Outside-air ductwork (rectangular):
      a. All sizes: 2 IN.
   2. Supply-air ductwork in mechanical equipment room:
      a. All sizes: 1-1/2 IN.
   3. Exhaust duct upstream of fans exposed to weather with ASJ facing, 2 IN.
   4. Relief and exhaust air ducts in mechanical rooms between plenum and isolation dampers plus 36 IN:
      a. All sizes: 2 IN.

3.5 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 that matches 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 air handling unit housing to ends of duct runs, including diffuser necks and register ducts, and silencers.
5. Do not apply insulation over coil and damper access panels.
6. Do not apply over internally lined ductwork: Coordinate with Section 23 31 13.

B. Provide flexible insulation on following ductwork in thicknesses indicated:
1. Supply-air ductwork (including downstream of terminal units) except where covered by non-flexible insulation:
a. All sizes: 2 IN, minimum installed R-Value of 5.0.
2. Return-air ductwork in non-air conditioned areas (including utility shafts):
a. All sizes: 2 IN, minimum installed R-Value of 5.0.
b. Ceiling spaces directly above conditioned spaces are considered conditioned.
3. Silencers in ducts are included.
4. Return-air/relief-air ductwork from relief plenum at louver (or other outside opening) back to relief-air damper plus 36 IN:
a. All sizes: 2 IN, minimum installed R-Value of 5.0.

C. Flexible Elastomeric for exterior ductwork exposed to weather:
1. Install per MICA National Commercial and Industrial Standards Plate No.: 20A.
2. Adhesive: applied as required to assist the installation.
3. Mechanical fasteners: as required to assist the installation.
4. Provide one of the 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 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 10 year limited warranty against breakdown of the membrane due to ultraviolet radiation.
5. Insulation of standing seams: insulation manufactures field-cut pipe insulation with weather barrier.
6. 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.
7. Provide flexible elastomeric insulation on the following exterior ductwork in thickness indicated:

3.6 INSULATION FOR 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, 1/4 IN from edge.
   3. Insulate flanges and fittings as indicated under "Pipe insulation, non-flexible."
   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 thicknesses indicated:
   1. Flash tanks: 2 IN.
   2. Heat exchangers: 2 IN.
   3. Steam meters.

C. Provide removable insulation jacket for all devices, like pressure reducing valves, which require service.

3.7 INSULATION FOR COLD EQUIPMENT

A. Apply insulation with manufacturer's approved adhesive:
   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 manufacturer's approved white latex enamel to outside layer.

B. Provide cold-equipment insulation on following equipment in number of layers and total thicknesses indicated:
   1. Chilled water pump casing: 1 layer, 3/4 IN.
   2. Domestic and chilled water meter: 1 layer, 3/4 IN.
   3. All above grade drain bodies which convey rain water: 1 layer, 3/4 IN.
   4. Chilled water expansion tanks: 1 layer, 3/4 IN.
   5. Chilled water air separators: 1 layer, 3/4 IN.
   6. Water-to-water heat exchangers: Layer 3/4 IN.

3.8 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 with method described as best 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 with method described as best by manufacturer.

3.9 HOT WATER AND WASTE LINES EXPOSED BENEATH ACCESSIBLE FIXTURES

A. Hot water and waste lines exposed beneath accessible fixtures, see Section 22 42 00.

END OF SECTION

SECTION 20 08 00
TESTING AND BALANCING

PART 1 - GENERAL

1.1 DESCRIPTION

A. 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 and cooling water systems including pumps.
   5. RO water systems including pumps.
   6. Heating and cooling coils.
   7. Domestic and laboratory hot water systems including pumps.
   8. Tempered water system and pumps.

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 the design documents and recommend additional volume control dampers and balance valves where necessary for proper balancing of the systems. Submit recommendations to the Mechanical Contractor prior to proposal date.

B. Schedule work with trades involved.

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

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

E. Prepare and submit test reports.

1.4 RESPONSIBILITIES OF MECHANICAL CONTRACTOR

A. Provide a set of sheet metal design and piping design documents to the Testing and Balancing Agency for their review.

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 additional balancing dampers and balance valves as required by the Testing and Balancing Agency at no cost to Owner.

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

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

1.5 JOB CONDITIONS

A. Balance at time directed by Test Engineer:
   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 their original positions at end of each day.

1.6 CORRECTIVE WORK

A. Provide extended warranty of 90 days, after completion of test and balance work, during which time Owner's Representative may, at discretion of Owner's Representative, 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 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(s):
      a. Use forms similar to AABC or NEBB latest editions.
      b. Report(s) signed by TAB Engineer.
      c. Floor plans with air terminal units and air devices numbered to match report.

PART 2 - PRODUCTS

2.1 JOB SITE INSPECTIONS

A. Job site inspections:
   1. 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.
   2. Note any deficiencies and submit them, in writing, to Owner and to Test Engineer:
      a. 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. 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. Fan and motor sheave manufacturer, model, size, number of grooves and center distance.
    i. Belt size and quantity.
    j. 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. 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 or steam pressure, primary side.
    e. Actual pressure drop and related water flow rate or steam pressure, secondary side.
    f. Primary side entering and leaving temperatures. (Not applicable for steam-to-water heat exchangers.)
    g. Secondary side entering and leaving temperatures.
    h. Temperature control setting.
7. 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 or steam pressure.
8. Air terminal units, air valves, 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).
9. 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. Accurately calibrate and maintain test instruments in good working order:
   1. If requested, conduct tests of instruments in presence of Test Engineer.

B. If requested, conduct balancing tests in presence of Test Engineer.

C. 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.

D. Proceed with final balancing and adjustments when systems are 95 to 100 percent complete.

E. 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 percent 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 percent of design requirements.

D. In cooperation with HVAC Controls Contractor, 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 hours duration to demonstrate to satisfaction of Test Engineer and Owner that system(s) comply with requirements of plans and specifications, and that equipment and controls are functioning properly.

END OF SECTION

SECTION 20 11 00
PIPE AND FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Pressurized piping.
   2. Nonpressurized piping.
   3. RO water piping.
   4. Pre-insulated steam and condensate piping.
   5. Accessories:
      a. Dielectric fittings.
      b. Unions.

1.2 QUALITY ASSURANCE

A. Pipe and fittings: ASME B31.3 for Process Piping; ASME B31.9 for Building Service Piping.

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

C. Welding pressure piping: Section 20 12 00.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Fittings, mechanical groove-end and plain-end pipe:
      a. Base:
         1) Victaulic Company of America.
      b. Optional:
         1) Central Grooved Piping Products.
         2) Star Pipe Products.
         3) Gruvlok.
   2. Dielectric waterway fittings:
      a. Base:
         1) Perfection Corp. Victaulic Company of America.
   3. Pre-insulated steam and condensate conduit piping system:
      a. Base:
         1) Perma-pipe.
      b. Optional:
         1) Thermal Pipe Systems.
         2) Thermacor Process.

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: ASTM-A135 and ASTM-A53, Grade-B, Schedule-40 or Schedule-30 with minimum 0.25 IN wall thickness.

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. Rolled grooved.

C. Stainless steel pipe:
1. Welded chromium nickel alloy steel ASTM-A312 or ASTM-A358, Grade-304L. Stainless steel pipe, 10 IN and larger, shall be Schedule 10 unless otherwise indicated. Piping less than 10 IN shall be standard weight.

D. Copper pipe:
1. Seamless copper tubing, ASTM-B88, Type-K or Type-L as indicated.
2. Joints:
   a. Soldered: Use ASTM-B32, 95 percent tin, 5 percent antimony solder, or Silvabrite 100.
   b. High temperature soldered: Use 1,000 degF solder.
   c. Roll grooved.

E. Cast iron soil pipe:
1. ASTM-A74.
2. Bell and spigot joints: Use oakum and lead, or neoprene gaskets (if allowed by code).
3. Gaskets: ASTM-C564.

F. No hub cast iron pipe:
1. CISPI-301 or ASTM-A888.
2. Mechanical joints conforming to CISPI-310.
3. Hubless couplings conforming to CISPI-310:
   a. Use stainless steel couplings with neoprene gaskets.
   b. Gaskets: ASTM-C564.
   c. Examples:
      1) Husky: No hub couplings shall have a shield constructed of corrugated 304 stainless steel with a minimum thickness of 0.010 IN. Coupling sizes 1-1/2 through 4 IN shall have four bands and sizes over 4 IN shall have six bands. The worm gear drive clamps shall have a hexagonal head to accept a 5/16 IN socket torque wrench.
      2) Clamp All: No hub couplings shall have a shield constructed of minimum 28 ga. 304 stainless steel. Coupling sizes 1-1/2 through 4 IN shall have two bands and sizes over 4 IN shall have four bands. The worm gear drive clamps shall have a hexagonal head to accept a 5/16 IN socket torque wrench.
      3) Clamps shall be tightened to a minimum of 80 IN/LBS.
      4) Gaskets shall be neoprene rubber meeting the requirements of ASTM C-564 and have sealing rings molded into the gasket.
      5) Couplings shall meet the performance requirements of the FM 1680 class 1.

G. Ductile iron pipe:
1. Centrifugally cast, ANSI/AWWA-C151/A21.51, bituminous lined and coated.
2. Joints:
   a. Gasketed mechanical joints: ANSI/AWWA-C111/A21.11:
      1) Gaskets: ANSI/AWWA-C111/A21.11.

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. 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. Shop coating and lining for ductile and cast iron pipe:
1. Cement lining: ANSI/AWWA-C104/A21.4, except lining thickness may be reduced to 0.5 ANSI specified thickness for "Enameling" coating.
2. Rust preventative: Non-Ox-Id 558.
3. Bituminous coating: Manufacturer's standard, minimum 1 mil thick.
4. Provide interior surfaces of ductile iron and cast iron pipe and fittings with cement lining.
5. Shop coat flange faces with rust preventative compound.
6. Shop coat other surfaces of ductile iron and cast iron pipe and fittings with bituminous coating.

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 with EPDM Grade-E gasket.
4. Flanged fittings: ANSI/ASME-B16.5 and ASTM-A105 with 1/8” thick full face EPDM gasket.
5. Flange bolts: ASTM HTSB7.
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 with 1/8” thick full face EPDM gasket.

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 with 1/8” thick full face EPDM gasket.
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 with 1/8” thick full face EPDM gasket.

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. Dielectric fittings:
1. General:
a. Standard product for prevention of galvanic corrosion.
2. Dielectric waterway fitting:
a. ASTM-F-492, steel pipe casing with inert, non-corrosive thermoplastic lining (NSF/FDA listed).
b. Threaded X threaded, or threaded X grooved connections.
c. Perfection Corp., "ClearFlow".

I. 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).

J. 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.

2.4 PRE-INSULATED CONDUIT PIPING SYSTEM

A. Pre-insulated conduit piping system for high pressure steam and condensate from 5 FT – 0 IN outside building to 1 FT – 0 IN inside building to match site piping system:
1. System consists of factory insulated carrier-pipe sections as specified in Section 31 23 50.

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. Make connections to components in piping systems with minimum 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 Owner, 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 PTFE pipe joint tape meeting MIL-T-27730A (ASG).
   3. Pipe joint compound is not to be used.

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

C. 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.

D. 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.

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 as directed by 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 waterway 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 necessary.

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. See Section 20 12 00.

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 Owner 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. Use lead-free solder.

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 PRE-INSULATED CONDUIT PIPING SYSTEM

A. Install as specified in Section 31 23 50 and per manufacturer's instructions.

END OF SECTION

SECTION 20 12 00
WELDING PRESSURE PIPING

PART 1 - GENERAL

1.1 REFERENCES

A. The most recent revision of the publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only:
   1. American Petroleum Institute (API):
      a. API STD 1104:
         1) Welding of Pipelines and Related Facilities.
   2. American Society of Mechanical Engineers (ASME):
      a. ASME B31.1:
         1) Power Piping.
      b. ASME BPVC SEC I:
         1) Boiler and Pressure Vessel Code:
            a) Section I Power Boilers.
      c. ASME BPVC SEC II-C:
         1) Boiler and Pressure Vessel Code:
            a) Section II Material Part C – Welding Rods, Electrodes, and Filler Metals.
      d. ASME BPVC SEC V:
         1) Boiler and Pressure Vessel Code:
            a) Section V Nondestructive Examination.
      e. ASME BPVC SEC IX:
         1) Boiler and Pressure Vessel Code:
            a) Section IX Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
   3. American Society for Nondestructive Testing (ASNT):
      a. ASNT SNT-TC-1A:
         1) Recommended Practice.
   4. American Welding Society (AWS):
      a. AWS A2.4:
         1) Symbols for Welding, Brazing and Nondestructive Examination.
      b. AWS A3.0:
         1) Welding Terms and Definitions Including Terms for Brazing, Soldering, Thermal Spraying and Thermal Cutting.
      c. AWS D1.1:
         1) Structural Welding Code - Steel.
      d. AWS B2.1:
         1) Specification for Welding Procedure and Performance Qualification.
      e. AWS QC1:
         1) AWS Certification of Welding Inspectors.
      f. ANSI/AWS Z49.1:
         1) Safety in Welding, Cutting and Allied Processes.
      g. 29 CFR 1910:
         1) Occupational Safety and Health Standards.
      h. 29 CFR 1926:
         1) Safety and Health Regulations for Construction.

1.2 SUBMITTALS

A. Submit the following in accordance with Section 01 30 00.
   1. Shop Drawings:
      a. Pressure piping layout that also denotes each field weld location and corresponding number.
   2. Certificates:
      a. Welding procedures qualification.
      b. Nondestructive examination (NDE) procedures.
      c. NDE personnel certification procedures.
      d. Inspector certification.
      e. Submit inspector certification and NDE personnel certification for record.
   3. Welding Logs:
      a. Periodic submittals of completed Welding Acceptance Logs.
   4. Closeout Submittals:
      a. As-builts with weld identifications shown.
      b. Welding Acceptance Logs.
      c. AWS-Certified Inspector Reports.

1.3 QUALITY ASSURANCE

A. Welding Pressure Piping:
   1. Show location, length, and type of welds and indicated nondestructive testing as required.

B. Procedures: Develop and qualify procedures for welding metals included in the work. Do not start welding until welding procedures, welders, and welding operators have been qualified. Perform qualification testing by an approved testing laboratory. Maintain current records of the test results obtained in welding procedure, welding operator/welder performance qualifications, and nondestructive examination (NDE) procedures. These records shall be readily available at the site for examination. Qualify the procedures for making transition welds between different materials or between plates or pipes of different wall thicknesses. Unless otherwise specified, the choice of welding process shall be the responsibility of the Contractor:
   1. Previous Qualifications: Welding procedures, welders, and welding operators previously qualified by test may be accepted for the work without requalification provided that the following conditions are fulfilled:
      a. Copies of welding procedures, procedure qualification test records, and welder and welding operator performance qualification test records are submitted and approved in accordance with the paragraph entitled “Submittals.”
      b. Testing was performed by an approved testing laboratory.
      c. The welding procedures, welders, and welding operators were qualified in accordance with ASME BPVC SEC IX or AWS B2.1; and base materials, filler materials, electrodes, equipment, and processes conformed to the applicable requirements of this specification.
      d. The requirements of paragraph entitled “Welder and Welding Operator Performance Qualification” for renewal of qualification were met, and records showing name of employer and period of employment using the process for which qualified are submitted as evidence of conformance.
   2. Performance: The Contractor shall be responsible for hiring an independent AWS-certified welding inspector to inspect the quality of joint preparation, welding, and examination. Clearly identify and record materials used in the welding operations. The examination and testing defined in this specification are minimum requirements. Provide additional examination and testing as necessary to achieve the quality required. AWS-certified welding inspector, working with PE, shall complete the Welding Acceptance Log entry for each weld inspected (see log form attached to this section) as well as his own Inspection Reports.

C. Welding Procedures Qualification: Qualification of the welding procedures for each group of materials to be welded is required as indicated in the ASME BPVC SEC IX. Record in detail and qualify the "Welding Procedure Specification" for every welding procedure proposed. Qualification for each welding procedure shall conform to the requirements of ANSI Standards and to this specification. The welding procedures shall specify end preparation for welds, including cleaning, alignments, and root openings. Procedures shall specify shielding gas requirements for welding of stainless steel. Preheat, interpass temperature control, and postheat treatment of welds shall be as required by ANSI Piping documents, unless otherwise indicated or specified. Describe the type of backing rings or consumable inserts, if used, and, if they are to be removed, the removal process. Welding procedure qualifications shall be identified individually and referenced on the shop drawings or suitably keyed to the contract drawings.

D. Welder and Welding Operator Performance Qualification: Qualify each welder and welding operator assigned to work covered by this specification by performance tests using equipment, positions, procedures, base metals, and electrodes or bare filler wires from the same specification, classification, or group number that will be encountered on his assignment. Welders or welding operators who make acceptable procedure qualification tests will be considered performance-qualified for the welding procedure used. Determine performance qualification in accordance with ASME BPVC SEC IX, ANSI Piping Standards and as specified.

E. Renewal of Qualification: Requalification of a welder or welding operator shall be required under one or any combination of the following conditions:
   1. When a welder or welding operator has not used the specific welding process for a period of 3 months. The period may be extended to 6 months if the welder has been employed on another welding process.
   2. There is specific reason to question the welder's ability to make welds that will meet the requirements of the specifications.
   3. The welder or welding operator was qualified by an employer other than those firms performing work under this contract and a qualification test has not been taken within the preceding 12 months. Renewal of qualification under this condition need be made on only a single test joint or pipe of any thickness, position, or material to reestablish qualification for any thickness, position, or material for which the welder or welding operator had qualified previously.

F. Special Requirements for Stainless Steel:
   1. Installer shall be responsible to supply and qualify welders, equipment, and materials for scope of work. The qualifications of welding procedures, welders, and welding operators shall be in accordance with the requirements of ASME, Section IX.
   2. Welding shall conform to the following:
      a. Stainless steel lines: Weld using the tungsten insert gas (TIG) arc welding process.
      b. During welding, all gas lines shall be continuously purged with argon and allowed to escape into the atmosphere through a purge restrictor. All lines shall be maintained, under restricted purge or under pressure at all times during installation (purge relief will vent above the plane of pipe). Portable hand held oxygen monitors shall be used on pipe sizes 2-1/2 IN and larger. Monitors are to read ppm level, percentage monitor are not acceptable. Welding and brazing shall be done at less than or equal to 50 ppm oxygen concentrations. Time purging is acceptable on line sizes 2 IN and smaller.
      c. No welding joint can be less than six inches away from the end of the purge line, which will require, in many instances, that an extension be used.
      d. Provide verification of all purge lines at the end of each shift. If only one shift is scheduled, reduce purge to a trickle purge for overnight purging or cap under pressure. Inspect each flow meter for proper flow and verify that source of argon will be sufficient until next shift startup.
      e. Maintain all installation and purging procedures for all pipe runs until installation is complete and accepted by Owner.

f. If the system becomes contaminated due to fabrication techniques, prior to Owner written acceptance, perform a total system re-clean or replacement. All expenses shall be borne by the installer, with no expense to Owner.

G. Qualification of Inspection Personnel: Qualify inspection personnel in accordance with the following requirements:
   1. Inspector Certification: Qualify welding inspectors in accordance with AWS QC1.
   2. Welding Procedures and Qualifications:
      a. Specifications and Test Results: Submit copies of the welding procedure specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.
      b. Certification: Before assigning welders or welding operators to the work, submit their names, together with certification that each individual is performance qualified as specified. Do not start welding work prior to procedure qualification. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

H. Safety: Conform to ANSI/AWS Z49.1, 29 CFR 1910-SUBPART Q, "Welding, Cutting, and Brazing, "29 CFR 1926-SUBPART J, "Welding and Cutting."

1.4 ENVIRONMENTAL

A. Do not perform welding when the quality of the completed weld could be impaired by the prevailing working or weather conditions. Owner will determine when weather or working conditions are unsuitable for welding.

1.5 DELIVERY AND STORAGE

A. Deliver filler metals, electrodes, fluxes and other welding materials to the site in Manufacturers' original packages and store in a dry place until used. Label and design packages properly to give maximum protection from moisture and to assure safe handling.

PART 2 - PRODUCTS

2.1 WELDING MATERIALS

A. Comply with ASME BPVC SEC II-C. Welding equipment, electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures.

B. 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.

PART 3 - EXECUTION

3.1 WELDING

A. Do not deviate from applicable codes, approved procedures and approved shop drawings without prior written approval from Owner. Material or components with welds made off the site will not be accepted if the welding does not conform to the requirements of this specification unless otherwise specified.

3.2 WELDING OPERATORS

A. Perform welding in accordance with qualified procedures using qualified welders and welding operators.

3.3 SUPPORTS

A. Welding of hangers, supports, and plates to structural members shall conform to AWS D1.1.

3.4 EXAMINATIONS AND TESTS

A. Visual examinations shall be performed by the Contractor's independent inspector to detect surface and internal discontinuities in completed welds. Employ the services of a qualified commercial inspection or testing laboratory. Visually examine the welds. Radiographic examination may be required as indicated in Tables I and II attached to this section. Random NDE testing applies to ASME B31.1 piping unless specified otherwise. When examination and testing indicates defects in a weld joint, a qualified welder shall repair the weld in accordance with the paragraph entitled "Corrections and Repairs" of this section:
   1. Random NDE Testing: When radiographic examination is required, Owner will do the radiographic examination of the welds to be examined. If random testing reveals that a weld fails to meet minimum quality requirements, defective welds shall be repaired. If any of the additional welds examined also fail to meet the quality requirements, the entire group of welds shall be rejected. Remove and re-weld rejected welds. All costs associated with re-welding, retesting and delays shall be incurred by the Contractor.
   2. Visual Examination: Visually examine welds as follows:
      a. Before welding, check for compliance with requirements for joint preparation, placement of backing rings or consumable inserts, alignment and fit-up, and cleanliness.
      b. During welding, check for conformance to the qualified welding procedure.
      c. After welding, check for cracks, contour and finish, bead reinforcement, undercutting, overlap, and size of fillet welds.
   3. Nondestructive Examination: NDE shall be in accordance with written procedures. Procedures for radiographic tests and methods shall conform to ASME BPVC SEC V.
   4. Examination and Tests: Examination and tests will conform to paragraphs "Visual Examination" and "Nondestructive Examination" of this section. When destructive tests are made, qualified welders or welding operators shall make repairs using welding procedures which will develop the full strength of the members cut. Welding shall be subject to examination and tests in the mill, shop and field.

B. Stainless Steel:
   1. Completed welds shall be subject to inspection wherever practical.
   2. Welds will be inspected, visually by Owner. Visual weld inspections shall be in accordance with AWS QC 1. Any weld falling below the AWS QC 1 standard and deemed unacceptable by Owner from a visual inspection, shall be repaired or cut out. At the request of Owner, in the event any welder-operator consistently produces unsatisfactory productions welds, he (she) shall be refrained from welding and re-qualified, per Section IX of the ASME Boiler and Pressure Vessel Code. Repair and removal of welds or the re-qualification of welder-operators shall be done at the expense of the installer and not Owner.
   3. Weld Rejection Criteria:
      a. No visible tacks on the ID or OD of the weld.
      b. No undercut or profile defect causing the wall thickness to fall below that of the parent metal.
      c. Concavity / Convexity exceeds 10 percent of the tube/pipe 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 percent of the bead width.
      f. There should be no unusual inclusion or porosity when viewed with the unaided eye.
      g. Misalignment exceeds 10 percent of the wall thickness.

4. Upon request of Owner, remove a random piece of installed work, sufficient to establish the quality of materials and workmanship. If the piece shows evidence of weld rejection as stated above, Owner may require testing of additional samples. If the additional samples are acceptable, Owner will pay for the direct labor and materials required for the cutting out and restoration of these sample. If they are not acceptable, the cost shall be paid by the installer.

3.5 ACCEPTANCE STANDARDS

A. Visual: The following indications are unacceptable:
   1. Cracks, external surface.
   2. Undercut, external surface.
   3. Weld reinforcement:
      a. ASME B31.1, 1989, conform to Table 127A.2:

Reinforcement of Girth and Longitudinal Butt Welds

	Maximum Thickness of Reinforcement for Design Temperature (inches)		
Thickness of Base Metal (inches)	Greater than 750 °F	350 °F – 750 °F	Less than 350 °F
Up to 1/8, incl.	1/16	3/32	3/16
Over 1/8 to 3/16, incl.	1/16	1/8	3/16
Over 3/16 to 1/2, incl.	1/16	5/32	3/16
Over 1/2 to 1, incl.	3/32	3/16	3/16
Over 1 to 2, incl.	1/8	1/4	1/4
Over 2	5/32	The greater of 1/4 IN or 1/8 times the width of the weld in inches.	

NOTES:
- For double welded butt joints, this limitation on reinforcement given above shall apply separately to both inside and outside surfaces of the joint.
- For single welded butt joints, the reinforcement limits given above shall apply to the outside surface of the joint only.
- The thickness of weld reinforcement shall be based on the thickness of the thinner of the materials being joined.
- The weld reinforcement thicknesses shall be determined from the higher of the abutting surfaces involved.
- Weld reinforcement may be removed is so desired.

   4. Lack of fusion on surface.
   5. Incomplete penetration (applies only when inside surface is readily accessible).
   6. Convexity of fillet weld surface greater than 10 percent of longest leg plus 0.03 IN.
   7. Concavity in groove welds.
   8. Concavity in fillet welds greater than 1/16 IN.
   9. Fillet weld size less than indicated or greater than 1-1/4 times the minimum specified fillet leg length.

B. Radiography: Welds that are shown by radiography to have any of the following discontinuities are unacceptable:
   1. Any type of crack or zone of incomplete fusion or penetration.
   2. Any other elongated indication which has a length greater than:
      a. 1/4 IN for *t* up to 3/4 IN, inclusive.
      b. 1/3 *t* for *t* from 3/4 IN to 2-1/4 IN, inclusive.
      c. 3/4 IN for *t* over 2-1/4 IN where *t* is the thickness of the thinner portion of the weld. ("*t*" pertains to the thickness of the weld being examined. If a weld joins two members having different thickness at the weld, "*t*" is the thinner of these two thicknesses.)

3. Any group of indications in line that have an aggregate length greater than t in a length of 12t, except where the distance between the successive indications exceeds 6L where L is the longest indication in the group.
4. Porosity in excess of that shown acceptable in Appendix A-250, Acceptance Standard for Radiographically Determined Rounded Indications in Welds, ASME BPVC SEC I.

3.6 CORRECTIONS AND REPAIRS

A. Remove defects and replace welds as specified in ANSI Piping Standards, unless otherwise specified. Repair defects discovered between weld passes before additional weld material is deposited. Wherever a defect is removed, and repair by welding is not required, the affected area shall be blended into the surrounding surface eliminating sharp notches, crevices, or corners. After defect removal is complete and before re-welding, re-examine the area by the same test methods which first revealed the defect to ensure that the defect has been eliminated. After rewelding, reexamine the repaired area by the same test methods originally used for that area. For repairs to base material, the minimum examination shall be the same as required for butt welds. Indication of a defect shall be regarded as a defect unless re-evaluation by NDE or by surface conditioning shows that no unacceptable indications are present. The use of foreign material to mask, fill in, seal, or disguise welding defects will not be permitted.

END OF SECTION

SECTION 21 10 00
FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Fire protection systems:
   1. Descriptions:
      a. Water based:

Automatic sprinkler system protection, conforming to NFPA 13 "Standard for the Installation of Sprinkler Systems," will be provided throughout the building. There will be multiple sprinkler system zones (basement, first floor, second floor, third floor, loading dock, and mechanical penthouse) corresponding to the hazardous material control areas. Sprinkler drains will discharge to the exterior or lab sewer.

1) Dry-pipe sprinkler system.

The dry pipe sprinkler systems for the loading dock area and exterior terrace area will be hydraulically sized. The system will be calculated with an Ordinary Group 2 density of 0.2 GPM per square foot sprinkler over the most hydraulically remote 1950 sq. ft. to reflect the 30% area increase required by NFPA 13.

The sprinkler heads are spaced to ordinary hazard. Total inside and outside hose requirement of 250 GPM for ordinary hazard has been added to the calculations.

2) Standpipe-and-hose system.

A standpipe system conforming to NFPA 14 is required by IBC Section 905 and the system will be a manual (water pressure supplied by fire apparatus) wet (piping system always water-filled) system. As requested by the ANL Fire Department, hose valves within the two enclosed stairways will be located on each floor landing, not at the intermediate landing as required by NFPA 14. A roof manifold shall also be provided at the entrance to the roof on the penthouse level. The class of hose valves, as listed in the IBC, will be "Class III" (2½ inch valve with a 2½ inch by 1½ inch reducer). The hose valves will be connected to the combination standpipe/sprinkler system risers. Calculations shall be provided in accordance with NFPA 14, 2010.

3) Wet-pipe sprinkler system.

The wet pipe sprinkler systems in the ESB will be hydraulically sized. Ordinary Hazard Group I density of 0.15 GPM per square foot sprinkler over the most hydraulically remote 1500 sq. ft. will be utilized in all areas except the Hazardous Material Storage Room and associated staging area which will be Extra Hazard Group 2 and other Ground Floor storage areas which will be Ordinary Hazard Group 2.

The sprinkler heads are spaced to ordinary hazard. Total inside and outside hose requirement of 250 GPM for ordinary hazard and 500 gpm for extra hazard shall be added to the calculations.

Dry Sprinklers will be used to protect the entrance vestibule.

Sprinkler protection shall be extended into exhausted gas cabinets as required by applicable codes and standards.

b. Products:
   1) Pipe, fittings, and supports.
   2) Air pressure maintenance devices.
   3) Alarm and signal devices.
   4) Backflow protection devices.
   5) Dedicated compressed air systems.
   6) Fire department connections.
   7) Fire department valves.
   8) Fire hose cabinets.
   9) Fire system valves.
   10) Manual valves.
   11) System accessories.
   12) Sprinklers.
   13) Flexible sprinkler hose fittings.

1.2 QUALITY ASSURANCE

A. Quality assurance, general:
   1. Provide complete fire protection systems as described in the Contract Documents and according to criteria of authority (ies) having jurisdiction (AHJ) and the Owner's insurance carrier.
      a. Where system requirements as described in the Contract Documents exceed those of the AHJ, meet requirements of both.
      b. Where discrepancies exist among the AHJ and Contract Documents, the most stringent requirements shall take precedence.
   2. Addition, deletion, or relocation of existing sprinklers, and rerouting of existing pipe may be necessary.

B. Authorities Having Jurisdiction:
   1. Code Enforcement Agencies.
   2. Fire Marshall's Office.
   3. Water Supply Authority.

C. Owners Insurance Carrier: None

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

E. 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 system valves.

F. Piping and Fittings: Section 20 11 00.

G. Outside Utilities: Section 20 10 10.

1.3 SYSTEM DESCRIPTION

A. Design requirements:
   1. Design fire sprinkler systems.
      Install a new dry pipe system and combination automatic wet pipe sprinkler and manual class III standpipe system in accordance with NFPA 13, 2010 edition and NFPA 14, 2010 edition. All sprinkler systems shall be designed using the area/density method of NFPA 13. The entire building shall be designed at a minimum to Ordinary Hazard Group 1. Refer to the design drawings for specified hazard classifications of other areas throughout the Energy Science Building.
   2. Design fire sprinkler and suppression systems.
      a. Obtain NFPA 291 compliant water supply fire flow test no more than six (6) months prior to sprinkler system installation. Verify testing location with the fire protection engineer of record.
      b. Compare flow test results to those listed below, and use lowest pressure of the two to design systems.
         1) Static pressure: 71 PSIG
         2) Residual pressure: 69 PSIG.
         3) Flow: 1,678 GPM.
      c. Design systems using adjusted water supply curve:
         1) Adjust the flow test water supply curve to correspond with the low hydraulic grade line as provided by the water supplier.
      d. Designs shall include a minimum safety allowance of 10 PSIG (or 10% if the system demand is over 100 PSIG) below the adjusted water supply curve.

1.4 SUBMITTALS

A. Shop drawings:
   1. Submit detailed data and complete layout of fire protection systems approved by authorities having jurisdiction and prepared in accordance with the requirements for Working Plans described in applicable NFPA standards. Drawings and calculations to be prepared by a NICET Level III Designer and approved by a registered Fire Protection Engineer.
      a. Include calculations prepared in accordance with the requirements for Hydraulic Calculations described in applicable NFPA standards. Sprinkler systems shall be designed using the area/density method of NFPA 13. Standpipe systems shall be designed using the methodology described in NFPA 14. Local fire department apparatus is equipped with a 1,250 GPM pump. All hazard areas must be designed using the most hydraulically most remote demand area.

B. Product data:
   1. Backflow protection devices.
   2. Dry-pipe sprinkler system.
   3. Standpipe-and-hose system.
   4. Wet-pipe sprinkler system.
   5. Fire hose valve cabinets.

C. Contract closeout information:
   1. Letter stating spare parts have been delivered.
   2. Operating and maintenance data.
   3. Warranty letter.
   4. Owner instruction report.
   5. Test reports:
      a. Certification that tests as indicated in FIELD QUALITY CONTROL (Part 3) have been successfully completed and approved by authorities having jurisdiction.

1.5 JOB CONDITIONS

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

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Alarm and signal devices:
      a. Base:
         1) Viking.
      b. Optional:
         1) Federal Signal.
         2) Fire-Lite Alarms/Notifier.
         3) Potter Electric Signal.
         4) Potter Roemer.
         5) Simplex Access Controls.
         6) United Electric Controls.
   2. Alarm-test device:
      a. Base:
         1) Viking.
      b. Optional:
         1) Grinnell.
         2) Victaulic of America.
         3) AGF Manufacturing Inc.
   3. Backflow protection devices:
      a. Base:
         1) Cla-Val.
      b. Optional:
         1) Febco.
         2) Hersey Measurement.
         3) Watts Control Valves.
         4) Wilkins Regulator.
         5) Ames Co./Fluid Controls Systems.
   4. Fire department connections, fire department valves, fire hose cabinets, and hydrants:
      a. Base:
         1) Elkhart Brass.
      b. Optional:
         1) Croker West.
         2) Grinnell.
         3) JL Industries.
         4) Larsen's Manufacturing.
         5) Potter Roemer.
         6) Seco.
         7) Waterous.
   5. Fire protection systems, water-based:
      a. Base:
         1) Viking.
      b. Optional:
         1) Firematic Sprinkler Devices.
         2) Globe Fire Sprinkler.
         3) Potter Roemer.
         4) Star Sprinkler.
   6. Sprinklers:

a. Base:
   1) Viking.
b. Optional:
   1) Firematic Sprinkler Devices.
   2) Globe Fire Sprinkler.
   3) Reliable Automatic Sprinkler.
   4) Star Sprinkler.

7. Fire Hose Valve Cabinets
   a. Base:
      1) JL Industries.
   b. Optional:
      1) Larsen's Manufacturing Company.
      2) Potter Roemer.
8. Flexible sprinkler hose fittings
   a. Base:
      1) Flexhead Industries, Inc.
   b. Optional:
      1) Victaulic, AquaFlex
9. Other manufacturers desiring approval comply with Section 00 26 00.

B. Submit other pipe materials, joining methods, and equipment not specified, but accepted by applicable NFPA standards and approved by authority(ies) having jurisdiction, in accordance with Section 00 26 00.

C. Use only new material of first class construction, designed and guaranteed to perform service required.

D. Provide fully operational systems.

2.2 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 and Schedule 5 pipe.
      b. Plain end, pressure fit type fittings.
      c. Hole cut mechanical tee fittings.
   4. Fittings: galvanized where galvanized piping is used (dry pipe system).
   5. Corrosion Resistance Ratio (CRR) of all pipe used: one to one.

B. Above ground pipe normally containing water:
   1. Examples: Wet-pipe and standpipe-and-hose fire protection systems.
   2. Black steel, Schedule-10 for pipe 2.5-inches to 6-inches:
      a. Welded joints.
      b. Mechanical coupling joints:
         1) Rolled groove type (cut grooving not allowed).
   3. Black steel, Schedule-40 for pipe size 2-inches and smaller:
      a. Threaded joints.
      b. Welded joints.
      c. Mechanical joints:
         1) Cut or rolled groove type.

C. Above ground pipe normally containing air:
   1. Examples: Deluge, dry-pipe, and dry-pipe/pre-action fire protection systems; piping for alarm and sensing devices.
   2. Galvanized steel, Schedule-40:
      a. Threaded joints.

b. Welded joints.
c. Mechanical joints:
1) Cut or rolled groove type.

D. Pipe, below ground:
1. Same as outside utility fire protection piping.
a. See Section 20 10 10.

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-A47.
a. Malleable iron, 500 PSI working pressure.
b. Coupling gasket material: Butyl rubber.
c. UL listed.
d. Approved by FM, NFPA-13, and NFPA-14.

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

2.3 ALARM AND SIGNAL DEVICES

A. Alarm and signal devices, general:
1. UL listed and FM approved.
2. Coordinate electrical requirements with electrical installer and specification section 28 31 00.

B. Alarm devices: Refer to specification section 28 31 00

C. Signal devices: Refer to specification section 28 31 00
1. Valve tamper switch are not used per direction from the AHJ – All control valves are provided with chain and lock.

2.4 BACKFLOW PROTECTION DEVICES

A. General:
1. Provide on water supply at location indicated on drawings to prevent contamination of potable water system.
2. Corrosion resistant materials.
3. Totally rebuildable.
4. Flanged ends.
5. Rating: Water at 175 PSI working pressure and between 33 to 110 degF.
6. Provide OS&Y inlet and outlet isolation valves. OS&Y valves to be provided with chain and lock in lieu of tamper switches.
7. Provide four test cocks.
a. Provide No. 1 test cock on inlet valve.

8. Approved by authority(ies) having jurisdiction.
9. UL listed and FM approved.

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

2.5 FIRE ALARM SYSTEM CONTROL PANEL

A. Fire alarm system control panel: Provided under Electrical Specification Divisions. See 28 31 00

2.6 FIRE PROTECTION SYSTEMS, WATER-BASED

A. Dry-pipe fire protection sprinkler system:
1. Description: Automatic system shall employ closed sprinklers attached to a piping system filled with pressurized air and connected to an accelerated dry-pipe valve that is opened by actuation of a sprinkler which relieves air pressure in the system.
   a. Normal operation:
      1) Actuation of sprinkler relieves air pressure opening dry-pipe valve and allowing water to flow through actuated sprinkler.
      2) Water flow through dry-pipe valve sends signal to Fire Alarm System Control Panel, and sounds local alarm.
   b. Failure operation:
      1) Failure of sprinkler relieves air pressure which opens dry-pipe valve allowing water to flow through failed sprinkler.
      2) Water flow through dry-pipe valve sends signal to Fire Alarm System Control Panel via pressure switch in dry-pipe valve trim, and sounds local alarm.
2. Air source:
   a. Provided by dedicated air compressor adjacent to the dry-pipe valve. Contractor shall provide either a riser mounted compressor for each dry-pipe valve or a single tank-mounted air compressor supply both dry-pipe systems.

B. Standpipe-and-hose fire protection system:
1. Class III:
   a. Standpipes, fire department connections, fire-hose cabinets, and fire department valves.

C. 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.

D. Dedicated compressed air systems:
1. Air compressor:
   a. UL listed and FM approved.
   b. Dedicated to fire protection service.
   c. Mount pump and motor on common base plate with coupling and guard.
   d. Provide for mounting on wall, floor, or pipe.
   e. Capacity: Capable of restoring normal air pressure in system within 20 minutes.
   f. Field adjustable cut-in and cut-out pressure switch.
   g. Motor electrical data:

1) Minimum 1/2 Hp.
2) 460V, 3 ph, 60 Hz.

2. Air compressor accessories:
   a. Inlet silencer and filter.
   b. Discharge air and water separator, with relief valve, gauge glass and ball float valve.
   c. Discharge check valve, isolation valve, and pressure gauge.
   d. Pressure switch: HIGH/LOW operation.
   e. Mounting hardware.
   f. Piping and fittings.
   g. Drip leg with drain valve to collect condensate, and keep it away from compressor.
   h. Desiccant dryer.
      1) Provide dryer when compressed air will be in piping exposed to freezing.
3. If a single compressor will be used to supply more than one sprinkler system, provide the following:
   a. A receiver with pressure gauge.
   b. On each sprinkler system supply: Check valve, pressure gauge, and isolation valve.

2.7 FIRE DEPARTMENT CONNECTIONS

A. Fire Department connections and hydrants:
   1. Components and assemblies UL listed and FM approved.
   2. Minimum 175 PSI non-shock cold-water working pressure.
   3. 5-in. Storz inlet connections to fit local fire department standards.
   4. Outlet threads for hydrants to fit local fire department standards.

B. Fire department (siamese) connections. Provide a 5” Storz type FDC.
   1. Outside free standing type.
   2. Inlet:
      a. Quantity:
         1) One Storz connection.
      b. Size:
         1) 5 IN.
   3. Outlet:
      a. Quantity:
         1) One.
      b. Size:
         1) 6 IN.
   4. Finish:
      a. Satin brass.
   5. Raised lettering:
      a. "AUTOSPKR STANDPIPE".
   6. Connection style:
      a. Free standing.

2.8 FIRE DEPARTMENT VALVES

A. Fire department valves and fire hose cabinets, general:
   1. Components and assemblies UL listed and FM approved.
   2. Valves: Minimum 175 PSI non-shock cold-water working pressure.
   3. Outlet threads shall match local fire department standards.

B. Fire department valves:
   1. General:
      a. 2-1/2 x 2-1/2 IN valve with 2-1/2 by 1-1/2 reducer.
      b. Cap and chain on 1-1/2 reducer.
      c. Pattern: Straight or angle.
   2. FDV, Fire department valve without cabinet:

a. Finish: Polished brass.

2.9 FIRE SYSTEM VALVES

A. Fire system valves, General:
1. UL listed and FM approved.
2. Body: Ductile or cast iron.
3. Pressure rating: 175 PSI non-shock cold-water working pressure.
4. 2 IN and smaller: Threaded.
5. 2-1/2 IN and larger: Flanged or grooved.
6. Trim to meet NFPA requirements.
7. Trim to meet performance as indicated in descriptions of fire protection systems.

B. Dry pipe valves:
1. Cast bronze clapper, clamp ring, and valve seat.
2. Teflon coated valve seat.
3. Neoprene diaphragm and rubber seat.
4. Stainless steel seat-rubber retaining ring.
5. Locks open upon actuation.
6. Trim for priming, connecting alarms, testing alarms, draining system, preventing water logging, reading air and water pressures, and connecting air supply.

2.10 MANUAL VALVES

A. 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.

B. Check valves 2-1/2 IN and larger: V-53 or V-54.

C. Grade-type post indicator valve assembly:
1. Valve: V-52.
2. Post: UL listed and FM approved indicator post to fit V-52.

D. 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.

E. 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.

2.11 SPRINKLERS

A. Sprinklers - general:
1. Provide UL listed sprinklers of style and type required for service indicated.
2. Orifice: Sprinklers shall have 1/2 IN nominal orifices.
3. Finish of exposed parts: As indicated.

B. Sprinkler types: Metallic fusible link or glass bulb.

C. Sprinkler styles:
1. Upright:
   a. Finish: Standard bronze.

2. Pendant:
   a. Finish: Standard bronze.
3. Pendant with escutcheon:
   a. Finish: Chrome.
4. Concealed pendant: Preferred in all Acoustical Ceiling Tile areas.
   a. Ceiling plate flush with finished ceiling.
   b. Housing: 1/2 IN adjustment.
   c. Finish: White.
5. Horizontal sidewall:
   a. Finish: Chrome.
   b. Dry horizontal sidewall sprinkler to be provided in entry vestibule (Room A172).
   c. Install sidewall heads where shown on drawing.
6. Flexible Sprinkler Hose Fittings:
   a. Hose fittings – general
      1) Hose fitting shall be stainless steel for use in connecting sprinkler heads in commercial suspended ceilings. A bracket attaches to the ceiling grid for supporting the hose.
      2) Hose fittings shall be braided stainless steel, hose fittings and accessories shall be FM 1637 approved.

2.12 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: See Section 20 05 19.
   1. UL listed and FM approved.

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: Use where indicated on drawings
   1. UL listed.
   2. Heavy duty welded wire.
   3. Red baked enamel finish.

E. Fire Hose Valve Cabinet
   1. Cabinet body shall be recessed on first floor and surface mounted on ground floor Cabinet body shall be heavy-gage steel with primed surfaces and baked white enamel interior. Exterior shall be powder coated white.
   2. Cabinet shall be sized to accommodate the valve, and either one 9.5 liter 2-1/2-gallon air-pressurized water fire extinguisher or one 7 kilogram 15-pound carbon-dioxide extinguisher. Extinguishers will be furnished by the owner.
   3. Recessed cabinet shall be of the fire-rated type.

4. Doors shall be of the full glass type, glazing shall be ¼-inch clear acrylic and doors shall be equipped with a lock and pull handle.
5. Cabinets shall be labeled (with red vertical letters) FIRE DEPARTMENT VALVE (in front of the hose valve) and FIRE EXTINGUISHER (in front of the fire extinguisher).

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate with other trades to ensure adequate space for equipment and piping placement. Sprinklers shall be centered in ceiling tiles in rooms with ACT ceilings.

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. Firestop penetrations in accordance with Section 20 05 29.

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.

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) Glass bulb: 155 degF.
         2) 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: 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 hours.
      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 applications by room types:
   1. Areas subject to freezing:
      a. Sprinkler styles: Upright or dry sidewall.
         1) Temperature rating: As required for room type.
      b. Provide sprinkler guards on pendant sprinklers.
   2. Electrical rooms/closets:
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall.
      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.
         1) Glass bulb temperature rating: 200 degF.
         2) Fusible link temperature rating: 212 degF.
      c. Provide sprinkler guards.
   4. Finished rooms (rooms with ceilings):
      a. Sprinkler styles:
         1) Concealed pendant.
         2) Horizontal sidewall.
         3) Flexible sprinkler hose fittings acceptable.
      b. Where ceiling is being replaced in existing areas, relocate existing sprinklers to coordinate with new ceiling layout.
      c. Where ceiling exists in area subject to freezing, comply with requirements for areas subject to freezing.
      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, pendant, or horizontal sidewall.
         1) Glass bulb temperature rating: 200 degF.
         2) Fusible link temperature rating: 220 degF.
      b. Provide sprinkler guards.
   6. Storage rooms:
      a. Glass bulb temperature rating: 286 degF.
      b. Fusible link temperature rating: 286 degF.
   7. Substations:
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall.
         1) Glass bulb temperature rating: 200 degF.
         2) Fusible link temperature rating: 220 degF.
      b. Provide sprinkler guards.
   8. Telephone/Communication rooms/closets:
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall.
      b. Provide sprinkler guards.
   9. Unfinished rooms (rooms without ceilings):
      a. Sprinkler styles: Upright, pendant, or horizontal sidewall.

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.

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 CABINETS

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

3.6 MANUAL VALVES

A. Provide isolation valves at following locations:
   1. Bases of standpipes.
   2. Fire system valves.
      a.
   3. 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. At each zone control assembly as shown on drawings.
   2. Fire department connection.

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 test header and backflow preventer test header shutoff valve.

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

3.7 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 lab wastewater floor drain.
   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 lab wastewater floor drain.
4. Required locations:
   a. At low points of systems.
   b. At alarm test loops.
   c. At bases of risers and standpipes. Lab wastewater drain is located outside of stairwells.
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 inlet and outlet of pressure reducing valves.
   e. At top of each sprinkler riser.
   f. At alarm test loops.
   g. At other indicated locations.
2. Provide shutoff valve and drain for each gauge.

D. Sprinkler cabinets:
   a. Install adjacent to sprinkler riser manifold.

3.8 ELECTRICAL WIRING – REFER TO SPECIFICATION SECTION 28 31 00

END OF SECTION

SECTION 22 10 16
PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   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.
         2) Acid resistant industrial waste, and industrial vent within building and 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) Floor drains.
         3) Funnels.
         4) Roof drains.
      d. Flashings.
      e. Traps.
      f. Valves:
         1) Automatic trap primer valves.
         2) Backwater valves.
         3) Balancing valves, constant flow control.
         4) Check valves.
         5) Manual valves, potable water.
         6) Manual valves, waste-water.
         7) Pressure reducing valves.
      g. Water-hammer arresters.
      h. Water meters.

B. Definitions:
   1. Caulked: Tamped lead and oakum joint.
   2. Drainage piping: Soil, waste, vent, industrial waste, industrial 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.

1.2 QUALITY ASSURANCE

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

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

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

D. American Water Works Association Standard AWWA-C601: Sterilization Standard.

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

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

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

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

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

1.3 SUBMITTALS

A. Shop Drawings:
   1. Piping layout drawings at 1/4 IN/FT scale.

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

C. Contract Closeout Information:
   1. Pressure test reports.
   2. Disinfection test report.
   3. Operating and maintenance data.
   4. Certificate of local utility approval of backflow preventer and water meter.

1.4 RELATED SECTIONS

A. Refer to related Sections under Division 20 – Mechanical General Requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Backflow protection device (Reduced-pressure principle):
      a. Base:
         1) Cla-Val.
      b. Optional:
         1) Watts Regulator.
         2) Febco.
         3) Hersey Measurement.
         4) Wilkins Regulator.
   2. Backflow protection device (Vacuum breakers):
      a. Base:
         1) Watts Regulator.
      b. Optional:
         1) Febco.
         2) Wilkins Regulator.
   3. Cleanouts and Drains:
      a. Base:
         1) Wade Division/Tyler Pipe.
      b. Optional:
         1) Watts Drainage - Ancon.

2) Josam Company.
3) JONESPEC Plumbing Products.
4) Jay R. Smith Manufacturing Co.
5) Zurn Industries, Inc.

4. Valves (Automatic trap primer):
   a. Base:
      1) Precision Plumbing Products.
   b. Optional:
      1) Jay R. Smith Manufacturing Co.
      2) Wade Division/Tyler Pipe.
5. Valves (Backwater):
   a. Base:
      1) Josam Company.
   b. Optional:
      1) Jay R. Smith Manufacturing Co.
      2) Watts Drainage-Ancon, Inc.
6. Valves (Constant flow control balancing valves):
   a. Base:
      1) Nexus #UX-050-S-050F-0.50-VGB
   b. Optional:
      1) Flow Design Inc. - Autoflow.
      2) Preso.
7. Valves (Pressure reducing):
   a. Base:
      1) Cla-Val.
   b. Optional:
      1) Watts Regulator.
      2) Fisher.
      3) Wilkins Regulator.
8. Water-hammer arresters:
   a. Base:
      1) Wade Division/Tyler Pipe.
   b. Optional:
      1) Jay R. Smith Manufacturing Co.
      2) Josam Company.
      3) Zurn Industries, Inc.
9. Water meters:
   a. Base:
      1) Hersey Measurement.
   b. Optional:
      1) Badger Meter.
      2) 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.
      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) Copper, type L, with roll-groove joints and wrought copper or cast brass fittings.
b. Hot water and soft water:
1) Copper, type L, with roll-groove joints and wrought copper or cast brass fittings.

B. Drainage piping (soil, waste, vent, indirect, and storm):
1. Above grade:
a. Cast-iron, hubless pipe, fittings, bituminous coated and lined and elastomeric sealing sleeves with stainless-steel or cast iron clamps, as allowed by code.
2. Below grade:
a. 2 IN diameter or larger.
b. Cast-iron, hubbed pipe and fittings, bituminous coated and lined with elastomeric push joints, as allowed by code.

C. Pressure drainage piping:
1. Galvanized steel, cast-iron drainage fittings with threaded joints.

D. Exposed piping in finished areas:
1. Stainless steel, 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:
1) Non-rising stem.
2) OS&Y.
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.
j. 6 IN pipe: 720 GPM.
k. 8 IN pipe: 1250 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 (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.

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 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. Dimensions: 12 x 12 x 6 IN floor sink with square top.
    b. Material of construction: 304 stainless steel.
    c. Stainless-steel sediment basket and optional dome bottom strainer, same grade as body.
    d. Grate:
        1) Removable, full size, medium duty anti-tilt type.
        2) Material of construction: stainless-steel, same grade as body.
        3) Size: 10 IN square.
    e. Example: Jay R. Smith 9697.

F. Funnels:
1. Material: Match to associated grate, strainer, or P-trap.
2. Secure to grates and strainers with screws.
3. 6 IN diameter, 4 IN tall.
4. 8 x 3 IN oval, 4 IN tall.

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 occurs 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: 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 extension to allow for insulation thickness.
        1) Coordinate extension height with roof insulator.
    h. Example: Wade 3000SD.

H. Terrace 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 occurs at steel decks).
2. DD-1:
    a. Flashing collar diameter: 13 IN.
    b. Flashing clamp with gravel stop.
    c. Mushroom dome: coated cast iron.
    d. Mushroom dome height: 4-3/4 IN.
    e. Mushroom dome diameter: 10 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 3223-189.

3. DD-2 (overflow drain):
   a. Flashing collar diameter: 13 IN.
   b. Flashing clamp with integral 2 IN tall water dam.
   c. Mushroom dome: coated cast iron.
   d. Mushroom dome height: 4-3/4 IN.
   e. Mushroom dome diameter: 10 IN.
   f. Provide bearing pan/sump receiver.
   g. Provide solid extension to allow for insulation thickness.
      1) Coordinate extension height with roof insulator.
   h. Example: Wade 3223-189SD.

2.6 DRIP PANS OVER CRITICAL AREAS

A. Drip pans:
   1. Field- or shop-fabricated: See detail.

2.7 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.

2.8 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: TP-1
      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.
   3. Automatic trap primer valve: TP-1
      a. Serves one to four drains.
      b. 1/2 IN brass.
      c. Integral backflow preventer.
      d. Designed to be installed at end of dead-end line with continuation to drain.
         1) Activated by 5 PSI drop or more in main.
      e. Automatically adjusts to line pressures between 35 and 75 PSIG.

f. Example: Precision Plumbing Products Prime-Rite.

4. Automatic trap primer valve: TP-1
   a. Serves one to eight drains.
   b. Body: Polypropylene.
   c. Internal parts: Stainless steel, monel metal.
   d. Integral backflow preventer.
   e. Designed to be installed at end of dead-end line with continuation to drain.
      1) Activated by 3 PSI drop or more in main.
   f. Automatically adjusts to line pressures between 35 and 75 PSIG.
   g. Example: Precision Plumbing Products Oregon #1.
5. Automatic trap primer valve: TP-2
   a. Serves one to four drains.
   b. 1/2 IN brass.
   c. Integral backflow preventer.
   d. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power
   e. Example: Precision Plumbing Products MP-500-115V. with distribution unit DU
6. Automatic trap primer valve: TP-1
   a. Serves one to eight drains.
   b. Body: Polypropylene.
   c. Internal parts: Stainless steel, monel metal.
   d. Integral backflow preventer.
   e. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power
   f. Example: Precision Plumbing Products MP-500-115V with two (2) distribution units

7. Trap primer distribution reservoir.
   a. Copper reservoir with brass fittings and clear plastic inspection cover.
      1) Feeds up to four traps through separate lines.
      2) Provide mounting brackets.
   b. Example: Precision Plumbing Products.

B. Backwater valves:
   1. Coated cast iron body.
   2. Hubbed inlet.
   3. Offset spigot outlet.
   4. Gasketed and bolted cover.
   5. Removable, automatic bronze valve seat and flapper that hangs open during periods of non-operation.
   6. Example: JayR. Smith 7012.

C. Balancing valves, constant flow control:
   1. Factory calibrated, direct acting, automatic pressure compensating.
   2. Control flow rates within 5 percent of flow rating over operating pressure differential range.
      a. Set flow rating according to pipe sizes indicated on plans:
         1) 1/2 IN: 0.5 GPM.
         2) 3/4 IN: 1.0 GPM.
         3) 1 IN: 3.0 GPM.
         4) 1-1/4 IN: 5.0 GPM.
   3. Pressure differential range:
      a. 1-5 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.

D. Check valves:
1. 2 IN and smaller: V-24 or V-25.
2. 2-1/2 IN and larger: V-28 or V-29.

E. 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.

F. Manual valves, waste-water:
1. Drainage piping shut off: V-37.
2. Pressure drainage piping:
   a. Shut off: V-2.
   b. Check: V-28.

G. Pressure reducing valves:
1. Use pilot-operated or direct-acting PRV based on pipe size indicated on plans.
   a. 2 IN and smaller: direct-acting.
   b. 3 IN and larger: pilot-operated.
2. Direct-acting PRV.
   a. Bronze bodied, diaphragm and spring type valve with integral thermal bypass and removable, stainless-steel strainer.
   b. Pressure adjustment range: 15 to 75 PSIG.
   c. Size PRV's to have a maximum fall-off pressure of 15 PSIG at flows indicated below (refer to plans for pipe sizes):
      1) 1/2 IN pipe: 2.2 GPM.
      2) 3/4 IN pipe: 6 GPM.
      3) 1 IN pipe: 13 GPM.
      4) 1-1/4 IN pipe: 22 GPM.
      5) 1-1/2 IN pipe: 35 GPM.
      6) 2 IN pipe: 75 GPM.

2.10 WATER-HAMMER ARRESTERS

A. Water-hammer arresters:
1. Engineered, and certified in accordance with Plumbing and Drainage Institute (PDI) Standard WH-201.
2. Type and construction:
   a. Bellows type and constructed entirely of stainless steel.
   b. Piston type is not acceptable.

B. Water-hammer arrestors shall be bellows type and constructed entirely of stainless steel.

2.11 WATER METERS

A. Water meters, general:
1. Use threaded fittings on meters 2 IN and less in size.
2. Use flanged connections on meters 2-1/2 IN and larger.
3. Provide valve on each side of meter.
4. Provide meters that can be remotely read by building's energy management system.

a. Coordinate with Control Provider.

B. Private water meters:
1. As shown on drawings
2. Provide vertical-shaft turbine meters on main water supply to building and on cold water supply to laboratory water system and make-up water lines to HVAC and Plumbing equipment.
3. 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 floor:
1. Provide reaction anchorage at buried elbow where water service turns up below the floor.
2. Terminate top of exterior piping material with flange connection.
   a. Tie flange back to buried elbow with tie rods of same diameter as flange bolts.
   b. Permanently protect below-grade tie rods against corrosion.
   c. Provide minimum of one tie rod for each two flange bolt holes.

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.
   c. Where specified in Section 22 60 80: High Purity Water Systems.

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 bibb 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 percent in excess of pipe's working pressure, but in no case less than 150 PSI.
   a. System shall hold pressure for 24 hours.
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 hour 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. 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 degrees.
      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.

E. Install piping and drains to allow for flashings provided under Roofing System section.
   1. Coordinate with Roofing installer.

F. Floor drains and floor sinks:
   1. At locations with waterproofing: Set top of flashing collar 1/2 IN below level of waterproofing.
   2. At locations without waterproofing: Place drain integrally with poured concrete. Set top of drain flush with finished floor.
   3. Set over P-traps.

G. Drains in plenums: Indirectly waste plenum drains to receptor outside of plenum.

H. 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.

I. 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 00
WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Compaction density test:
   1. See Section 31 23 33, TRENCHING, BACKFILLING AND COMPACTING FOR UTILITIES.

B. Reference: NFPA 24.

1.2 SUBMITTALS

A. Project information:
   1. Manufacturer's certification for materials.

B. LEED Information:
   1. LEED Credit MR 4.1 [4.2], Recycled Content: Manufacturer's product data for products with recycled content indicating amount of post-consumer and post-industrial recycled content
   2. LEED Credit MR 5.1, Local/Regional Materials: Manufacturer's certification indicating final point of assembly for products and materials located within 500 miles of Project site. Include manufacturer's name, address and phone number.

1.3 JOB CONDITIONS

A. Verify location of existing utilities and structures and underground utilities.

B. Protect existing utilities and structures and replace if damaged.

C. Repair if damaged by this work.

D. Lengths indicated on drawings are for information only.

E. Furnish lengths as required.

F. Verification of existing utilities and structures:
   1. Plans indicate existing utilities as indicated on site survey.
   2. Verify accuracy, location and depth of each utility prior to trenching or tunneling.
   3. If pipe adjustment is necessary due to location of other utilities, secure approval from Owner.

G. Revisions to Contract Drawings:
   1. If it becomes necessary to change location of lines due to building construction, secure prior written approval from Owner.
   2. If Contractor initiated, make approved changes without added cost to Owner.

H. Do not change pipe sizes without securing prior written approval from Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Water mains:

1. Ductile iron pipe and fittings, ANSI/AWWA-C151/A21.51, ANSI/AWWA-C105/A21.5, ANSI/AWWA-C111/A21.11, and ANSI/AWWA-C110/A21.10, thickness Class 2, or heavier, bituminous coated, cement mortar lined in accordance with ANSI/ AWWA-C104/A21.4.

B. Service lines 3 IN and smaller: ASTM-B88 copper tubing type "K" hard drawn, with solder type bronze fittings.

C. Valves: AWWA C500, gate type, with mechanical joint ends or as otherwise may be necessary; cast iron body, bronze mounted, parallel seat, double disk, non-rising stem, open left (counter clockwise), working pressure 200 PSI; valves from a single manufacturer.

D. Valve boxes: Roadway type, cast iron, 2 section, adjustable screw type, proper length and base size for depths required; word "water" cast in cover; compatible with valves.

E. Fire hydrants:
1. AWWA C502, dry barrel type designed for 150 PSI working pressure.
2. Valve opening at least 5 IN in diameter.
3. 6 IN bell connection.
4. Two 2-1/2 IN hose connections.
5. One 4-1/2 IN pumper connection.
6. Outlets: American National Standard fire hose coupling threads.
7. Working parts: Bronze.
8. Latest stock pattern produced by manufacturer.
9. Opening counterclockwise.
10. Hydrant bonnets and hose valve outlet caps shall be painted light blue to conform with NFPA 291 Standard. Hydrant barrels to be painted yellow (color to match Owner's Standard).

F. Corporation and service stops: Bronze with flange joint coupling, threads on inlet end conforming to AWWA C800; tested to minimum hydraulic pressure of 200 PSI.

G. Buttresses:
1. Portland cement concrete, 6 bag mix.
2. Minimum 28 day compressive strength: 3,000 PSI.

H. Backfill material:
1. See Section 31 23 33.

PART 3 - EXECUTION

3.1 TRENCH EXCAVATION AND PREPARATION FOR PIPE LAYING

A. See Section 31 23 33.

3.2 CLEANING PIPES

A. Thoroughly clean pipes and fittings before laying.

B. Keep clean until acceptance of Work.

C. Thoroughly clean inside of every pipe and fitting just before lowering into trench, to remove foreign matter.

D. Carefully lower into trench in manner to exclude foreign matter while jointing to other pipe.

E. At close of each work day, or during period when job is not being actively pursued, tightly seal pipe ends with an expansion type stopper or other approved type of watertight seal so that no foreign substance or water may enter line.

F. Keep seal in place until pipe laying is again resumed.

G. Under no circumstances use pipe that has been contaminated inside with petroleum products or other liquid that will soak into cement lining or soften bituminous lining.

H. In event that foreign matter or water enters pipe that has already been laid, immediately cease work and lay no more pipe until contamination has been removed to satisfaction of Owner.

3.3 LAYING PIPE

A. Use only proper and suitable tools and appliances for safe and convenient handling and laying of pipes and fittings.

B. Carefully place pipe, fittings and valves into trench.

C. Do not dump or roll pipe or fittings into trench.

D. Do not allow pipe or fitting to drop against pipe or fitting already in trench.

E. Take care to prevent damage to pipe lining and coating.

F. Repair lining or coating damaged to satisfaction of Owner.

G. Install pipe so ends of pipe abut and there is no shoulder or unevenness inside main.

H. Take special care to insure that pipes are well bedded on a solid foundation.

I. Repair defects due to settlement at Contractor's expense.

J. Dig bell holes large enough to insure proper jointing.

K. Do not allow pipe to rest on rock.

L. Whenever a pipe or fitting requires cutting, perform work in a satisfactory manner with tools which leave smooth right angle cuts without damaging lining or pipe.

M. Make such cuts at no added cost to Owner.

N. Do not spring joints to effect a change in direction unless directed to do so by Owner.

O. Secure pipe, fittings and valves in place on concrete foundation, thrust blocks or by strapping, as indicated.

P. Where foundation or thrust blocks are not indicated, secure pipe, fittings and valves in place as directed by Owner.

3.4 PERMISSIBLE DEFLECTION AT JOINTS

A. Wherever it is necessary to deflect pipe from a straight line, either in vertical or horizontal plane, amount of deflection allowed shall not exceed that required for satisfactory calking or assembly of joint.

B. Make such necessary deflection in accordance with values and tolerances established by pipe manufacturer.

3.5 JOINTS

A. Ductile Iron mechanical joint pipe:
   1. Rubber gasket, cast iron gland ring and T bolts with hex nuts.
   2. Before joint is made, insure that outside of spigot and inside of bell are entirely free of oil, tar and greasy substances to insure to tight bond.
   3. Make joint in accordance with manufacturers instructions.
   4. Tighten bolts with a torque wrench set between 50 and 60 LB.

B. Ductile Iron push on joint pipe:
   1. Circular rubber gasket which fits into specially designed bell or socket end of pipe and a specially prepared lubricant.
   2. Make joints in following manner:
      a. Thoroughly clean gasket seat and gasket.

b. Wipe with a cloth and apply thin film of lubricant to inside surface of gasket which will come into contact with entering pipe.
c. Use only lubricant furnished with pipe.
d. In no case use mineral oil or petroleum base lubes.
e. Thoroughly clean plain end of pipe to be jointed and start it into socket so it is in contact with gasket.
f. Apply a thin film of lubricant to outside of plain end for about 1 IN back from end.
g. Complete joint by exerting sufficient force on entering pipe so that it's plain end is moved past gasket until it makes contact with socket base.
h. Method, which does not harm pipe, may be used to hone pipe.

3.6 FITTINGS AND VALVES

A. Place fittings, gate and air valves, blowoff connections and valves, valve and blow off vaults, air valve manholes and valve boxes along water mains as indicated or where designated by Owner.

B. Place in accordance with requirements as provided elsewhere in these specifications.

C. Set fittings and valves and join to pipe in manner specified for cleaning, laying and jointing pipe.

D. Where valves are placed on end of a pipe line place a cast iron plug secure in exposed bell before backfilling.

E. Provide valve box for every nut operated valve and grease case enclosed operating mechanism valve.

F. Carefully place valve box at right angle to main.

G. Do not allow valve box to transmit shock or stress to valve; center it plumb over wrench nut of valve, with box cover flush with surface of finished pavement, or set to elevation indicated.

H. Rest flange at bottom of top section on planks which extend 8 IN into solid ground on trench sides.

I. Take care in tamping backfill around valve to keep box in place and firmly supported to preclude settlement.

J. Remove and reset boxes found out of place or not firmly supported at no added cost to Owner.

K. Determine whether valve or valves are in proper working order before and after installation.

L. If not, notify Owner and replace.

3.7 HYDRANTS

A. Install hydrants in accordance with AWWA C600 or C603, as applicable, except as modified herein.

B. Set operating nut not over 4 FT above finish grade.

C. Thoroughly compact backfill around hydrants to grade.

D. Make hydrant available for beneficial use.

E. Set hydrant on slab of stone or concrete, minimum 4 IN thick and 15 x 15 IN.

3.8 CONNECTION TO EXISTING WATER SYSTEM

A. Make connections to water system as indicated.

B. Make connections at such hours, determined by Owner, to cause least disturbance of water supply to existing consumers.

C. Notify Owner at least 3 days in advance of time Contractor desires to make connections.

D. Make no connections without Owner's prior approval.

E. Include expense of making connections in proposed price.

3.9 ARTIFICIAL FOUNDATION

A. When directed, lay pipe upon an artificial foundation, consisting of gravel, sills, wedges, plank or timber, or of concrete, sized and placed as directed by Owner.

B. Include necessary excavation for such construction.

3.10 TESTING WATER MAINS

A. Test completed water mains for leakage.

B. Test sections as directed or approved by Owner.

C. Maximum allowable leakage not exceeding 1.0 GAL/1000 FT of pipe per hour for 16 IN pipe when tested at 150 PSI.

D. Fill length of water main under test with water and bring to test pressure of 150 PSI.

E. Operate valves in test section during test.

F. After valves have been tested and deficiencies corrected; fill length of main under test with water, taking care to eliminate air from line.

G. Raise pressure to test pressure by means of compressed air.

H. Maintain at test pressure for at least 2 HR.

I. At end of test period, again fill pipe with water from either measured receptacle or an accurately calibrated meter and determine leakage.

J. Repair every leak which Owner deems important, and every section of line in which leakage exceeds maximum allowable amount, whether or not trench has been filled.

K. Replace every pipe, fitting, valve, etc., which gives evidence under test of being defective.

L. If line indicates excessive leakage during any phase of test, retest line after correction of defects.

M. Continue correcting defects until leaks exceeding allowable leakage have been remedied.

N. Repair leaks and defects or otherwise remedy at no added expense to Owner and to complete satisfaction of Owner, at whatever time that they become apparent.

3.11 STERILIZATION OF WATER MAINS

A. Sterilize water mains as specified and directed.

B. Perform sterilization by either of following methods:
   1. By introducing a chlorine gas/water mixture by means of a solution/feed chlorinating device.
   2. By introducing a mixture of calcium hypochlorite (comparable to commercial products known as HTH or Perchloron) and water.

C. Prior to beginning of sterilizing operations, submit for Owner's approval, schedule listing details of procedure to be followed.

D. Before beginning sterilization, remove dirt and foreign matter from mains by a thorough flushing with clean water.

E. Introduce water slowly and introduce sterilant through corporation cocks at rate 1 LB chlorine gas/2400 GAL of water, or at rate of 1 LB calcium hypochlorite (measured in a dry state prior to preparation of slurry) per 1,680 GAL of water.

F. After sterilizing agent has been in pipe minimum of 3 HR, take samples and analyze.

G. If less than 5 mg/L residual chlorine is indicated, drain pipe and repeat treatment.

H. If more than 5 mg/L residual is indicated, drain lines to waste and refill with clear water.

I. Take care to prevent contamination of sterilized pipe.

3.12 BACKFILLING AND COMPACTION

A. See Section 31 23 33.

3.13 MAINTENANCE DURING WARRANTY PERIOD

A. If prior to expiration of warranty period, broken pipes or defects are found in mains or in their appurtenances, remove and replace with proper material and workmanship, at no added cost to Owner.

B. Carefully examine materials for defects prior to placing; do not place defective material.

END OF SECTION

SECTION 22 11 23
PLUMBING PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Circulating pumps.
   2. Storm Liftstation
   3. Sump pumps.

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-__").

1.3 SUBMITTALS

A. Product data:
   1. Circulating pumps:
      a. Include pump curves with point of operation indicated.
   2. Storm liftstation:
      a. Include pump curves with point of operation indicated.
   3. Sump pumps:
      a. Include pump curves with point of operation indicated.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pumps, general:
   1. Motors: Section 20 05 00.
   2. Motor data: As scheduled on drawings.
   3. Pump capacities: As scheduled on drawings.
   4. Provide disconnects.
   5. Provide starters for 3-phase motors.
   6. Basins: As specified and as detailed on drawings.

B. Vibration isolation:
   1. Provide in accordance with Section 20 05 50.

2.2 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.

2.3 STORM LIFTSTATION PUMPS

A. Rail-mounted, duplex, submersible sump pumps:

1. General:
    a. Each pump: Liftable out of basin along guide rails by chain or cable.
    b. When lowered into place, pump automatically realigns with and seals against permanently mounted discharge elbow at bottom of basin.
    c. Personnel can service pumps and controls without entering basin.
2. Pumps:
    a. Permanently wet pit installation.
    b. Cast-iron housings and impeller.
    c. Stainless-steel shaft.
    d. Provide discharge elbow and lift chain/cable.
        1) Lift chain: Hot-dipped galvanized carbon steel.
        2) Stainless-steel cable.
        3) Chain/cable lifting capacity shall be at least 1.5 times the weight of the pump.
    e. Stainless-steel trim.
3. Controls, wall or basin-cover mounted:
    a. Float-operated non-mercury type switches.
    b. High-water alarm:
        1) Able to integrate with building's energy management system.
        2) Coordinate with Control Contractor.
    c. Automatic alternation to sequence pump operation and to cause both pumps to operate if one pump cannot handle load.
    d. Common trouble alarm integrated with building management system.
4. Basin:
    a. Prefabricated reinforced fiberglass made with commercial grade polyester resin and glass fibers, include a 0.010 to 0.020 IN resin rich inner surface layer. Minimum wall and floor thickness of 1/2 IN. Provide with reinforcing rings, anti-floatation and anchoring flanges, inlet and outlet sizes: As indicated on plans. Meeting ASTM D3753.
    b. Provide gas-tight, water-tight aluminum basin cover (minimum 1/4 IN thick) and quick opening hinged manway access door(s).
    c. Coordinate pump mounting brackets and inserts which need to be pre-installed in basin.
    d. Test basin for no leaks at 5 psig air pressure.
5. Warranty: 18 months from start up.

2.4 SUBMERSIBLE, SIMPLEX SUMP PUMPS (IN ELEVATOR PITS)

A. Pump housing: Cast iron ASTM-A48.

B. Impeller: Cast iron, ASTM-A48, Class 30.

C. Motor shaft: Stainless steel.

D. Permanently lubricated sealed bearings.

E. Double mechanical seal on motor shaft.

F. Provide with differential non-mercury type float switch and oil minder switch with sufficient cable length to reach control panel.

G. Basins:
    1. Size: As detailed on Structural drawings.
    2. Inlet and outlet sizes: As indicated on drawings.

PART 3 - EXECUTION

3.1 GENERAL

A. General:
    1. Install as indicated and in accordance with manufacturer's instructions and recommendations.

2. Sump pumps with gas-tight covers: Extend vent independently through roof.
3. Provide galvanized guide rails for rail-mounted pumps.
4. Seal all piping, conduit and wiring penetrations into basin to be liquid tight.

B. Furnish piping, isolation valves, check valves, and fittings not included as a part of equipment as recommended by manufacturer:
   1. Provide manual isolation valves at following locations.
      a. On inlet and outlet of each circulating pump.
      b. On outlet of each sump pump.
      c. On outlet of each storm and sanitary liftstation sump pump.
      d. As indicated and as required to adequately service parts of systems and equipment.
   2. Provide check valve at outlet of each pump.
   3. See Section 22 10 16 for valve requirements.

END OF SECTION

SECTION 22 11 26

PACKAGED DOMESTIC-WATER PRESSURE-BOOSTER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Booster pumps.
      a. Adjustable speed system.

1.2 QUALITY ASSURANCE

A. References:
   1. Hydraulic Institute.
   2. NEMA - National Electrical Manufacturers Associations.
   3. UL - Underwriters Laboratories.
   4. NEC - National Electric Code.

B. Packaged-system manufacturer's requirements:
   1. UL listed as control panel manufacturer.
   2. Written and operational Quality Assurance program.
   3. Minimum 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 percent 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. Operating 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 GENERAL

A. Acceptable manufacturers:
1. Packaged domestic-water pressure-booster system:
a. Base: Canariis.
b. Optional:
1) Armstrong Pumps.
2) Aurora Pump.
3) Tigerflow.
4) Syncroflow.
2. Pumps:
a. Base: Aurora Pump.
b. Optional:
1) Allis-Chalmers, ITT.
2) Armstrong Pumps.
3) Goulds Pumps.
4) Bell & Gossett, ITT.
5) PACO Pumps.
6) Peerless Pump.
7) Taco.

2.2 PACKAGED SYSTEM, GENERAL

A. Packaged system, general:
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, general:
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) Base-mounted end suction with backout design.
    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, general:
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 mounted in control enclosure for indication of suction and discharge pressures.
6. Shut-off valves on control sensing lines and gauges.

2.3 ADJUSTABLE SPEED PACKAGED SYSTEM

A. Adjustable speed packaged system, general: In addition to general packaged system requirements, provide the following:
1. Additional control panel features.

2. Adjustable frequency drives.
3. 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:
   a. Direct digital type.
   b. Data entry in engineering units by keypad.
   c. PID control: Capacity to select signal that has deviated farthest from setpoint from up to 10 transmitters.
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 adjustable 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.
   b. Install transmitter(s) in following locations:
      1) Cold-water main in mechanical room.

C. Adjustable frequency drives: 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 hours 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 35 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, (adjustable speed system only).

END OF SECTION

SECTION 22 13 00
SANITARY SEWERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. Engineer: Soils Engineer employed by Owner, empowered to conduct inspections and make approvals.
   2. Unsuitable material: Debris and/or soil material judged unsuitable by Engineer for support of slabs or other site improvements.

1.2 QUALITY ASSURANCE

A. See Section 31 23 33 for soil testing and compaction requirements.

B. Compaction density test:
   1. Standard Proctor, ASTM-D698.

C. Owner will hire an independent soils laboratory to conduct in place moisture and density tests:
   1. Contractor pay for retests of material not passing initial tests.

1.3 JOB CONDITIONS

A. Verify locations of existing and new underground utilities and coordinate installation with all other utility installers.

B. Verification of existing utilities and structures:
   1. Plans indicate existing utilities indicated on site survey.
   2. Verify accuracy, location and depth of each utility prior to trenching or tunneling.
   3. If pipe adjustment is necessary due to location of other utilities, secure approval from Architect.

C. Protect existing structures and utilities from damage:
   1. Repair if damaged by this work.

D. Lengths indicated on drawings are for information only:
   1. Furnish lengths as required.

E. Perform no pipe work in fill areas until embankment or fill has been completed to at least 2 FT above top of pipe and has been properly compacted.

F. Revisions to Contract Drawings:
   1. If it becomes necessary to change location of sanitary lines due to building construction, secure prior written approval from Architect.
   2. If Contractor initiated, make approved changes without added cost to Owner.

G. Do not change pipe sizes without securing prior written approval from Architect.

H. Site utility installer and building plumbing installer shall interface work 5 FT outside face of building:
   1. Building plumbing installer shall provide necessary materials (adaptors).

1.4 SUBMITTALS

A. Shop drawings:
   1. Precast manhole drawings showing size and type of structure base.

B. Product data:
   1. Manufacturer catalog cuts and literature for pipe, manholes, manhole frame and covers and cleanouts.

C. Project information:
   1. Manufacturer's certification for materials.

1.5 EXTRA WORK

A. Removal and replacement of unsuitable material will be paid for as extra work:
   1. Notify Owner's agent in time to have Engineer measure and record quantity removed.
   2. Recorded quantity will be basis for payment.
   3. Include unit price per cubic yard on Proposal Form.

B. Rock excavation will be paid for as extra work:
   1. Notify Owner's agent in time to have Engineer measure and record quantity removed.
   2. Recorded quantity will be basis for payment.
   3. Include unit price on Proposal Form.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cast iron soil pipe and fittings:
   1. ASTM-A74 Class SV with ASTM-C564 rubber gasket joints.

B. Ductile iron pipe and fittings:
   1. Pipe:
      a. Ductile iron pressure pipe; Class 52, bituminous coated outside; AWWA C151/ANSI A21.51.
      b. Lining: Bituminous; AWWA C104/ANSI A21.4.
   2. Joints: Push on type; AWWA C110/ANSI A21.10.
   3. Fittings: Cast iron; AWWA C110/ANSI A21.10.

C. Polyvinyl chloride (PVC) pipe and fittings:
   1. 4 IN through 15 IN diameter: ASTM-D3034, SDR 35 with ASTM-D3212 flexible elastomeric gasket joint.
   2. 4 IN through 48 IN diameter: ASTM-F794 Series 46 for ribbed sewer pipe with smooth interior with ASTM-D3212 flexible elastomeric gasket joint.

D. Concrete materials:
   1. Comply with requirements of Division 03 "Concrete." Minimum compressive strength 4000 psi at 14 days.

E. Cleanout covers: ASTM-A48, cast iron with machined bearing surfaces.

PART 3 - EXECUTION

3.1 EXCAVATION, BACKFILL AND COMPACTION

A. Refer to Section 31 23 33, TRENCHING, BACKFILLING AND COMPACTING FOR UTILITIES.

3.2 INSTALLATION OF PIPE

A. Lay pipelines on uniform grades between inverts.

B. Locate structures as indicated and construct lines between them.

C. Lay pipe upgrade beginning at lower end with bell ends of pipe upstream.

D. Provide proper facilities for lowering pipe into trench.

E. Do not lay pipe in water.

F. Do not lay pipe when trench condition or weather is unsuitable for such work.

G. Remove sections of pipe already placed found to be out of alignment, defective or damaged.

H. Relay or replace without additional cost to Owner.

I. Bedding:
   1. Lay pipe directly on shaped subgrade.
   2. No blocking permitted.
   3. Form a continuous bearing with a minimum width of bearing equal to 0.6 of outside diameter of pipe, for full length of pipe, except for portion excavated for joint.

3.3 CLEANOUT STRUCTURES

A. Construct cleanout risers of 6 IN pipe laid on angle on undisturbed natural ground.

B. Tamp backfill around and above pipe in layers not exceeding 8 IN depth so that no settlement occurs.

C. Lay base of cleanout on concrete block.

3.4 WYE BRANCHES

A. Install where sewer connections are indicated or required.

B. Cutting into piping for connections not permitted except as approved by Architect.

3.5 BUILDING CONNECTIONS

A. Building connections shall include lines to and connection with building waste drainage piping at a point approximately 5 FT outside building, unless otherwise indicated. Where building drain piping is not installed, terminate building connections approximately 5 FT from site of building and plug pipe end.

3.6 LEAKAGE TESTS

A. Test lines for leakage by low pressure air testing or exfiltration tests, as appropriate:
   1. Low pressure air testing ASTM-C828.
   2. Exfiltration test: Fill line to be tested with water so that a head of at least 2 FT is provided above both water table and top of pipe at upper end of pipeline to be tested. Allow filled line to stand until pipe has reached its maximum absorption, but not less than 4 hours. After absorption, head shall be re-established. Amount of water required to maintain this water level during a 2-hour test period shall be measured.
   3. Leakage as measured shall not exceed 250 gallons per inch diameter per mile of pipeline per day.
   4. When leakage exceeds maximum amount specified, satisfactory correction shall be made and retesting accomplished.

END OF SECTION

SECTION 22 33 00
DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Factory testing: Subject tank and elements to hydrostatic test pressure, 150 percent in excess of working pressure. Certify that components are free of leaks.

B. Manufacturing standard: ASME Pressure Vessel Code.

1.2 SUBMITTALS

A. Product data:
   1. Water heaters.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.

1.3 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Steam-heated semi-instantaneous water heater:
      a. Base:
         1) Armstrong International.
      b. Optional:
         1) Aerco.
         2) Adamson.
         3) RECO.
   2. Temperature/pressure relief valves:
      a. Base:
         1) Watts.
      b. Optional:
         1) A W Cash.
         2) Wilkins.

B. High-temperature limits shall prevent delivery of water that is hotter than that selected for delivery from heater.

C. Concrete linings shall comply with MIL-T-12295.

D. Unless indicated otherwise, water pressure drop through heater shall not exceed 10 PSI.

2.2 STEAM-HEATED INSTANTANEOUS WATER HEATER

A. Steam-heated instantaneous water heater:
   1. Factory-assembled, packaged commercial water heater with 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. Capable of being disassembled and heater section removed without breaking domestic water connections.
   5. Easy access to heater tubes without moving heater from installed position.
   6. Factory fabricated steel supports.
   7. Provide manufacturer's standard enamel finish.

B. Scheduled information:
   1. Entering water temperature.
   2. Leaving water temperature.
   3. Recovery capacity.
   4. Steam pressure.
   5. Power: BTUH.

C. Shell:
   1. Labeled ASME Code construction for not less than 150 PSI working pressure.
   2. Shell: Copper silicon or carbon steel with copper lining.
   3. Insulation: Minimum 1-1/2 IN thick fiberglass complying with ASHRAE 90.1.
   4. Steel outer jacket with manufacturer's standard finish.

D. Heater section:
   1. Removable.
   2. Copper tubes.
   3. Steam chamber: Carbon steel.
   4. Provide leak-indicating, double-wall isolation between steam and water.

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. Pneumatic temperature control valve with temperature controller.

F. Other components:
   1. Temperature/pressure relief valve.
   2. Leaving water temperature gauge.
   3. Steam pressure gauge.
   4. Steam strainer.
   5. Condensate orifice or F & T trap.

2.3 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.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 STEAM-HEATED WATER HEATERS

A. Pipe steam condensate to receiver so that it flows by gravity. Provide additional steel channel stands if additional height is required.

3.3 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.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 22 42 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. 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.

1.2 QUALITY ASSURANCE

A. Manual-valve standards: 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.

C. Accessibility:
   1. Manufacturing standards:
      a. Americans with Disabilities Act (Public Law 101-336).
      b. ANSI-A117.1, current edition.
   2. Installing standards:
      a. Americans with Disabilities Act (Public Law 101-336).
      b. ANSI-A117.1, current edition.
      c. Local authorities.
      d. State authorities.

1.3 SUBMITTALS

A. Product Data:
   1. Assemble submittals by mark number. Include sufficient information to verify compliance with descriptions. Where model numbers differ from descriptions, submit to meet description requirements:
      a. Drinking fountains.
      b. Electric water coolers.
      c. Emergency fixtures.
      d. Hose bibbs.
      e. Hose reels.
      f. Lavatories.
      g. Mixing valves.
      h. Sinks.
      i. Standpipe and supply boxes.
      j. Urinals.
      k. Wall hydrants.
      l. Water closets.
      m. Undersink protective covers.

B. Contract Closeout Information:
   1. Operating and maintenance data.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Electric water coolers and drinking fountains:
      a. Base:
         1) Halsey-Taylor.
      b. Optional:
         1) Elkay Manufacturing.
         2) Haws Corporation.
         3) EBCO Manufacturing (Oasis).
         4) Sunroc.
   2. Faucets (Sensor operated):
      a. Base:
         1) Sloan Valve.
      b. Optional:
         1) Chicago Faucet.
         2) Hydrotek.
   3. Faucets (Single-lever mixing):
      a. Base:
         1) American Standard Plumbing.
      b. Optional:
         1) Chicago Faucet.
         2) T&S Brass & Bronze Works.
   4. Faucets (Two-handled):
      a. Base:
         1) American Standard Plumbing.
      b. Optional:
         1) Chicago Faucet.
         2) T&S Brass & Bronze Works.
   5. Fixtures (Enameled cast iron):
      a. Base:
         1) Kohler.
      b. Optional:
         1) American Standard.
         2) Crane Plumbing.
         3) Eljer Plumbingware.
   6. Fixtures (Molded stone, precast terrazzo, fiberglass-reinforced polyester):
      a. Base:
         1) Fiat.
      b. Optional:
         1) Creative Industries Terrazzo Products.
         2) Standard Elsemere.
         3) Stern and Williams.
         4) Swan.
         5) Mustee & Sons, EL.
   7. Fixtures (Stainless steel):
      a. Base:
         1) Elkay Manufacturing.
      b. Optional:
         1) Just Manufacturing.

2) Advance Tabco.

8. Fixtures (Vitreous china):
   a. Base:
      1) American Standard Plumbing.
   b. Optional:
      1) Eljer Plumbingware.
      2) Kohler.
9. Fixture carriers:
   a. Base:
      1) Wade.
   b. Optional:
      1) Watts/Ancon.
      2) Jonespec.
      3) Josam.
      4) J R Smith.
      5) Zurn Industries.
10. Flow control devices:
   a. Base:
      1) Same as installed faucet or shower head.
   b. Optional:
      1) American Standard Plumbing.
      2) Chicago Faucet
      3) Crane Plumbing.
      4) Coyne & Delany.
      5) Delta Commercial.
      6) Eljer Plumbingware.
      7) Hydrotek.
      8) Kohler.
      9) Omni.
      10) Sloan Valve.
      11) T&S Brass & Bronze Works.
11. Flushometer valves:
   a. Base:
      1) Sloan Valve.
   b. Optional:
      1) Coyne & Delany.
      2) Zurn Industries.
12. Hose bibbs:
   a. Base:
      1) Chicago Faucet.
   b. Optional:
      1) Acorn Engineering.
      2) Delta Commercial.
      3) Crane Plumbing.
      4) Croker West.
      5) Sloan Valve.
      6) Speakman.
      7) T&S Brass & Bronze Works.
      8) Woodford Manufacturing.
13. Mixing valves (Pressure-balanced):
   a. Base:
      1) Symmons.
   b. Optional:
      1) Chicago Faucet.
      2) Leonard Valve.

14. Mixing valves (Thermostatic):
    a. Base:
        1) Symmons.
    b. Optional:
        1) Lawler Manufacturing.
        2) Leonard Valve.
        3) Powers.
15. Mixing valves (Tempering):
    a. Base:
        1) Powers.
    b. Optioinal:
        1) Watts.
        2) Leonard.
16. Standpipe and supply boxes:
    a. Base:
        1) Acorn Engineering.
    b. Optional:
        1) Amsco.
        2) Bradley.
        3) Guy Manufacturing.
17. Trim:
    a. Base:
        1) McGuire Manufacturing.
    b. Optional:
        1) American Standard Plumbing.
        2) Brass-Craft Manufacturing.
        3) Chicago Faucet.
        4) Crane Plumbing.
        5) Dearborn.
        6) Eljer Plumbingware.
        7) Elkay Manufacturing.
        8) Just Manufacturing.
        9) Kohler.
        10) T&S Brass & Bronze Works.
18. Wall hydrants:
    a. Base:
        1) Wade.
    b. Optional:
        1) Watts-Ancon.
        2) Jonespec.
        3) Josam.
        4) J R Smith.
        5) Woodford Manufacturing.
        6) Zurn Industries.
19. Water closet seats:
    a. Base:
        1) Beneke.
    b. Optional:
        1) Bemis.
        2) Centoco.
        3) Olsonite.
20. Undersink Protective Covers:
    a. Base:
        1) Truebro.
    b. Optional:
        1) McGuire.

2) TCI Products.
3) Brocar Products.

21. Fixtures (Emergency):
    a. Base:
        1) Speakman.
    b. Optional.
        1) Bradley.
        2) Encon Safety Products.
        3) Western.
        4) Haws Corporation.
        5) Guardian Equipment.

B. Construct or equip fixtures with air gap or anti-siphon devices to prevent siphoning non-potable water into potable water supply system.

C. Piping exposed in finished areas (including fittings and trim): See Section 22 10 16.

D. 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.

E. Manufacture accessible fixture assemblies to meet requirements of accessibility manufacturing standards (see Quality Assurance article in Part 1 of this section).

F. Faucets, general (Following general conditions apply unless detailed otherwise in specific descriptions):
    1. Renewable cartridges with integral seats (or renewable seats and stems).
    2. Materials: Brass, bronze, copper, stainless steel, ceramic. (Plastic components are not acceptable.)
    3. Finish: Polished chrome.
    4. Gooseneck spouts: Discharge at least 5 IN above rim of fixture.
    5. Electric, sensor-operated faucets:
        a. Mount transformer and control panel in concealed but accessible location.
        b. Coordinate with Electrical and Casework contractors.
        c. If mixing valve is not included in faucet description, provide a tempering, under-counter mixing valve. Mechanical mixing valves shall not be used.

G. Flow control devices, general:
    1. Provide flow control devices with indicated maximum flow rates on listed fixtures:
        a. Lavatory, public:
            1) Metering: 0.25 gallons per metering cycle.
            2) Non-metering: 0.5 GPM.
            3) All locations shall be considered public, except as specifically identified above for private.
        b. Sinks: 1.5 GPM at 60 psi
        c. Showers: 1.5 GPM at 80 psi.
    2. Material: Brass.
    3. Finish: Chrome.
    4. Accomplish controlled flow without aeration of water stream. Aerators are not acceptable unless specifically identified in the faucet description.
    5. Flow control devices shall be disinfectable.

H. Lavatory fixtures, general (Following general conditions apply unless detailed otherwise in specific descriptions):
    1. Vitreous-china and enameled, cast-iron fixtures:
        a. Color: White.

b. Overflows: Integral.

2. Stainless-steel fixtures:
   a. Finish: Soft satin.
   b. Type: 302 (18-8) or 304 (18-8).
   c. Thickness: 20 GA, minimum.
   d. Sound deadening that covers complete underside of bowl.
3. Provide integral faucet ledge with holes:
   a. Coordinate hole quantities, locations, and centerings with faucet types indicated in fixture descriptions.
   b. Provide exact number of holes necessary. Use of faucet hole covers is not acceptable.

I. Mixing valves, general (Following general conditions apply unless detailed otherwise in specific descriptions):
1. Materials: Brass, bronze, copper, stainless steel, ceramic:
   a. Thermostatic mixing valves: Thermostat may contain plastic parts.
   b. Escutcheon may be pot metal.
2. Finish of exposed surfaces: Polished chrome.
3. Hot/cold color coding.
4. Coordinate number of ports with trim indicated in fixture descriptions:
   a. Four-port valves:
      1) If diverter spout is indicated in fixture description, provide built-in choke.
      2) If external diverter valve is indicated in fixture description, provide without choke.
5. Tempering type mixing valve:
   a. ASSE 1016 Type: T/P.
   b. Integral checks and service stops on inlets.
   c. Inlet screens: stainless steel.
   d. Adjustment: adjustable locking type.
   e. Connections: 3/8 IN.
   f. Example: Powers model e480.
6. Pressure-balanced mixing valves:
   a. Renewable stainless-steel piston with brass seat.
   b. Integral checks and service stops on inlets.
   c. Temperature control with built-in shut off; opens from cold to hot.
   d. Single lever handle.
   e. Adjustable, temperature-limit stops.
   f. "OFF-COLD-HOT" marking in block type letters (minimum 7/32 IN high).
7. Thermostatic mixing valves:
   a. ASSE 1017 compliant.
   b. Renewable thermostatic and pressure-balance elements.
   c. Compensates for changes in both temperature and pressure.
   d. Integral checks and service stops.
   e. Temperature control with built-in shut off; opens from cold to hot.
   f. Single lever handle.
   g. Adjustable, temperature-limit stops.
   h. "OFF-COLD-HOT" marking in block type letters (minimum 7/32 IN high).

J. Mixing valve trim, general:
1. Cabinets:
   a. Stainless steel construction.
   b. Hinged doors:
      1) Removable when in the open position.
      2) Hinge on side.
   c. Size cabinets to hold valve and accessories as required in each description.
2. Thermometers:
   a. 3-1/2 IN dial.
   b. Hermetically sealed.
   c. Bimetal element.

d. Range: 0 to 140 degF.
e. Construction: Welded stainless steel.
f. White-faced, three-color dial.

3. Vacuum breakers and valves:
   a. See "Faucets, general" in Article 2.01.

K. P-traps and continuous wastes, semi-cast:
1. P-trap, semi-cast:
   a. 1-1/4 or 1-1/2 IN NPS cast-brass return bend with clean out.
   b. 17 GA x 1-1/4 or 1-1/2 IN OD copper tube tailpiece.
   c. Nuts: Cast brass.
2. Continuous waste, semi-cast:
   a. 1-1/2 IN NPS cast-brass tee.
   b. 17 GA x 1-1/2 IN OD copper tube tailpieces.
   c. Nuts: Cast brass.

L. Shower heads, general (Following general conditions apply unless detailed otherwise in specific descriptions):
1. Nozzle designed to prohibit liming and clogging.
2. Body:
   a. Material: Brass.
      1) Hand-held shower-head body may be plastic.
   b. Finish: Chrome.
      1) Hand-held shower-head body may be white.
3. Internal components:
   a. Foul resistant.

M. Sink fixtures, general (Following general conditions apply unless detailed otherwise in specific descriptions):
1. Vitreous china: White.
2. Stainless steel:
   a. Finish: Soft satin.
   b. Type: 302 (18-8) or 304 (18-8).
   c. Sound deadening that covers complete undersides of each bowl, unless noted otherwise.
   d. Thickness:
      1) Sink depth less than or equal to 10 IN: 18 GA, minimum.
      2) Sink depth greater than 10 IN: 16 GA, minimum.
3. Molded stone and terrazzo:
   a. Marble chips in reinforced Portland cement:
      1) 7-day compressive strength: 3000 PSI.
      2) Exposed surfaces: Ground smooth, grouted and sealed to resist staining.
   b. Drain body opening: Integrally cast.
   c. Color: As selected from manufacturer's standard line by Architect.
4. Enameled cast-iron:
   a. Color: White.
5. Counter-top sinks: Self-rimming.
6. Provide integral faucet ledge with holes:
   a. Coordinate hole quantities, locations, and centerings with the following:
      1) Faucets and trim indicated in fixture descriptions.
      2) Hot-water dispensers.
      3) High-purity water faucets.
   b. Provide exact number of holes necessary. Use of faucet hole covers is not acceptable.

2.2 ELECTRIC WATER COOLERS

A. Electric water coolers, general (Following general conditions apply unless detailed otherwise in specific descriptions):
1. Self contained, refrigeration units:

a. Capacity based on 90 degF room temperature, 80 degF inlet-water temperature, and 50 degF drinking-water temperature.
b. Air cooled condensing units:
1) 115V.
2) Hermetically sealed compressor.
2. Bubbler drain-pan: Stainless steel.
3. Stainless steel: Type 304 with satin finish.
4. Chrome-plated, brass bubbler:
a. Bubbler guard may be plastic and need not be chrome-plated.
5. Stream regulator(s) mounted inside cabinet or in bubbler. Regulator shall maintain constant stream height while line pressure varies between 30 and 90 PSI.
6. Certified lead free as defined by the Safe Drinking Water Act.

B. EWC-1, Accessible (forward facing), dual-level:
1. Fixture:
a. Brushed stainless steel, recessed refrigeration unit, dual level extensions with oval receptors, access panel cover, rounded corners, rounded edges, designed to eliminate splashing and standing waste water. Provide self-closing, semi-circular push bars with full 180 degree activation. Minimum capacity: 8 GPH:
1) Halsey Taylor OVL-II-Q.
2. Trim:
a. Supply: Chrome plated brass, quarter turn ball valve, 1/2 IN threaded by 3/8 IN OD, soft-copper tube, stops, CSA certified to 200 psig:
1) McGuire Model BV02.
b. P-trap: Chrome or satin, 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.

2.3 EMERGENCY FIXTURES

A. Emergency combination shower/eyewash or shower units are furnished by Division 12:
1. 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).

B. TWMV-1, Mixing Valve, thermostatic:
1. Cabinet mounted valve, example: Leonard TM-850ststl-exp-view.
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 by-pass if valve should fail.
3. Cabinet: exposed stainless steel; door with view port, hinge and lock.

2.4 FIXTURE CARRIERS

A. Fixture carriers:
1. Application:
a. This paragraph describes carriers for wall-hung valves and wall-hung fixtures except water closets. 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. 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.

2.5 HOSE BIBBS

A. Hose bibb, general (Following general conditions apply unless detailed otherwise in specific descriptions):
   1. Material: Brass.
   2. Finish: As indicated.

B. HB-1, polished brass hose bibb with vacuum breaker:
   1. Fixture:
      a. 1/2 IN IPS male inlet, adjustable / removable wall flange, lever handle, 3/4 IN garden hose outlet:
         1) Model: T&S Brass B-0718.
      b. Vacuum breaker: Garden hose vacuum breaker, 3/4 in female garden hose inlet & male outlet:
         1) Model: T&S Brass B-0972.

2.6 LAVATORIES

A. See Article 2.01 MATERIALS – GENERAL.

B. L-1, Lavatory, oval, under counter mounted, stainless steel:
   1. Fixture:
      a. 17.5 x 12.5 IN oval, under counter, stainless steel, with overflow assembly:
         1) Just Manufacturing UOIF-1521.

2. Faucet:
   a. Electric sensor-operated, ledge-mounted, 4 IN centerset faucet, integral spout, faucet-mounted sensor:
      1) Sloan ETF-600.
   b. Mixing valve:
      1) Provide thermostatic mixing valve with checkstops.
      2) Valve shall be mounted under lavatory.
      3) Provide chrome plated copper tubing for all exposed piping.
3. Trim:
   a. Supplies: Chrome plated brass quarter turn ball valve stops, 13 1/2 IN sweat with 5 IN extension by 3/8 IN OD, soft-copper tube, , escutcheons, CSA certified to 200 psig:
      1) McGuire Model BV170.
   b. Grid drain: Chrome 1-1/4 IN cast-brass with 17 GA x 1-1/4 IN OD copper-tube tailpiece:
      1) McGuire Model 155A.
   c. P-trap: Chrome or satin, 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:
      1) McGuire Model 8902.

C. L-2, Lavatory, oval, under counter mounted, stainless steel, accessible:
1. Fixture:
   a. 17.5 x 12.5 IN oval, under counter, stainless steel, with overflow assembly:
      1) Just Manufacturing UOIF-ADA-1521.
2. Faucet:
   a. Electric sensor-operated, ledge-mounted, 4 IN centerset faucet, integral spout, faucet-mounted sensor:
      1) Sloan ETF-600.
   b. Mixing valve:
      1) Provide thermostatic mixing valve with checkstops.
      2) Valve shall be mounted under lavatory.
      3) Provide chrome plated copper tubing for all exposed piping.

3. Trim:
   a. Supplies: Chrome plated brass quarter turn ball valve stops, 13 1/2 IN sweat with 5 IN extension by 3/8 IN OD, soft-copper tube,, escutcheons, CSA certified to 200 psig:
      1) McGuire Model BV170.
   b. Grid drain: Chrome 1-1/4 IN cast-brass with 17 GA x 1-1/4 IN OD copper-tube tailpiece:
      1) McGuire Model 155A.
   c. P-trap: Chrome or satin, 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:
      1) McGuire Model 8902.

2.7 MIXING VALVES

A. See Article 2.01 MATERIALS – GENERAL.

B. EMV-1. Electronic Mixing valve:
1. Exposed valve with cabinet:
   a. Armstrong RADA EMC-123.
2. Capacity: 75 gpm maximum with no minimum system draw-off requirement.
3. Components:
   a. 12V DC electronic temperature controllers.
   b. Inlet and return check valves.
   c. Pressure gauges (Refer to Specification 15120 for requirements).
   d. Inlet, system blend and return line thermometers.
   e. Isolation valves.
   f. 110 V UL-listed transformer enclosed in a NEMA 4X enclosure.

g. Low Voltage control wiring with protective conduit.
h. Circulating pump rated at design flow and pressures as scheduled on drawings.
i. System control module.

4. Temperature Controller: non-thermostatic featuring integrated circuit board technology.
5. Package:
   a. All required installation components shall be supplied pre-plumbed and pressure-tested, mounted to an enameled steel frame terminating in five standard union connections for hot and cold supply in, blended water to the system, and system and water heater return lines.
   b. Electronic control box shall be supplied pre-wired, terminating at a knockout for Romex or BX cable connector.
   c. Mounting restrictions:
      1) Valve package with cabinet to fit within 42 wide recessed wall space. Refer to drawings for location and additional restrictions.
      2) Cabinet: Flush-mounted with lockable, hinged door.
6. Operating requirements:
   a. Recirculated water control within plus or minus 2 degF with minimal recirculation of 4 2 gpm.
   b. Control of blended water drawn from the system at a point of use within plus or minus 2 degF.
   c. Minimum of 2 degF recirculation system temperature loss required for effective loop control.
   d. Visual operation “set” and “actual” temperature display for effective commissioning, adjustment and system monitoring.
   e. Visual signal by display to show “error” mode or “out of range” system failure, coupled with output for audible alarm and/or downstream solenoid valve relay.
   f. Integral two-way data port for PC and BMCS interface.
   g. Automatic shutoff of hot water flow in the event of a power failure.
7. Standards compliance:
   a. Temperature controllers compliant with:
      1) ASSE Standard 1017.
      2) CSA B125.
8. Building Automation System Interface components:
   a. Integral 4-20 ma output connection for Mixing Unit temperature transmission to BMCS.
   b. Integral 4-20 ma output connection for Mixing Unit remote set point adjustment via BMCS.
   c. Unit Control Module to Mixing Unit (interface cable provided).
   d. Unit Control Module to BMCS (wiring to BMCS by Section 25 50 00).
   e. Additional temperature transmitter for downstream mixed water temperature transmission to BMCS (wiring by Section 25 50 00).
   f. Image file containing EMC system graphic template.

2.8 SINKS

A. See Article 2.01 MATERIALS – GENERAL.

B. S-1, Double bowl, single lever control, swing spout:
1. Fixture:
   a. 33 x 21 x 8 IN counter-top, stainless-steel, double-bowl, 3-1/2 IN outlets, centered faucet hole.
      1) Elkay Lustertone LR-3321.
2. Faucet:
   a. Ledge-mounted, 8 IN spread escutcheon, single-lever mixing, 8 IN cast swing spout.
      1) American Standard Plumbing Reliant 4205.000.
3. Trim:
   a. Supplies: Chrome, 3/8 IN OD, soft-copper tube, loose-key stops, escutcheons.

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.
c. Continuous waste assembly, chrome or satin: 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.
d. P-trap: Chrome or satin, 1-1/2 IN semi-cast with cleanout, with 17 GA x 1-1/2 IN OD copper-tube trap arm.

2.9 SINKS, CUP

A. CS-1, Cup Sink, oval:
1. Fixture:
a. Furnished by others.
2. Faucet:
a. Furnished by others.
3. Trim:
a. 1-1/2 IN tailpiece and P-trap of specified material for acid waste piping (see Section 22 10 16).
b. Supplies: Chrome plated brass, 1/2 IN threaded to 3/8 IN compression, quarter turn ball valve, CSA certified to 200 psig. McGuire BV02.

2.10 SINKS, LABORATORY

A. S-C:
1. Fixture:
a. Furnished by others.
2. Faucet:
a. Furnished by others.
3. Trim:
a. 1-1/2 IN tailpiece and P-trap of specified material for acid waste piping (see Section 22 10 16).
b. Supplies: Chrome plated brass, ½ IN threaded to 3/8 IN compression, quarter turn ball valve, CSA certified to 200 psig. McGuire BV02.

2.11 SINKS, MOP

A. See Article 2.01 MATERIALS – GENERAL.

B. MS-1:
1. Fixture:
a. One-piece, terrazzo composite, floor-mounted basin, 3 IN brass or stainless-steel drain body, removable dome strainer, vinyl or stainless-steel bumper guards on sides not adjacent to wall:
1) Sterm Williams-EBC-150, 36 x 36 x 36 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.

2.12 SPARE PARTS

A. Provide two of each type of renewable cartridge, stem, and seat.

2.13 URINALS

A. See Article 2.01 MATERIALS - GENERAL

B. 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: 0.125 GPF.

C. UR-1, Urinal, Sensor Operated, 120-volt:
   1. Fixture:
      a. Wall-hung, Ultra High Efficiency, 3/4 IN top spud, 2 IN outlet, elongated rim, integral trap, flushing rim:
         1) American Standard Plumbing Washbrook FloWise 6590.525.
      b. Fixture carrier: Hanger-plate type:
         1) Jay R. Smith Model 0637.
   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 3/4 IN top spud, screwdriver back-check angle stop. Equipped with solenoid and sensor unit, wall cover plate for electrical gang box with tamper proof screws. Match flush volume to fixture requirements. Provide 120VAC/24VAC 50VA transformer:
         1) Sloan Optima Royal 186-0.13-ES-S TMO.

D. UR-2, Accessible Urinal, Sensor Operated, 120-volt:
   1. Fixture:
      a. Wall-hung, siphon jet, 3/4 IN top spud, 2 IN outlet, elongated rim, integral trap, flushing rim:
         1) American Standard Plumbing Allbrook 6541.132.
      b. Fixture carrier: Hanger-plate type:
         1) Jay R. Smith Model 0637.
   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 3/4 IN top spud, screwdriver back-check angle stop. Equipped with solenoid and sensor unit, wall cover plate for electrical gang box with tamper proof screws. Match flush volume to fixture requirements. Provide 120 VAC/24VAC 50 VA transformer:
         1) Sloan Optima Royal 186-0.13-ES-S TMO.

2.14 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. Bowls: Elongated.
3. Color: White.
4. Fixture material: Vitreous china.
5. Spud material: Brass.
6. Spud size: 1-1/2 IN.
7. Nominal flush volume: 1.28 GPF.

D. Water-closet seats, general:
1. Solid plastic.
2. Color: Black.
3. Resistant to scratching, stains, chemicals, and cleaning agents.
4. Elongated-bowl style.
5. Stainless-steel hinge pins, bolts, and hardware.
6. Check hinges.
7. Integrally molded bumpers.

E. WC-1, Public wall-hung, Sensor operated, 120-volt:
1. Fixture:
a. Wall-hung, siphon jet, top spud:
1) American Standard Plumbing Afwall FloWise 3351.128.
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. Provide 120 VAC/24VAC 50 VA transformer:
1) Sloan Optima Royal 111-1.28-ES-S TMO.
3. Seat:
a. Open-front seat without cover:
1) Beneke Model 523 SS.

F. WC-2, Public wall-hung, Sensor operated, 120-volt, accessible:
1. Fixture:
a. Wall-hung, siphon jet, top spud:
1) American Standard Plumbing Afwall FloWise 3351.128.
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. Provide 120 VAC/24VAC 50 VA transformer:
1) Sloan Optima Royal 111-1.28-ES-S TMO.
3. Seat:
a. Open-front seat without cover:
1) Beneke Model 523 SS.

2.15 UNDERSINK PROTECTIVE COVERS

A. Undersink protective covers, vinyl:
1. Material: Molded closed cell vinyl.
2. Minimum thermal conductivity at mean temperature:

a. k ≤ 1.17, 75 degF.

3. Attachment method: Reusable snap clips or seamless pre-wrapped.
4. Service: Provide lock-lid access covers or openings for service of angle valves and cleanouts.

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 during construction.

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-type 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 (see Quality Assurance article in Part 1 of this section).

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 60 80
HIGH PURITY PLASTIC PIPING SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes requirements for procurement, fabrication, installation, and testing of high purity plastic piping systems:
   1. RO water distribution piping systems.
   2. Connections to RO equipment furnished by others, as indicated on the Drawings.

1.2 RELATED WORK

A. Refer to other Mechanical Specification Divisions in Division 20 for general mechanical requirements.

B. Refer to other Mechanical Specification Divisions in Division 20:
   1. Pipe hangers and supports.
   2. Piping identification.

1.3 SUBMITTALS

A. Shop Drawings.

B. Product Data:
   1. Submit valve cut-sheets indicating materials of construction, testing, and quality assurance procedures.
   2. Submit copies of valve ordering schedule for approval before ordering valves.
   3. Submit manufacturer's preshipment cleaning procedures for pipe, fittings, and valves for review and approval 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.
   4. Submit 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. Submit a definitive plan for the provision of a temporary clean, dry and well maintained facility to be used on the site for prefabrication of piping spools in preparation for installation. This facility must have controlled environments of a minimum 55 degF to maximum 85 degF ambient temperatures.
   5. Submit Installation Quality Control and Field Quality Assurance procedures for review and approval by Owner prior to start of piping system fabrication.

1.4 QUALITY ASSURANCE

A. Follow requirements of ASME B31.3 Process Piping Code.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Pipe:
   1. GF Plastic Systems.
   2. Asahi.

B. Fittings:
   1. GF Plastic Systems.
   2. Asahi – extended legs on 2 IN and smaller.

C. Unions:
   1. GF Plastic Systems.
   2. Asahi.

D. Gaskets:
   1. RO Gaskets: EPDM.

E. Valves - Diaphragm:
   1. GF Plastic Systems.
   2. Asahi.

F. Valves - Zero Dead Leg one piece molded for PVDF Piping Systems:
   1. GF Plastic Systems.
   2. Asahi.

G. Valves - Check:
   1. GF Plastic Systems.
   2. Asahi.

H. Valves – Sample:
   1. GF Plastic Systems – 3/8 IN Type 525 Sample valve (PVDF systems).
   2. Asahi.

I. Valves – Pressure Relief:
   1. GF Plastic Systems.
   2. Asahi.
   3. Plast-O-Matic – RVT 000 V PF.

J. Regulators – Pressure:
   1. GF Plastic Systems.
   2. Asahi.

K. Gauge Isolators - PVDF:
   1. GF Plastic Systems - Type 523.
   2. Asahi.

L. Flow Meters – In-line type polypropylene or PVDF tube ends, polysulphone tube, PVDF float, EPDM O-rings, maximum working temperature 150 degF:
   1. GF Plastic Systems Type 801.
   2. Asahi.

2.2 PIPING, FITTINGS AND VALVES

A. General:
   1. RO water distribution is to be polypropylene (PP) material. 4 IN and smaller: 10 bar (150 psi) rated pipe and fittings.
   2. Purchase semiconductor grade prepared piping, fittings, and valves from the manufacturer. Materials shall be initially manufacturer cleaned, capped or sealed in a bag, and enclosed in a container to prevent contamination during shipment, and are to remain in “clean container” until fused into the system.

B. Piping:
   1. RO Water Distribution Fittings, and Valves: Fabricated of non-toxic virgin non-contaminating, natural unpigmented polypropylene, copolymer Type 2, sanitary type SDR 11 pipe.

C. Piping, Fittings, and Valve Joints: Radiant heat (IR) butt-fusion, RO water distribution to be also Bead and Crevice Free (BCF) process in strict accordance with manufacturer's recommendations.

D. Valves Up to 2 IN:
   1. RO Water Distribution; PP body with EPDM diaphragm, butt-fused, with a position indicator
   2. RO Water Distribution; PVDF body with Teflon® diaphragm, butt-fused, with a position indicator.

E. Check Valves: Stainless Steel check valves shall be fully opening with external spring or arm.

2.3 CLEANING

A. General: Perform no operations other than those explicitly stated herein without the approval of Owner.

B. Chemicals: Low mobile ion and low particulate grade.

C. Nitrogen:
   1. Provide zero gas grade certified THC as CH_4 <0.5 ppm, 99.998 percent minimum purity.
   2. Alternatively, gas phase nitrogen drawn from a liquid nitrogen dewar can be used. The gaseous nitrogen so obtained shall be medical grade. Provide certification of compliance to Owner for each and every dewar.
   3. Filter gaseous nitrogen at the point-of-use, which is defined as being a maximum of 10 FT of interconnect piping between the filter outlet and the component being cleaned. Provide a Type 316L stainless steel filter housing assembly with a 0.2 micron absolute membrane filter cartridge.

D. Piping Inspection Procedure:
   1. Immediately upon use at the site, visually inspect each and every length of pipe to assure the interior is free of stains, discoloration, oils, residue, impurities, damaged ends, warping, cracks and signs of mishandling. Mark rejected pipe with a red tag and immediately remove from the job site.
   2. Store accepted pipe, fittings, and valves in their bagged condition in a separate, clean, well-maintained room. Use racks and bins to keep material organized and off floor.

E. Cleaning of contaminated Pipe, Fittings, and Valves: Installer shall be responsible for the cleanliness integrity of the system as specified. Cleaning is only required on contaminated materials. Cleaning shall be as follows:
   1. Rinse the pipe with filtered high purity DI. Use filtered DI water once only and discard:
      a. If approved by Owner, on-site DI water may be available to the installer for rinsing PVDF piping spools.
      b. Prior to connecting to an existing DI water source for rinse up the installer must submit temporary piping schematics to Owner QAR / Contamination Control for final approval.
      c. The cost of materials and labor for temporary rinse stations shall be borne by the installer.
   2. Dry the pipe filtered Nitrogen to remove residual moisture.
   3. Immediately seal pipe ends with clean plastic caps.
   4. Cover pipe ends with small polyethylene bags and secure with PVC tape. Do not allow tape to adhere to the pipe, only the bag.

2.4 PACKAGING AND SHIPPING AT MANUFACTURER

A. Pipe:
   1. Immediately following the drying step, securely bag the ends of each pipe length in 6 mil polyethylene bags and place a hard plastic cap over polyethylene bagged ends.
   2. Package piping in heat-sealed polyethylene bags to maintain purity, finish, and ovality. Securely package the bagged piping for shipment to the site. Do not use cardboard boxes or loose packing materials such as Styrofoam pieces for packing of piping.
   3. All piping shall be properly supported to prevent ovality problems during shipping.

B. Fittings: Supplied by the manufacturer in a cleaned condition in accordance with the approved procedures. Immediately upon completion of cleaning operation double package each fitting separately in heat-sealed polyethylene bags.

C. Valves: Supplied by the manufacturer in a cleaned condition in accordance with approved procedures and individually packaged in heat-sealed polyethylene bags for shipment.

PART 3 - EXECUTION

3.1 FACILITIES

A. Perform subassembly fabrication operations in a separate, temporary facility located either in installer's on-site shop or within the building. As a minimum, the facility must be a clean, dry and well-maintained area. A controlled 55 degF (min) to 85 degF (max) ambient environment is required for fabrication.

3.2 COMPONENTS

A. Upon delivery to the site, store valves, fittings, and pipe in a clean, dry, well-maintained environment. Store material in the original shipping containers. Open containers only as components are used.

3.3 TOOLS AND EQUIPMENT

A. Provide clean, dedicated tools for piping system fabrication and installation, keep separate from other tools, and use exclusively for working on the piping system.

B. Clean tools at the start of each shift with IPA/DI water solution, and dry with pure, filtered nitrogen.

3.4 WORKMANSHIP

A. In addition to approved procedures and provisions stipulated in the installer's "Field Quality Assurance Program," the following procedures shall apply:
   1. Conduct qualification tests for the fusion equipment and the fusion operators prior to the start of system fabrication. Conduct tests with the fusion system manufacturer's (e.g. George-Fisher / Asahi IR-Fusion Testing Representative for IR-Butt fusion operator qualifications), representative present and subject to approval by the manufacturer and Owner.
   2. Submit a duplicate of the manufacturer's published operating instructions for the use of the radiant heat butt fusion equipment to Owner for review and approval.
   3. A sample radiant heat butt-fusion joint shall be made up by each fitter for each pipe diameter to be used, for both vertical and horizontal weld orientations. Submit sample joints to Owner for inspection prior to the start of the project. The Owner shall compare the joint quality with high-quality welds produced by manufacturer.
   4. The Owner reserves the right to suspend fusion operations via Construction Management for noncompliance with specified procedures or standards.
   5. Owner reserves the right to request the removal of any system joints deemed substandard or otherwise unacceptable. The acceptable IR weld criteria shall be:
      a. Uniform double beads on pipe OD. The complete absence of one bead (half) or the other, no matter how slight is cause for rejection.
      b. Weld will have no offset or joint misalignment greater than 10 percent of pipe wall.
      c. No angular deviation, due to misalignment.
      d. No visible inclusions or voids within the parallel lines of the wall thickness.
      e. The mid-point of the double bead shall never be less than or compromise the wall thickness.
      f. The pipe or fitting exteriors must show no evidence of slippage in the clamps or the fusion machine. This condition is not acceptable regardless of bead formation.

6. Random field samples will be checked by Owner for excessive and/or thin wall anomalies. Refer to PVDF Permissible Variation / Physical Dimensions Chart for tolerances.
7. The installing/IR-Operator shall perform 100% inspections on all personally made fusion joints.
8. Owner shall inspect and sign off 100% of all PVDF/PP IR-Fused joints.

3.5 PROCEDURES

A. Do not locate or use flux plastic primer/cement compounds near the piping system work area.

B. Fitters and helpers involved with the fabrication and installation of the piping system shall wear non-soiled apparel and clean latex gloves at all times.

C. Valves and fittings shall be used immediately upon being individually unpacked. No further attempt at cleaning shall be made.

D. Protect piping system components from contamination at all times. Replace any system component contaminated during fabrication and installation with a new, clean item. Do not attempt to re-clean contaminated components in the field unless authorized by Owner.

E. Maintain valves, fittings, and pipe under clean, dry, dust-free conditions to the greatest extent possible when the internal aspects of the components are exposed to the environment.

F. Immediately process each lot of pipe arriving at the site as follows:
   1. Owner shall randomly inspect samples of pipe. Acceptance of each lot by Owner is required prior to utilization of pipe.

PVDF Permissible Variation / Physical Dimensions Chart

Nominal Sizes Standard / Metric		Outside Diameter	Nominal Wall Thickness	Wall Thickness Tolerance
½ IN	20 mm	0.787	0.0745	+ 0.12 / - 0
¾ IN	25 mm	0.987	0.0745	+ 0.12 / - 0
1 IN	32 mm	1.260	0.0945	+ 0.12 / - 0
1 ¼ IN	40 mm	1.575	0.0945	+ 0.12 / - 0
1 ½ IN	50 mm	1.969	0.118	+ 0.12 / - 0
2 IN	63 mm	2.480	0.118	+ 0.12 / - 0
2 ½ IN	75 mm	2.953	0.142	+ 0.16 / - 0
3 IN	90 mm	3.543	0.169	+ 0.20 / - 0
4 IN	110 mm	4.331	0.209	+ 0.24 / - 0
5 IN	140 mm	5.512	0.174	+ 0.24 / - 0
6 IN	160 mm	6.300	0.193	+ 0.28 / - 0
8 IN	200 mm	7.874	0.244	+ 0.32 / - 0
9 IN	225 mm	8.858	0.275	+ 0.36 / - 0

   2. The taking of pipe samples shall comply with the procedures as specified in Part 2. It is essential that the sampling procedures in no way compromise the cleanliness of the pipe.

3.6 FABRICATION

A. Pay strict attention to progress of assembly to ensure that system ends and components are not left exposed to the environment when work is not in progress.

B. Prior to joining long runs or subassemblies together in final location environment (e.g. when two separate pipe runs meet for final connection), the surrounding ambient environment must be under temperature control at 70 degF, plus or minus 5 degF. Prior to final connections, the HVAC system should be in operation for ambient temperature control. If HVAC is still under construction, final connections must be postponed until such, or installer may submit for Owner approval, a definitive plan for ambient temperature control up to the time of normal HVAC operations.

C. Whenever field fabrication / installation is required in non-controlled / non-protected areas, the installer is required to protect the area of the fusion joint from adverse weather conditions. The permitted material and equipment ambient temperature range for IR-Fusion joining is between 50 F and 90 F. Outside this range, suitable action shall be taken to ensure that these conditions are maintained. Materials shall be at surrounding ambient temperatures prior to IR-fusion welding.

D. Cleanrooms and areas of strong air currents are of particular importance for IR-Welding. Due to the non-contact heating method of the fusing system, any stray air current can interfere with the radiant heat transfer process. Therefore, air currents must be addressed by the installer, i.e:
   1. Shield the IR welder to prevent any drafts from interfering with the IR heater plate.
   2. Place approved tape over the clamping halves to prevent air from entering the small gaps between the two halves.
   3. Close off holes in the IR end caps since the holes may allow enough air infiltration to interfere with the weld.
   4. Whenever possible, move the IR welder away from direct air currents prior to IR welding.
   5. All fittings and pipe ends must be covered prior to IR welding. Note: This applies to all ambient conditions.

E. Piping shall be set on hangers/racks to adjust to the ambient temperature environment prior to final field joining of long runs or subassemblies.

F. For weld traceability provide a fusion log on each fused joint noting joint number, date, and operators' name. Logs shall be turned over to Owner at the end of the project for project archiving.

G. A thermal transfer printed label shall be placed beside the actual joint on the pipe / fitting and/or valve. Labels shall be made of white polyester and acrylic adhesive type material. Labels shall be High Purity labels for cleanroom and standard quality for non-cleanroom applications. HP labels must resist against: high temp (140 C/ 280F), 95% humidity, IPA cleaning agents and UV-rays. The IR fusion machine must interface with a printer to create a unique number identifying the IR machine, date, joint number, process status, plus designation for operator and QA/QC signatures. This information shall be recorded on each label.

H. The installing tradesman shall inspect all PVDF materials prior to installation. Using a white light source, materials shall be inspected for OD & ID surface imperfections, i.e. pits, scratches, stains, residues and discoloration. Surface or sub-surface anomalies within 1/4" of the fusion ends and/or any deficiency which compromises the wall thickness or integrity of the material shall be rejected and removed from the job-site. PVDF material anomalies discovered in the field by the installer and/or Owner; shall be recorded in a report generated by the installer and transmitted to Owner.

3.7 JOINTS

A. Radiant Heat Butt /Fusion: Make up in strict accordance with manufacturer's instructions.

B. Threaded: Use only at equipment connections. Make up with PTFE tape using no more than 2 wraps, beginning at large end of threads, wrapping toward small end, leaving 2 end threads exposed. Sealant material other than 100% pure PTFE tape will not be acceptable. Use Fluoroware 100 percent pure PFTE teflon tape or an approved equal.

C. Joints on long straight runs of piping may be flanged at no less than 40 foot intervals in buildings and tunnels.

3.8 VALVES - MAINS, SUBMAINS, BRANCH, SAMPLING AND VENTS

A. Locate valves and in-line piping specialties to be readily accessible for operation and maintenance. Provide unions, flanges, or flaretek hose connections at equipment and work station connections or at other in-line locations requiring maintenance as indicated on the Drawings.

B. Provide Millipore or GF Plastics sampling valves as indicted on the Drawings. Sampling valve protection may be required. Use PVDF Zero Dead Leg (ZDL) style socket x 3/8 FPT style valve for all sampling ports for DI systems.

C. Install piping system to prevent or minimize high points which may prevent complete system venting. Where high points are unavoidable, use PVDF Zero Dead Leg (ZDL) style socket x 3/8 FPT style valve for venting.

D. Provide one of the following methods to limit dead leg lengths on branch mains and equipment branch lines:
   1. Install zero dead-leg valves.
   2. Install in-line valves to limit dead leg length to a maximum of six (6) internal pipe diameters.

E. All zero dead-leg valves (up to 4 IN x 2 IN) shall have a full size +GF+ union IR-welded directly downstream of the valve (male union half next to valve). Reducers shall be placed downstream of unions for desired line size requirements.

F. All zero dead-leg valves designated for future tool-hookup and/or branch-line capped for futures shall have male union halves IR-welded directly downstream of the valve. A white ¼” polymer blank insert shall be placed between the male/female union body halves and hand tightened. The union shall then be double poly-bagged and taped with cleanroom approved tape for contamination control. Minimize tape contact with PVDF tube, fittings, and valve assemblies.

G. Within the fusion area, the component and tube to be jointed shall have the same wall thickness with a maximum permissible wall displacement of 10%.

3.9 HANGERS

A. Securely support piping with cushioning to prevent swaying and vibration, allowing the pipe to move when thermal expansion and contraction occurs. Install supports at no greater than the following intervals:

Maximum Support Spacing for Hangers	
Nominal Pipe Size (IN)	Max. Spacing (FT)
1/2, 3/4 and 1	3.0
1-1/2 and 2	4.0
3 and 4	4.0
6	7.0
8 and larger	7.5

B. The above spacing requirements are based on piping carrying fluid at 68 degF operating temperature, where, due to operating conditions, manufacturers support spacing dimensions are less than those listed above, manufacturer’s requirements take precedence. As an alternate, provide continuous vee channel support with vee bottom clevis hangers at 10 ft spacing.

C. Where pipe is installed outdoors or where temperature changes may occur, supports shall be fabricated and installed to allow for pipe movement due to thermal expansion, allowing supports to act as guides rather than attaching the pipe rigidly at each hanger.

D. Unless noted otherwise, thermal growth for plastic pipe is 1 IN per 10 degF temperature change per 100 FT. Evaluate the system for the requirement for and location of expansion loops, anchor points, and pre-stressing of piping in conjunction with the manufacturers recommendation and Owner. Locate any takeoff valves and branch lines, so that there is no interference when these lines move due to thermal expansion.

E. Install piping in strict accordance with manufacturer's recommendations.

3.10 FINAL TEST PROCEDURES

A. Pipe System:
   1. Test fluid:
      a. RO piping shall be RO water filtered to 0.2 micron absolute for all process lines.
   2. Pressure test piping hydrostatically.
   3. Fill the piping system with water, opening all valves and ports to purge system of air.
   4. For piping systems apply 125 psi pressure water using a hydro pump for 4 hours. Bring piping system to pressure in 25% increments, allowing the system to stablize. Note leaks if any, release pressure, and remove water by purging with specification-grade nitrogen.
   5. Take special care when repairing leaks. Remove fragments and particulate matter produced during joint preparation. Repair leaks, resume test.
   6. Recharge piping system and maintain 125 psi test pressure for a period of 4 hours with no decay.
   7. Tests shall be witnessed by Owner.
   8. Check system to assure compliance with flow requirements.
   9. Check all controls and alarms to assure proper operation.
   10. Unless a constant recirculation can be achieved through the piping system or piping segment that is being pressure tested, open valves and ports, drain and blow dry the system using filtered Nitrogen upon completion of the pressure test(s). At the completion of all pressure tests on the system, proceed with the sterilization of the system. Disinfection shall be witnessed by Owner.
   11. At the completion of the disinfection procedure, proceed with Final Purity Testing.

B. Final Purity Testing shall be carried out by the installer and witnessed by Owner. Testing methodology shall be in accordance with this section.

C. Taking Samples:
   1. Flush sample ports for a minimum of 10 minutes before taking samples.
   2. Following each port flush, rinse sample containers with 4 times container volume of sample to be tested.
   3. Avoid contact with the container neck when filling containers and drawing test samples.

D. Sample Stations Locations:
   1. Inlet & outlet of the water purification equipment.
   2. Mid-stream in the supply and return pipe system.
   3. As indicated on the Drawings.

E. Contractor shall run the following tests on each sample at weekly intervals over 30 days for compliance with purity specification:
   1. Conduct resistance test on site. All sample stations shall meet 18 megohm-cm at 25 degC. Instrument shall provide a direct readout in megohm-cm at 25 degC using a flow-through cell.
   2. Draw 3 samples of RO water at points noted above for determination of "viable organism count." Prepare 2 cultures from each of the 3 samples taken in Millipore total count growth media and incubate for 48 hours at 28 degC. Stain cultures and count at 5X magnification.
   3. Total organic carbon (TOC) using an Anatel TOC analyzer, Model A-1000.
   4. Particulate testing using on-line particle counter.
   5. Total silica ($Si0_2$) per Scientific Instruments CFA 1000.
   6. Sodium (Na) per ASTM-D3561 or Ion Chromatography.

3.11 STERILIZATION

A. Conduct sterilization process after water purification system and end use equipment are operational and the piping system has been pressure and leak tested. Do not install filters and RO membrane elements, and other chemically sensitive equipment until after sterilization is complete.

B. Consult with Owner to schedule sterilization date.

C. Give the Owner at least a 4 day notice that sterilization will be done.

D. Lock out automatic and manual electric circuits, and shut and tag out feed valves to the system. Remove or isolate all sensitive instrumentation.

E. Persons performing this operation must use proper PPE as outlined in the chemical's Material Safety Data Sheet (MSDS).

F. Do not work alone. Work in pairs!

G. The following safety equipment must also be available: Scott air packs, ladders, exhaust fan, safety harness, life line, domestic water, hose for washdown, and a backup person with a radio, if required.

H. Pump 500 ppm Paraoxyacetic acid into the RO supply line to the polish system and downstream distribution/recirculation loop for 4 hours.

I. Open and close outlets and sample ports each hour for 2 minutes.

J. At the end of the 4-hour recirculated period contact Owner to determine proper drain/disposal method. When draining the system, the disinfection solution may need to be diluted with domestic water.

K. Open valves, unlock electric currents, and flush with semiconductor grade deionized water filtered to 0.2 microns absolute until the disinfection solution is below detection upon sampling.

L. Follow ASTM-F60 to determine the bacterial population. This analysis requires the use of a Millipore MHBG03700 bacteriological filter disk with incubation of 24 hours using Pseudomonas specific isolation agar. Bacterial population of the outlet water shall not exceed that of the water entering the system.

M. Install filters and RO membranes, furnished by others.

N. Rinse or flush newly installed system components and system piping with fresh RO water filtered to 0.015 micron, absolute.

O. Continue rinsing until accepted by Owner.

P. At the completion of the sterilization process, place the semiconductor grade deionized water on line with equipment in operation and with the distribution piping system in recirculation mode.

END OF SECTION

SECTION 22 61 13
LABORATORY AIR SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes the equipment requirements for the compressed Laboratory Air (LA) system:
   1. Air compressors.
   2. Air receivers.
   3. Air dryer/filter skids.

B. Refer to the Drawings for work covered by these specifications.

1.2 QUALITY ASSURANCE

A. All laboratory air system components shall be furnished by a single supplier.

B. The 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. Operating and maintenance data.
   2. Owner instruction report.
   3. Warranty.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Air compressors:
      a. Base:
         1) Beacon Medaes.

b. Optional:
    1) Atlas Copco.
2. Air receivers:
    a. Base:
        1) Beacon Medaes.
    b. Optional:
        1) Hanson Tank.
        2) Silvan Industries.
        3) Manchester Tank.
3. Air dryers and filters:
    a. Base:
        1) Beacon Medaes.
    b. Optional:
        1) Atlas Copco.
        2) Pneumatic Products.
        3) Deltech.
        4) Gardner Denver.
4. Other manufacturers desiring approval comply with Section 00 26 00.

2.2 AIR COMPRESSOR

A. The air compressor shall be a continuous duty rated scroll type with sealed bearings, single stage air cooled compressor capable of delivering 100 percent oil-free air. There shall be no lubricants in the compression chamber.

B. The assembly shall be fully packaged, including air compressor, drive motor, intercooler, aftercooler, lubrication system, regulation and control system, inlet air filter and silencer, sound attenuation cabinet, moisture separators with automatic drains, pressure relief valve(s), aftercooler check valve, base frame, and internal wiring and piping.

C. Noise shall be 80 dBA or less at 3 FT measurement from compressor unit.

D. For water-cooled compressors (as indicated on the drawings), the compressor system shall have a cooling water conservation system. Chilled water is available for compressor cooling. Contractor shall provide an automatic control valve and approved temperature sensor to throttle cooling water as required. Provide automatic tight shutoff valve to stop water flow on compressor failure/shutoff. Valve and actuator shall be industrial quality equal to Fisher. Intercooler and aftercoolers shall be ASME coded and stamped. Aftercooler shall be sized to cool discharge air to within 20 degrees F of leaving water temperature.

E. A separate direct-driven lubrication system shall be provided to ensure positive lubrication. Bearings and timing gears shall be prelubricated for at least 15 seconds before startup and continue to be lubricated for at least 20 seconds after shutdown. Splash lubrication is normally unacceptable and requires specific concurrence of the Engineer. Means shall be provided for accurate measurement of oil level while compressor is in operation.

F. A dry-type inlet filter silencer shall be included on the compressors. The device shall be designed for at least 125 percent of the compressor's expected capacity in scfm.

G. Antifriction bearings shall be selected to provide an AFBMA L10 life of not less than 120,000 hours and to be regreasable while running via installed grease fittings. Bearings shall be factory greased with adequate supply of wide temperature range, rust-inhibiting grease. Contractor shall provide details concerning motor shaft to compressor connection, including shaft seals. The shaft seal shall be a spring-loaded carbon ring which shall be cooled by oil during operation. Provide gravity-fed oil reservoir to provide lubrication in the event of a power failure coast down. Provide access covers for each bearing chamber and oil reservoir.

H. Motors: Basic requirements applicable to motor(s) that are provided and installed under this Section are set forth in Section 20 05 00.

I. Control system:
   1. The control system shall be integral to the compressor package and shall provide manual and automatic operation and be equipped with a fused disconnect switch capable of being padlocked in the off position. Compressor local panel and control devices shall be skid mounted and factory wired. The control system is to provide an adjustable timer for loading delay to prevent excessive starts. Control system shall also provide for automatic shutoff of the compressor during periods of low demand and excessive idling to conserve energy. Control voltage shall be 120 V, 60 Hz, and shall be provided by others.
   2. Adequate safety devices shall be incorporated to shut down the unit and require manual reset in the 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: The compressor local panel on the compressor shall be housed within a NEMA 12 enclosure and shall be UL labeled for use as an industrial control panel. Include the following instruments:
   1. Intercooler air pressure gauge
   2. First- and second-stage discharge air pressure gauge
   3. Oil pressure gauge
   4. Intake filter differential pressure gauge
   5. First- and second-stage discharge air temperature gauges and lights
   6. Low-oil pressure light
   7. Hour Meter:
      a. Running time
      b. Loaded time
   8. Auto-operation light
   9. Power on light
   10. Motor overload light
   11. Unload/normal toggle switch
   12. Reset/start push button
   13. Stop push button
   14. High-oil temperature light
   15. High-bleedoff air pressure light
   16. High-discharge water temperature switch and gauge
   17. Hand-off-auto switch (in auto, accept a run contact from BMCS)
   18. Use push-to-test indicating lights
   19. Second-stage inlet air temperature gauge and light
   20. Output for connection of common trouble alarm to the Owner control system.

K. Factory wiring of all components to motor starters and control panels is required and shall be in accordance with Division 16 requirements.

L. Accessories:
   1. Automatic drain traps shall be electric stainless steel drain valve assembly (ASCO CDVA 120 V, 60 Hz, or equal). Power to be provided by Vendor via prewired skid system. Automatic drains shall be controlled by a field-adjustable timer located in the local control panel.
   2. Pressure safety relief valves shall be ASME coded for Section VIII air service. Safety valves shall be capable of relieving the total rated capacity of the compressor at the 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 receiver(s) as shown on the drawings.

B. Receivers shall be suitable for a maximum working pressure at the top tangent line, of 10 percent or 25 PSIG above the highest normal operating pressure, whichever is greater, and shall be furnished with ASME stamp and certification papers.

C. Floor mounted receivers shall be provided with steel support legs or skirt, designed for bottom of tank 12 IN above floor, and suitable for the applicable seismic zone.

D. Receivers shall be internally lined with a combination epoxy and polyamide-type resin; Plasite 7133 or approved equal. Receiver exterior shall be sandblasted, primed and painted with a coat of machinery enamel.

E. Provide the following 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, ½ 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. Nozzle gaskets (EPDM).

F. Nameplates: Each receiver shall be supplied with a 316L stainless steel equipment identification label mounted on a raised flat surface permanently attached to the receiver.

G. Spare parts: Provide one spare gasket for all manways and nozzles.

2.4 AIR DRYER

A. The air dryer(s) shall be packaged systems which are skid mounted, complete with interconnecting tower piping, valve manifold, filter units, and control wiring. The air dryer unit shall be packaged ready for an air inlet, air outlet, and single-point electrical power connection. The dryer package shall include a particulate pre-filter, coalescing pre-filter, and particulate after-filter on the skid fully piped and valved.

B. The air dryer(s) shall be dual tower, heated regenerative desiccant dryers. An external heater and process air shall be used to regenerate the dryer. The heater shall be mounted externally to the desiccant bed and shall have an inconel sheath. Heater and associated purge piping shall be thermally insulated. Maximum purge volume shall be 7 percent for heated dryer package of inlet airflow.

C. Air dryers shall all be mounted with two chambers on a common baseplate. The package shall include all valves, controls, and wiring necessary for complete system operation. Regeneration shall use dry outlet air. Regeneration shall be initiated by the dewpoint of the outlet air, with an in-bed capacitance type moisture sensor and control system.

D. The dryer package shall be designed for drying compressed air from a saturated condition at 100 DEGF and 100 PSIG to a design dew point of -40 DEGF. At no time, including switchover to a regenerated bed, shall the dew point of the distributed air exceed the design dew point.

E. Air dryer vessels shall be ASME code stamped for 150 PSIG, designed in accordance with Section VIII, Division 1, and stamped by the code inspector. The air dryer design shall be in accordance with all state and federal codes, including ANSI, NEMA, NEC, and ISA.

F. Dryer system shall be designed with a maximum pressure drop of 5 PSI at rated flow, temperature, and pressure.

G. Provide exhaust muffler on purge prior to exhaust to room, such that during purge, regeneration, and dry gas sweep, the air noise shall be reduced to 80dBA or less at 3 FT measurement.

H. Dryer shall have separate desiccant fill and drain ports located such that dryer piping does not have to be disturbed for desiccant change.

I. The dryer skid mounted air filters shall include three-valve bypass piping, such that any filter element can be safely serviced while the 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. The dryer control system shall automatically alternate towers for regeneration in such a manner as to provide an uninterrupted air supply without any downstream pressure fluctuations. The pressures in both desiccant chambers shall be equalized prior to changeover.
   2. Provide for single point power connection. If required, provide a control voltage transformer. A power interruption shall not result in the interruption of air flow through the dryer. The system shall operate on 480V/60HZ/3 for heated air dryer or 120 VAC for heatless.
   3. Changing of a tower from a drying mode to regeneration mode shall be accomplished with switching valves. The valves shall have carbon steel bodies, stainless steel internals, and Teflon seats and seals. The valves shall be rated for 500,000-cycle life.
   4. The switching valves shall be controlled by a four-way solenoid valve which directs dry air to the air cylinder on the control valve.
   5. Each dryer shall be provided with a purge/ regeneration control system to minimize the regeneration cycles and maintain the outlet dew point at or below the specified requirement.
   6. The local dryer control panel shall be NEMA 12, UL listed, and include indication of the following:
      a. Power on.
      b. Left chamber depressurizing.
      c. Right chamber depressuring.
      d. Left chamber heating.
      e. Right chamber heating.
      f. Left chamber repressurizing.
      g. Right chamber repressurizing.
      h. Inlet valve malfunction.
      i. Exhaust valve malfunction.
      j. Dryer inlet pressure.
      k. Dryer outlet pressure.
      l. Left chamber pressure.
      m. Right chamber pressure.
      n. Moisture indicator.
      o. Heater on.
      p. Adjustable heater thermostat.
   7. All 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. The pre-filter and coalescing pre-filter shall be located upstream of air dryer. The after filter shall be mounted downstream of the dryer to capture desiccant or other particulate before they pass downstream.

B. Particulate pre-filter, 1.0 micron rating.

C. Coalescing pre-filter, 5.0 micron rating, 5 ppm(w) oil carryover.

D. Particulate after-filter, high efficiency, 0.01 micron rating.
   1. Filter shall be high temperature for heated air dryer applications.

E. Filter Elements:
   1. Filter media shall be suitable for mineral or synthetic oils.
   2. Provide double O-ring seals. Filter element must positively seal to the filter housing using elastomeric seals.
   3. Media shall be supported inside and out.
   4. The coalescing element shall consist of a rigid perforated sleeve for structural strength and an outer drain layer to permit oil and water to drain to the bottom of the element and not re-enter into the 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 that the elements can be replaced without removing the housing from the piping.
   3. Pressure rating: 300 psig.
   4. Provide with integral differential pressure indicator.

G. Provide the following 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 PIPING SYSTEM

A. For skid piping and valve requirements, refer to specification section 22 67 19.

2.7 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. General: Install equipment as indicated on the drawings, and in strict accordance with the manufacturers written instructions.

B. Install equipment on vibration isolation bases where specified elsewhere in the construction documents.

3.2 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

END OF SECTION

SECTION 22 63 80

HIGH PURITY STAINLESS STEEL PIPING SYSTEMS (Issued AD-4)

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This section includes general administration and procedural requirements for fabrication, installation, and testing of high purity stainless steel piping systems for gas and liquid distribution.
   1. Cylinder Specialty Process Gases.

1.2 RELATED WORK

A. Refer to other Mechanical Specification Divisions for:
   1. General and special mechanical requirements.
   2. Piping and equipment identification.
   3. Hangers and supports.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Submit piping system shop fabrication drawings and details prior to any sub-assembly fabrication, including model numbers of components used for review and approval by the Owner.
   2. Submit for review and approval prior to start of component delivery or fabrication.

B. Product Data:
   1. Submit catalog information or O&M manuals pertaining to automatic tube butt- welding system proposed for use.
   2. Submit catalog and procedural information for all instruments used in performing leak checking, particulate certification, and purity analyses of the distribution system prior to the start of any testing.
   3. Submit UHP Materials and Components list for approval by the Owner.
   4. Submit for review and approval prior to start of component delivery or fabrication.

C. Samples:
   1. Submit sample labels including material, color, letter size, and verbiage that will be used on installed materials. Labels require thermal transfer lettering. Lettering must not smear when lines are wiped down with Production Cleaners, i.e. acetone, isopropyl alcohol and/or DI water mixtures.
   2. Submit for review and approval prior to start of component delivery or fabrication.

D. Project Information:
   1. Submit source and on-site Material Quality Control, Shop Fabrication Quality Control, Installation Quality Control and Field Quality Assurance procedures.
   2. Submit for review and approval prior to start of component delivery or fabrication.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. UHP Electropolished Tubing:
   1. O'Brien "Cardinal Tubing" – Tech 100 and Tech 50.
   2. Valex – 401 and 301, BO Grade or Higher.

B. Butt-Weld by Face Seal (VCR) Fittings and Butt-Weld Mini Fittings (0.005 to 0.012 percent sulfur range):
   1. Swagelok/Cajon.
   2. Parker Hannifin.

C. VCR Clamps:
   1. Clamp design must not counter-torque VCR connection when secured to joint.
   2. Cajon / Swagelok – 1/4 IN VCR clamp, SS-4-VCR-FLC-06497.

D. 3/8 IN Diaphragm Valves:
   1. Flow rates are Cv .40 – Cv .80.
   2. Round indicating handles.
   3. Springless diaphragm.
   4. Inlet pressure max. 250psi.
   5. Acceptable models:
      a. APTech – 4650SZ (Cv .50).
      b. Tescom – PV71HK (Cv .40).
      c. Nupro – DF Series (Cv .80).
      d. Veriflo – 955 IS (Cv .55).

E. 1/4 IN Isolation Valves:
   1. Flow rates are Cv .22 – Cv .50.
   2. Round indicating handles.
   3. Springless diaphragm valve.
   4. Inlet pressure max. 250psi.
   5. Acceptable models:
      a. APTech – AP3650 (Cv .22).
      b. APTech – AP4650 (for higher flows Cv .50).
      c. Tescom – PV 71L Series (Cv .17) (H – Series for higher flows Cv .40).
      d. Veriflo – 944 I (Cv .25).

F. Valves for Higher Pressure Bulk and Specialty Gases (1/4 IN):
   1. Flow rates are Cv .17 – Cv .25.
   2. Round indicating handles.
   3. Springless diaphragm.
   4. Inlet Pressure max. 3000psi.
   5. Acceptable models:
      a. APTech –AP3600 SZ Series (Cv .22).
      b. Tescom – PV 71 Series (Cv .17).
      c. Veriflo – 944 I (Cv .25).
      d. Nupro HD Series (Cv .20).

G. UHP Regulators: Per Section 11 53 69.

H. High Purity Nitrogen Purifier
   1. HP Nitrogen purifier shall be high flow, Type 316L stainless steel material of construction, electropolished wetted surface (< 15 microinch Ra).
   2. Purifier shall have maximum flow capacity of 100 slpm and shall be designed to remove moisture, oxygen, CO, CO_2, and hydrogen from the high purity nitrogen stream.
   3. Purifier shall include the following components:
      a. Sintered metal particle filter, 0.003 micron.
      b. External band heater and temperature controls.
      c. High flow mass meter.
      d. VCR fittings.
   4. Approved manufacturers:
      a. NuPure.
      b. SAES Pure Gas.

I. Other manufacturers desiring approval comply with Section 00 26 00.

J. All products must be delivered with appropriate manufacturer's quality assurance documentation stating, materials composition; mill test reports; certification of conformance report; testing and compliance with leak rate specifications.
   1. Submit test and cleaning methodology to the Owner for review prior to shipment.

K. Enclose pipe and fittings in heat-sealed; 6-mil, dlb. polyethylene bags.

2.2 CARRIER TUBING

A. Seamless up to 1 IN, seam-welded 1 1/2 IN and larger, Type 316L stainless steel, ASTM-A269 and ASTM-A632; hydrogen bright annealed, 20um maximum surface finish from the extruding mill. Tubing shall have a controlled inside diameter electropolished to a 10 Ra with a 20um (±10um) maximum finish and a hardness of Rb 60 to Rb 80, with 5 percent maximum allowable chromium carbide, and 0.005 to 0.012 percent maximum sulfur content, 0.017 maximum sulfur for seam-welded tubing. Consistent Heat Numbers are preferred on all UHP Tube and Fittings.

B. Provide certification and test method used as part of tubing submittal. Tubing shall conform to the following permissible variation:

OD Size (IN)	Nominal Wall Thickness (IN)	Ovality Dia. (IN)	Percent Wall Thickness
1/4	0.035	+/- 0.005	+/- 10 percent
3/8	0.035	+/- 0.005	+/- 10 percent
1/2	0.049	+/- 0.005	+/- 10 percent
3/4	0.065	+/- 0.005	+/- 10 percent
1	0.065	+/- 0.005	+/- 10 percent
1 ½	0.065	+/- 0.010	+/- 10 percent
2	0.065	+/- 0.010	+/- 10 percent
4	0.083	+/- 0.015	+/- 10 percent
6	0.134	+/- 0.030	+/- 10 percent

   1. Copies of the material test reports for tubing & fittings shall be submitted to the Owner for review.
   2. For systems exceeding 200psi, on tubing 1 IN and larger, the above tube wall thickness(s) must first be approved.

2.3 VALVES

A. All compressed gas cylinders shall be equipped with a high purity CGA (Compressed Gas Association) or DISS fitting.

B. All valves shall have Type 316L stainless steel body with internal surfaces Type 316L electropolished to a 10 Ra with a 20um (±10um) maximum finish.
   1. All point of use branch equipment isolation valves shall be tube (welded) by male VCR ends. Ends shall be capped with stainless steel VCR caps.
   2. End-of-line valves for future expansion shall be tube (welded) by tube.
   3. End-of-line 1/4 IN valves, shall be capped with stainless steel Swagelok or Parker A-lok caps, using PFA or nylon ferrules (minimal torque for sealing).
   4. For end-of-line valves 3/8 IN and larger, welded caps shall be installed.
   5. All end-of-line valves located outdoors to have welded caps.
      Note: The welding of caps must be made after Particle and Analytical Testing is completed and approved by the Owner. Caps to be welded by the installer.

C. T-handle, toggle, or plastic material actuators or handles on valves are not acceptable.

D. Provide the following valve types per pipe size:

Size	Gases
1/4 inch	Diaphragm
3/8 inch	Diaphragm

1/2 inch	Diaphragm
3/4 inch and above	Bellows

E. Valves with tube extensions:
   1. Extensions must be of sufficient length to allow for facing and orbital welding.
   2. For future line expansion, all end-of-line valves 3/8 IN and larger shall have (downstream) tube extensions long enough for weld cap removal, facing and orbital welding.
   3. Extension material must have traceability for verifying welding compatibility with carrier piping for each respective size is required.

F. All valves must pass outboard and across the seat test. Pressurize to 200 psi or maximum rating of valve, which ever is less, with Helium. There shall be no detectable Helium within the contents of the bag using a Helium detection device. Each valve shall be tested for compliance for minimum 5 minutes with a leak rate not exceeding 1 x 10-9 atm. cc/sec.

G. All valves with VCR fittings must be configured with female VCR inlet and male VCR outlet unless otherwise directed.

2.4 PRESSURE REGULATOR

A. All pressure regulators shall have Type 316L stainless steel body with internal surfaces Type 316L electropolished to a 10 Ra with a 20um (±10um) maximum finish.

B. All source gas pressure regulators shall have a tied diaphragm design.

C. All pressure regulators shall be configured with female VCR inlet and male VCR outlet unless otherwise directed.

D. All pressure regulators shall be 100 percent outboard Helium leak tested and certified to 1x 10-9 atm cc/sec.

2.5 FACTORY COMPONENT & MATERIAL PACKAGING PROCEDURES

A. 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. Piping shall be double bagged in heat sealed 6-mil polyethylene bags.
   3. Pipe shall be properly supported to prevent ovality and distortion problems while being shipped.

B. Fittings: Immediately double package upon completion of cleaning and electropolishing operation each fitting separately in heat-sealed polyethylene bags purged with 0.01 um absolute filtered Nitrogen or Argon.

C. Valves: Supplied by the 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 3 - EXECUTION

3.1 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.

3.2 QA 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 inches 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 percent, whichever is greater, of random tubing lengths of approximately 20'-0" for examination. As a minimum, for 10 percent 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 percent 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 percent (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 percent shall be sampled and any further rejections will result in rejection of the lot.

3.3 FACILITIES

A. Perform subassembly fabrication operations in a separate on-site clean room. Construct an adequately sized room(s) for subassembly manufacturers. Provide equipment and materials required, maintaining the room in compliance with the following:
   1. Cleanroom classification 100 per Fed STD 209E at 0.5 um during normal production use.
   2. Provide HEPA filtered supply air to maintain class 100 environment.
   3. Maintain room at a minimum positive static pressure of 0.02inch water at all times. Verify with Magnahelic gauge.
   4. Provide adequate ventilation at cleaning stations in compliance with OSHA regulations.
   5. Certified UHP (18 megohm) DI rinsing station.
   6. Field certified UHP Argon purge station.

B. Upon delivery to the Site, properly store valves, fittings, and piping in original shipping containers in a clean, dry, well-maintained trailer or fully enclosed, lockable storage room.

C. All off-site fabrication and facilities must first be verified and approved in writing by the Owner prior to the start of such fabrication. If approved, all Quality Control procedures, inspections and specifications shall be in place and adhered to during all off-site fabrication, including the receiving of and/or shipping of materials, components and/or fabricated pieces to the Owner's construction job-site.

3.4 SHOP CLEAN ROOM PROCEDURES

A. Within cleanroom environments, welders, fitters, and helpers involved with the fabrication and installation of the piping system shall wear approved clean room garments and gloves. Each worker shall have a clean garment at the beginning of each shift. Change garments and gloves during a shift if torn or unusual soiling occurs and as frequently as necessary to maintain clean conditions. Once gloves are removed, they are not to be reused. Outside of cleanroom environments, cleanroom gloves shall be worn at all times during any material handling, fabrication and installation of UHP materials.

B. Prior to any materials being used from any lot, the lot shall be inspected by the installer's QC person and verified by Owner's QAR Representative.
   1. Owner's QAR Representative shall select random samples for inspection. Provide labor and equipment as directed by Owner's QAR.
   2. It is essential that the sampling procedure in no way compromise the cleanliness of the tubing. Tube inside diameter inspection shall be done by soaking approved clean wipes or plugs in 18 meg-ohm DI water and forcing through the pipe by using filtered Argon gas pressure. The piping shall be deemed clean only when the once-used wipe or plug shows no discoloration. Take care to prevent scratching, pitting, or distortion of all inside surfaces. Purge pipe with heated .01um filtered Argon until dry. The remnant tube shall be recapped with a static Argon purge, re-bagged, bags Argon or Nitrogen purged, heat sealed and stored for spool fabrication. All inspections will be documented, with copies submitted to the Owner's QAR for review.

C. Use tubing, valves and fittings immediately upon being individually unpacked. Make no further attempt at cleaning.

D. Protect piping system components from contamination at all times both internally and externally. Replace any system component that is contaminated during fabrication and installation with a new, clean item. Make no attempt to re-clean contaminated components in the field.

E. Pay strict attention to progress of assembly to insure that ends of the system and components are not left exposed to the environment when work is not in progress.

F. Maintain valves, fittings, and tubing under Class 100 laminar flow stations to the greatest extent possible when the internal aspects of the components are exposed to the environment. Whenever possible, perform welding and cleaning operations under Class 100 VLF conditions.

G. Sections of piping that have been pre-built for future installation shall be Argon filled and securely capped using compression fitting with a PFA or nylon ferrule or VCR up to 1 inch. For sizes 1-1/2 IN and larger, cover with patch and plastic cap. Ends shall be double bagged and taped with low residue cleanroom tape four inches from the end. Bagged sections shall be stored in a clean, secure area protected from physical and environmental damage.

3.5 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. For field bent tubing, if there is any kind of deformation of the tubing during bending, discard the bender immediately and replace the tubing.
   2. Only one VCR gasket is to be used at one time VCR gaskets shall not be reused. Tighten VCR connection per manufacture recommendations.
   3. VCR clamps shall be used on all valves and/or components that are not base-mounted and directly connected to each another.
   4. Any VCR connected line or spool that transfers radial torque to valves and/or components shall have VCR clamps.
   5. 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 percent 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 inch.

E. Maintain a continuous 0.01um metal sintered filtered Grade 6 Argon gas purge, minimum 99.9 percent 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.

3.6 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 hours.

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 hours 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.

3.7 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.

   Tag Format:
   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.

Fill out tags with a Black Sanford Sharpie pen.

Note: The installer(s) performing the tasks to sign-off applicable tag sections as installation or testing is COMPLETED.

3.8 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.

3.9 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.

3.10 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.

3.11 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 hours 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: Do not use liquid 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.

3.12 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, CO2, CH4: 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
   O2 <40 PPB MAX w/ delta relative to source <20 PPB
   H2O <40 PPB MAX w/ delta relative to source <20 PPB
   CO <40 PPB MAX w/ delta relative to source <20 PPB
   CO2 <40 PPB MAX w/ delta relative to source <20 PPB
   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.

3.13 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

SECTION 22 66 00
WASTE TRANSFER

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes the following:
   1. Process waste piping, services, and accessories. Rough piping and final connections to all equipment (other than process tools) whether furnished in this Section or not.
   2. Sleeves and supports, cutting, patching and framing of openings, and flashing of wall penetrations for work under this Section.
   3. Systems and equipment:
      a. Laboratory Waste (LW).
   4. Laboratory Waste System will collect drainage from the following systems:
      a. Cleanroom tools and support equipment.
      b. Scrubber Blowdown.
      c. Emergency Safety Shower/Eyewash.
      d. Laboratory drains.

1.2 RELATED WORK

A. Refer to other Mechanical Specification Divisions for the following:
   1. Plumbing systems.
   2. General and special mechanical requirements.
   3. Pipe hangers and supports.
   4. Piping and equipment identification.
   5. Insulation and heat tracing.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Detailed shop drawings for each equipment item.
   2. For components such as pumps submit complete detailed drawings giving all dimensions, connections, weights, electrical motor data and performance data (such as pump curves and computerized selection sheets) specifically for the required duty.
   3. Submittals shall be approved by the Owner's Representative before any purchase is made.

B. Product Data:
   1. Catalog cut sheets for equipment items.
   2. For piping and valves, submit list of suppliers with make and model number for materials, and manufacturer's printed data and illustrations of manufactured items identifying each size furnished.
   3. Submittals shall be approved by the Owner's Representative before any purchase is made.

1.4 OPERATION AND MAINTENANCE MANUALS

A. Include the following:
   1. All items covered under submittals.
   2. Equipment detailed parts list.
   3. Spare parts lists for each item of equipment. Lists shall include manufacturers address, name and address of nearest representative.
   4. Operating procedure for each piece of equipment.
   5. Routine maintenance requirements and schedule.

1.5 FINAL DOCUMENTS

A. Operation and maintenance manuals.

B. Warranties.

C. Manufacturer's certification of proper installation and function of equipment.

PART 2 - PRODUCTS

2.1 PIPE MATERIALS

A. Gravity industrial waste piping shall be flame retardant polypropylene, Schedule 40, Type 1 conforming to ASTM-D4101. Material shall be flame retardant with maximum average flame spread of zero seconds and a maximum extent of burning of 13 mm, in accordance with ASTM-D635. Fittings shall be flame retardant polypropylene.

B. Fittings shall be designed to lock into a machined groove on mating piping. Connections between for above-grade piping polypropylene pipe and matched fittings shall be made using the Labline joint.

C. Application:
   1. Gravity lab drains.
   2. Gravity drains in cleanroom subfab.

D. Piping below grade shall be same material as specified in Section 2.1.A. Fittings shall be flame-retardant polypropylene with an integral heavy gauge, nickel/chrome electrical resistance wire molded in place in the fitting body. Connections between pipe and fittings shall be fusion weld, enfield joint.

2.2 ACCEPTABLE COMPONENT SUPPLIERS

A. Polypropylene Piping and Fittings:
   1. Above Floor:
      a. Orion.
      b. George Fisher Fuseal MJ.
      c. IPEX.
      d. Labline.
   2. Below Floor:
      a. Enfield.
      b. Orion.
      c. George Fisher Fuseal II.
   3. George Fischer:
      a. Fuseal MJ (above finished floor).
      b. Fuseal II (below grade).

B. Other suppliers desiring approval comply with Section 00 26 00.

2.3 OTHER COMPONENTS

A. Acid Resistant Floor Drains and Cleanouts: Match piping system per design.
   1. R.G. Sloane.
   2. Chemtrol (PVC, CPVC).
   3. Floway (polypropylene).

B. Trench Drains: Precast polymer drains with drop-in grates suitable for pallet lifts and fork lifts loading.
   1. Acco.
   2. Zurn.

C. Lab sink outlets and traps:
   1. Labline.

D. Trap primers:
   1. Sloan.
   2. Precision Plumbing Products.

E. Other manufacturers comply with Section 00 26 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide all rigging, transportation, on and off loading personnel, etc., for all equipment furnished under this Contract.

B. Install and connect all equipment and components to provide a complete operating system.

C. Provide 2 days start-up and personnel training time.

D. Startup to include checkout of controls and alarms.

E. Drain piping exterior to buildings or located in areas that are practicably susceptible to freezing conditions shall be freeze protected.

F. Sleeves shall be installed where non-metallic drain piping passes through masonry, concrete, or any fire separation.

G. Exterior wall penetrations and roof openings shall be made watertight using approved flashing materials and/or sealants.

H. The grade of horizontal gravity drainage piping is to be minimum 1/4 IN per foot (2 percent) uniform slope. Where a 2 percent slope is not achievable or practical, a slope of 1/8 IN per foot (1 percent) may be permitted if authorized by the Owner.

I. Install piping parallel to building surfaces with a minimum of fittings.

J. Pipe the discharge of each relief valve, backflow preventer, and similar device to floor sink, floor drain, exterior or other acceptable location, except in attics and ceiling spaces.

K. Piping subject to expansion or contraction shall be installed with anchors and expansion loops or joints as required. Provide adequate anchors and guides to prevent misalignment.

L. Use DWV elbows, wyes, etc. as specified for each system.

M. Install non-conductive material between dissimilar materials.

N. Install unions or flanges at all connections to equipment, on both sides of control valves, and elsewhere as required to facilitate maintenance.

O. Install single piece chrome plated escutcheons on less than two inch pipe penetrations through walls or ceilings that are exposed to view and are in “finished rooms” (i.e. offices). Do not use split escutcheons.

P. Arrange piping and hangers to allow for expansion, contraction and structural settlement. Do not install piping in contact with the building structure. Hanger spacing shall be per piping manufacturer's specifications.

Q. Install flexible connectors only where absolutely necessary.

R. Core drilling: Drill holes 1 IN larger than O.D. of pipe for pipe less than four inches diameter, and 2” larger than O.D. of pipe greater than four inches diameter. Where pipes pass through sleeves or core drilled holes, recommend backer rod and fill outer ½ IN depth of the annular space with sealer. Penetration sealants and caulking are to satisfy the requirements under NFPA.

S. Label all piping valves in accordance with Mechanical Specification Divisions.

T. Air vent piping shall be compatible with adjoining materials.

U. For buried pipe, provide detection using a magnetic anomaly detector or other means to trace.

3.2 PIPING

A. General:
   1. Where different pipe materials interconnect, provide appropriate manufactured adapters or flanged connections with Teflon gasket, torque to manufacturer's specifications.
   2. Locate all hand operated vertical valves which require daily or more frequent operation, at a height not more than 7 FT-0 IN above floor.
   3. Stubs: Install valves where indicated on the drawings and elsewhere to facilitate pipe cleaning, venting, drainage, flushing or testing.
   4. Label all piping in accordance with Mechanical Specification Divisions.
   5. For gravity process drain piping, install cleanouts (bi-directional vent T's) at end of mains and laterals, every 50 feet on horizontal runs, and at every 135-degree change in direction. The flanged T's shall be out of the waste stream, and labeled or tagged as cleanouts to differentiate from futures.

B. Plastic: Install all plastic piping systems in strict accordance with pipe manufacturer's recommendations, including preparation of pipe and fittings for jointing, selection of solvent and primer, and curing and installation. Prior to fabricating system, demonstrate, in the presence of the Owner, the proposed field method of making joints.

3.3 PIPE PRESSURE TEST

A. Test all piping as noted below, with no leaks or loss in pressure. Repair or replace defective piping and re-test until tests are accomplished successfully. Any failures on test will require restart and complete time testing after repair.

Test System	Test Pressure	Test Medium	Test Time
Gravity Drains	10 ft.	water	4 hours

B. Any leaks found shall be repaired in the following manner:
   1. Plastic joint - Remove/Reinstall per manufacturer's instructions.

END OF SECTION

SECTION 22 67 19

PROCESS LABORATORY PIPING SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes the following:
   1. Process piping, services and accessories. Rough piping and final connections to all equipment (other than process tools) whether furnished under this Section or not.
   2. Sleeves and supports; cutting, patching and framing of openings; and flashing of wall penetrations for work under this Section.

B. Systems and accessories:
   1. Utility Nitrogen (N).
   2. Clean Dry Air (LA).

1.2 RELATED WORK

A. Refer to other Mechanical Specification Divisions for general and special mechanical requirements.

B. Work of other Plumbing and Mechanical Specification Divisions 20 and 22:
   1. Welding and brazing requirements.
   2. Piping specialties.
   3. Insulation.
   4. Plumbing systems.
   5. Pipe hangers and supports.
   6. Piping and equipment identification.

1.3 SUBMITTALS

A. Product Data:
   1. For piping and valves, submit list of suppliers with make and model number for materials, and manufacturer's printed data and illustrations of manufactured items identifying each size furnished.
   2. Submittals shall be approved by the Owner's representative before any purchase is made.

B. Contract Closeout Information:
   1. Operating and maintenance data for items requiring operational instructions or periodic maintenance such as: air vents, constant flow control valves, pressure relief valves, water flow measurement devices, etc.

PART 2 - PRODUCTS

2.1 PIPE MATERIALS

A. Utility Nitrogen (N) and Compressed Dry Air (LA):
   1. General: Pipe and fittings cleaned for oxygen service or equal, per CGA pamphlet G-4.1. Use tubing filled with nitrogen purge and pipe ends capped. The interior surface shall be uniform, bright, smooth finish with particulate matter of no more than 0.038 g/in2 (as called for in ASTM-B280 specification).
   2. 4 IN and Smaller: Type L hard-drawn copper tubing, plain ends certified to ASTM-B280 ACR specifications with brazed solder-type wrought copper (castings not allowed) fittings per ANSI Standard B16.22. May use rack grade, degreased, schedule 10S, 304L or 316L stainless steel, per ASTM-A269, when approved by Owner (see below):
      a. Copper Tubing Joining Materials: AWS – BcuP-5 Classification, "Silverflow-15" or approved equal.

b. Brazing Copper Pipe to Brass Flanges: Flux is acceptable only if written permission is given to the installer by Owner before each respective project. A condition of the approval is that each joint be bench brazed, and inspected (and approved) prior to installation. Approved brazing procedures are described under the Execution section in this specification. Approved flux products include Stay-Silv, Stay-Brite, and Stay-Clean.

3. 6 IN and Larger: Rack grade, degreased, schedule 10S, 304L or 316L seam-welded stainless steel per ASTM-A269:
   a. Minimum pipe wall thickness is as follows (+/- 12.5 percent per ASTM-A312); 0.134 IN for 6 IN dia., 0.148 IN for 8 IN, 0.165 IN for 10 IN, 0.180 IN for 12 IN, and 0.188 IN for 14 IN to 18 IN diameter pipe.
   b. Stainless Steel Joining Materials and Methods: Orbital or Gas Tungsten Arc Welding.
   c. Fittings will be factory made with radius bends. Pulled Tee may be used if authorized by the Owner in advance of installation (sample will be required).
4. Metals Free Areas:
   a. Acrylonitrile butadiene styrene (ABS) material according to ASTM D3965, cell classification 54322. Specifically designed for compressed air, manufactured from a specially engineered formulation, modified extensively to produce a homogeneous shatter-resistant piping system.
   b. Pipe designed to iron pipe standard (IPS) outside diameters with heavy-duty wall thickness conforming to a standard dimension ratios (SDR) of 9.0 (1/2 IN to 2 IN) and 10.0 (3 IN to 4 IN).
   c. All pipe systems shall have been tested for and meet the safety requirements of Cal OSHA "Plastic Piping Systems for Compressed Air" Title 8, Chapter 4.
   d. All fittings shall be injected molded. Fittings shall have same wall thickness and pressure rating as the pipe. Fittings shall be solvent cement style in ½" – 4".
   e. Pipe and fittings shall be 185 PSI rated at 100 °F.
   f. All valves shall be produced in the same manner as the pipe fittings.

2.2 VALVES

A. Utility Nitrogen (N) and Compressed Dry Air (LA):
   1. 2 IN and Smaller: Non-lubricated, bronze body, Teflon® seats and seal, stainless steel ball, two piece, full port ball valve with threaded ends and lockable handle. Apollo No. 77-100 or owner approved equal.
   2. 2-1/2 IN and Larger: Amri "Cosmia", Mueller Series 56, Grinnell Series 8000 or Keystone Series 222 butterfly valve. Ductile iron body, lug style drilled and tapped, EPDM seat with stainless disc and stem. All butterfly valves shall be rated for 150 PSI dead-end service in both directions, and bi-directional.
   3. Pressure Regulator: Direct acting, setscrew adjustment, stainless steel body and trim, flanged end connections. Jordan Valve Mark 60/61 Series.
   4. Pressure Relief: Stainless steel body, stainless steel trim; EPDM, Viton or Teflon seals, direct-pressure actuated. Relief device shall comply with the requirements of the ASME boiler and pressure vessel code for relief devices. Crosby Series 800.

2.3 PIPING ACCESSORIES

A. All inline piping accessories, devices and specialty items shall be constructed from materials suitable for use with the other system components, and the system it serves.

B. For piping specialties, refer to specification Section 20 05 19. Additional requirements shall be as noted below, and shall govern:
   1. System drains for hydronic systems:
      a. Provide with all stainless steel construction, including wetted materials.

C. Flexible pipe connectors (FPC) for pumps, refer to specification Section 20 05 50:
   1. Provide with EPDM elastomers.

2.4 INDICATING DEVICES

A. Additional requirements shall be as noted below, and shall govern:
   1. Pressure gauges:
      a. Provide with all stainless steel construction, including wetted materials.
      b. Provide stainless steel body, PTFE (Teflon®) diaphragm seals for gauges mounted in plastic piping.
   2. Thermometers:
      a. Provide with stainless steel wetted materials and thermowells.

PART 3 - EXECUTION

3.1 PIPING

A. General:
   1. Where different pipe materials interconnect, provide appropriate manufactured adapters or flanged connections with using expanded PTFE, non-ink embossed "Gore-Tex" cut sheet gaskets; 1/8 IN thick. Teflon® gasket. Torque to manufacturer's specifications.
   2. Locate all hand operated vertical valves which require daily or more frequent operation, at a height not more than 7 FT-0 IN above floor.
   3. Stubs: Install valves where indicated on the drawings and elsewhere to facilitate pipe cleaning, venting, drainage, flushing or testing.
   4. Label all piping in accordance with Mechanical Specifications Divisions.

B. Copper: Cut copper piping with wheel cutter. Debur all cut ends and blow out chips with nitrogen.

3.2 VALVES

A. Pipe risers:
   1. Provide isolation valves at main feed points to risers.
   2. Provide isolation valves at branch take-offs from risers.

3.3 COPPER PIPE INSTALLATION

A. Installation: All materials and installation work shall conform to all applicable codes and regulations. All work shall be done in a competent manner using the latest techniques of the trade:
   1. Thread Fitting / Connections:
      a. Only 100 percent pure PTFE Teflon® tape is acceptable for all Process Piping Systems.
   2. Copper:
      a. Installer is responsible to supply qualified brazers, equipment, and materials for scope of work.
      b. Brazing shall conform to the following:
         1) Copper lines shall be brazed using an oxygen-fuel flame.
         2) For all copper lines, all joints will be brazed with AWS – BcuP – 5 Classification; Silverflow – 15 or owner approved equal.
         3) During brazing all gas lines must be continuously purged with 0.1 micron absolute filtered nitrogen gas, which shall be allowed to escape into the atmosphere through a purge restrictor. Purge relief vent will be positioned above the plane of the pipe. Open ends will be closed and spool piece stored at ambient temperature until installed. Portable hand held oxygen monitors will be used on pipe sizes 2-1/2 IN and larger. Monitors are to read in parts per million (ppm) level, percentage monitors are not acceptable. Welding and brazing will be done at less than or equal to 50ppm oxygen concentrations. For Sizes 2" and down, timed purging is acceptable:

*Based upon 20ft. linear footage.

Tube O.D Diameter	Tube I.D. Flowrate	Purge Time
0.250	15 CFH	2 Min.
0.375	15 CFH	2.5 Min.
0.500	20 CFH	3 Min.
0.750	20 CFH	3.5 Min.
1.00	20 CFH	4 Min.
1.50	20 CFH	6 Min.
2.00	20 CFH	8 Min.

Purge Restrictor Size:

Tube O.D. Diameter	Orifice Size
3/8 IN and smaller	1/8 IN
1/2 IN up to 1-1/2 IN	1/4 IN
2 IN	3/8 IN
4 IN to 6 IN	1/2 IN
8 IN and larger	3/4 IN

4) No brazed joint can be less than 12 IN away from the end of the purge line, which will require, in many instances, that an extension be used.
5) Verification of all purge lines at the end of each shift. If project only has one shift, reduce purge to a trickle purge for overnight purging or capped under pressure. Inspect each flow meter for proper flow and verify that source of nitrogen will be sufficient until next shift startup.
6) Maintain installation and purge procedures, for all pipe runs, until installation is complete and accepted by the Owner.
7) All joints which show evidence of overheating, cracking, poor penetration, or other defects of fit-up or workmanship, shall be replaced at installer's expense.
8) If the system becomes contaminated due to fabrication techniques, prior to Owner's written acceptance, perform a total system re-clean or replacement. All expenses shall be borne by the installer, with no expense to the Owner.
9) No more than 60 feet of pipe should be assembled in line prior to brazing.
10) Pipes shall be cut with ends squared and true to size. Only clean tubing cutters with sharp cutting wheels shall be used. Hacksaws or similar type cutting tools shall not be used. All burrs must be removed.
11) When cool, wire brush all fittings.

B. Inspection: All material and workmanship shall be subject to inspection and examination by the Owner:
   1. Copper:
      a. Upon request of the Owner, remove a random piece of installed work, sufficient to establish the quality of materials and workmanship. If the piece shows evidence of oxidation or contamination, the Owner may require testing of additional samples. If the additional samples are acceptable, the Owner will pay for the direct labor and materials required for the cutting out and restoration of these samples. If they are not acceptable, the cost shall be paid by the installer.

3.4 SYSTEMS PRESSURE TESTING

A. Test all piping as noted below. Piping shall meet test conditions with no leaks or loss in pressure. Repair or replace defective piping until tests are accomplished successfully. The use of oil pumped air or nitrogen is expressly forbidden. All nitrogen used for testing and purging operations shall be from a cryogenic source. Re-testing following piping repairs shall be performed for full specified time period:

System	Test Pressure	Test Medium	Test Time
Process Cooling Water	150 PSIG	Water	4 hours
UN2, CDA and PV	150 PSIG	Nitrogen	24 hours

Note: Plastic piping may be pre-tested with 5 psi nitrogen prior to final Hydro-Testing.

B. Any leaks found in copper or plastic piping systems shall be repaired in the following manner:
   1. Brazed joint – Remove/replace fitting and re-braze new joints.
   2. Plastic joint – Remove and install new fitting.

3.5 INSULATION

A. Refer to Mechanical Specification Divisions for materials and installation requirements.

3.6 PURITY AND PARTICLE ANALYSIS FOR UTILITY NITROGEN AND COMPRESSED DRY AIR

A. General: Cycle a volume of gas through the line to maximum pressure (not less than 30 psi.) and then discharge the line through a particle counter. The maximum flow rate for the gas discharge is 3 cfm. The line shall be cycled enough times to exchange the total gas volume five times. Procedure of cleaning shall be clean for oxygen system (CFOS).

B. Take particle measurements and establish a baseline of particle counts that is no more than 5 percent of the starting value. If the baseline particle counts do not reach a 5% point, then the gas line must be examined for sources of contamination and repaired.

C. Equipment:
   1. PMS Low Pressure Gas Probe with interface.
   2. Two 1/4 turn valves.
   3. One pressure gauge.
   4. One flow meter, 0-4 cfm.
   5. One notebook computer.
   6. One mass flow controller.
   7. Control and processing software.
   8. Misc. hardware.

D. Procedure:
   1. Connect particle counter to gas line.
   2. Charge gas line and adjust flow to 3 cfm using downstream valve.
   3. Close the upstream valve and charge line to max pressure.
   4. Enable the particle counter.
   5. Open the upstream valve and discharge the line until pressure is stable at minimum.
   6. Close the valve and recharge the line to maximum pressure.
   7. Note the particle count and gas volume.
   8. Cycle system five times (or five gas exchanges).
   9. Calculate particle counts (total particles/total gas volume).

E. Test Results:
   1. The required test results are based on particle counts measured at specific particle size classes for the different pipe use categories. Also the percent of line clean up is measured for the five cycles.
   2. UN2:
      a. 100 particles/ft^3 maximum at 0.2um size.
      b. 10 particles/ft^3 maximum at 0.5um size.
      c. Final particle count less than 5 percent of the first cycle particle count.

END OF SECTION

SECTION 22 67 21
DEIONIZED WATER SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This section includes the equipment requirements for the Reverse Osmosis (RO) and Deionized (DI) water systems:
   1. Water softeners.
   2. Dechlorination filters.
   3. Reverse osmosis (RO) systems.
   4. RO water storage tanks.
   5. Repressurization pumps.
   6. Deionized (DI) mixed beds.
   7. Ultraviolet (UV) sterilizers.
   8. Final filters.

B. The RO and DI systems Vendor shall be responsible for the design, procurement, fabrication, and delivery of skid assemblies, equipment, valving, controls and all loose shipped materials required for a complete, operating system. Installation of equipment and interconnecting piping, wiring, and controls will be by the Mechanical and Electrical Contractors under the supervision of the RO and DI systems Vendor.

C. The Vendor shall provide assistance in system commissioning, as specified herein.

D. Refer to the Drawings for work covered by these specifications.

1.2 QUALITY ASSURANCE

A. Installer qualifications: Manufacturer, of reputable, established organization regularly engaged in supply and servicing high purity water systems, including providing engineering services.

B. All RO or DI system components shall be furnished by a single supplier.

1.3 RELATED WORK

A. Work by Others: The Vendor is responsible for fabrication, procurement, and delivery of all components of the RODI system except as specified herein. Installation responsibilities by others shall include:
   1. Installation of Vendor-furnished equipment.
   2. Furnish and installation of interconnecting piping and valves between Vendor-furnished skids and/or Vendor-furnished equipment, based on fabrication drawings provided by the Vendor.
   3. Furnish and installation of power and control wiring to Vendor furnished control panels and skid-mounted disconnects for feeds to skid-mounted equipment, based on wiring schematics provided by the Vendor.
   4. Wiring of Building Management and Control System (BMCS) inputs from Vendor-furnished control panel or devices to the BMCS system I/O cabinet(s).
   5. Furnish and installation of the RODI water distribution piping.
   6. Furnish and installation of off-site regenerate mixed bed ion exchangers.

B. Work of other Mechanical Specifications:
   1. General and special mechanical requirements.
   2. Plumbing systems.
   3. Pipe hangers and supports.
   4. Piping and equipment identification.

5. High purity water piping system.

C. Refer to Electrical specifications for electrical requirements:
   1. Electrical work.
   2. Variable frequency controllers.
   3. Medium voltage cables.
   4. Motor starters and motor control centers.

D. Refer to Integrated Automation Division for instrumentation and controls requirements:

1.4 SUBMITTALS

A. Shop Drawings:
   1. Process flow schematic of the proposed system, showing all equipment and accessories, major flow piping, sizes, flow rates, stream conditions, and field connections.
   2. P&ID of the proposed system, with all equipment, accessories, piping, meters and gauges, instrumentation and control devices, and major control loops..
   3. Equipment and component layout.
   4. Drawings for interconnecting piping systems.

B. Product Data:
   1. Performance data, including pump curves.
   2. Physical dimensions and weight data.
   3. Vibration and acoustical data.
   4. Piping diagrams, and field connections.
   5. Detailed list of all required utilities and estimated rates of peak and average consumption.
   6. Electrical and controls wiring data, and field connections.
   7. Detailed electrical power requirements, including in-rush current, recommended fuse size, locked rotor and full load amperes.
   8. Wiring diagrams showing terminations for all interconnecting power and control wiring between panels and skids, including wiring to devices that are field installed.
   9. Panel layouts.
   10. Annotated catalog cut sheets of all proposed controls and instrumentation.
   11. Project specific Sequence of Operations (SOO).
   12. Seismic calculations.
   13. Installation procedures.

C. Contract Closeout Information:
   1. Operating and maintenance data.
   2. Instrumentation and controls data.
   3. Owner instruction report.
   4. Warranty.
   5. Test reports.

1.5 DESIGN CRITERIA

A. The RO water system shall be designed to circulate water supply to the facility at 20 PSIG supply pressure at the system outlet, and shall provide for 1 GPM of water make up.

B. The DI water system shall be designed to circulate water supply to the facility at 20 PSIG supply pressure at the system outlet, and shall provide for 1 GPM of water make up

C. The RO water system shall be designed to the following make up water conditions (supplied from the domestic water system). Vendor shall be responsible for verification of make up water characteristics:.

1. Temperature (degF)	55 – 86 range, 75 typical
2. Pressure (psig), min	50
3. pH (pH units)	7.2 – 9.0 range, 7.8 typical
4. Hardness (mg/l as $CaCO_3$)	69 – 290 range, 190 typical
5. Silica (mg/l as $Si0_2$)	9 – 32 range, 14 typical

6. Chlorine (mg/l as Cl) 37 – 280 range, 164 typical
7. Alkalinity (mg/l as $CaCO_3$) 56 – 210 range, 130 typical
8. Conductivity (micro-siemens/cm) 801 – 1660 range, 1254 typical
9. Magnesium (mg/l as $Mg/CaCO_3$) 16 – 44 range, 22 typical
10. Total Dissolved Solids (mg/l) 180 – 780 range, 560 typical

D. The DI system shall be designed to get makeup water from the RO system.

E. System performance criteria (product RO water quality) shall meet ASTM Type III as follows:
1. Resisitivity, min.= 4.0 megohm @ 25 deg.C
2. Conductivity, max. = 0.25 micromhos/cm @ 25 deg.C
3. pH, units = Not Applicable at 25°C
4. Total Organic Carbon, max.= 200 ug/l
5. Sodium, max. = 10 ug/l
6. Chloride, max. = 10 ug/l
7. Total Silica, max. = 500 ug/l

F. System performance criteria (product DI water quality) shall meet Semiconductor Type E-2 as follows:

Parameter	Value	Procedure
Resistivity	18.2 Megohm-cm @ 25°C, min.	ASTM-D1125
Bacteria	<1 CFU/1000 ml	ASTM-F60
Particles (> 0.2 µ)	<55 /liter, max.	PMS On-line particle counter
Total Organic Carbon	< 5.0 ppb, max.	Anatel A-1000 on-line
Silica (dissolved)	<3.0 ppb, max.	Scientific Instruments CFA 1000
Sodium	< 0.02 ppb, max.	Ionic and metallic species to be determined by IC, ICPMS, AA
Chloride	< 0.04 ppb, max.	ASTM-D512 or ion chromatography
Boron	<10 ppb	Ion chromatography

G. Piping system velocities shall be limited to the following:
1. Supply Main and Laterals 3 FPS min., 5 FPS max.
2. Return Laterals and Main 3 FPS min, 5 FPS max.

H. The RO and DI water storage tank capacities, sizes, and connections shall be as indicated on the drawings. The vertical tank shall have a top which is capable of withstanding an external uniformly distributed loading of 25 pounds per square foot, or a concentrated weight of 250 pounds.

1.6 AVAILABLE FACILITY UTILITIES

A. The following utilities are available for the RO and DI water system:
1. Clean Dry (instrument grade) Air:
   a. Pressure 80 PSIG
2. Utility Nitrogen (utility grade):
   a. Pressure 80 PSIG
3. Electric Power:
   a. Feed Voltage 480 V, 3-phase, 4-wire
   b. Frequency 60 Hz
   c. Control voltage 24 V
   d. Max fluctuation ± 5% for connected loads

B. Local UPS capacity shall be provided by the Vendor for all RO and/or DI system controls and instrumentation.

1.7 REGULATORY REQUIREMENTS

A. Seismic design of equipment, piping, and conduit supports and restraints shall meet or exceed the latest edition of the International Building Code for the project's jurisdiction. Submit four sets of wet-stamped calculations by registered civil or structural engineer in the state where the project is located.

1.8 FACTORY TESTING

A. Vendor shall perform factory testing of all factory-assembled components and skid assemblies prior to shipment and certification shall be furnished.

B. The piping subassemblies shall be hydraulically leak tested as specified herein.

C. Onwer shall be notified at least 5 working days in advance of all factory testing so that he may be present to observe the factory testing.

D. RO and DI Water Tank Testing:
   1. Tank shall be tested and inspected by the Vendor at the point of manufacture with written documentation of the test results supplied to Owner. Tests shall include, but are not limited to the following:
      a. At the rated tank pressure, hydrostatic test for 24 hours duration to detect leakage shall be performed by the Vendor. Any leakage or weeping is unacceptable.
      b. Compliance check of tank and accessory dimension per the Drawings shall be performed by the Vendor.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Shipment:
   1. Each skid or equipment item shall be suitably prepared for the shipment in a manner requiring minimum re-assembly prior to operation.
   2. The Vendor shall be solely responsible for the adequacy of the preparation for shipment provisions employed with respect to materials and application.
   3. All flange faces shall be protected by securely fastened Schedule 80 PVC blind flanges and full-faced red colored NBR gaskets on all vessel nozzles and face piping flange faces to prevent damage and contamination during shipment.
   4. Equipment and components shall be completely free of water prior to any shipment preparation.
   5. Adequate protection shall be provided against mechanical damage and atmospheric corrosion in transit.
   6. The following shall be shipped to prevent freezing and exposure to temperature extremes in excess of manufacturer's recommendations:
      a. RO membranes.
      b. Ion exchange resin.
   7. All instruments and valves, including auxiliary systems, must be securely mounted and/or supported to eliminate damage during shipment, and storage.
   8. Supports and rigging connections shall be provided to prevent damage during lifting or unloading.
   9. Threaded connections shall be provided with a pipe plug of the same material as the connections. Plugs shall have a hex head. Only 100% Teflon tape shall be used as thread sealant.
   10. Opened ends of tubes and pipe shall be capped (taping alone is not adequate) for protection, and double wrapped to minimize contamination.
   11. All equipment shall be packed, securely anchored (frame mounted when required) and weather protected. Separate, loose, or spare parts shall be boxed and each part individually protected as required. Each individual container shall be marked both inside and outside with the equipment number and service for which the parts are intended.
   12. Each container shall also include a complete Bill of Materials identifying each part. In some instances, such as instruments, specific tagging shall be required.

13. Piping connections to skids or field-installed equipment shall be match marked to agree with Vendor's submitted connection table.

B. UV Sterilizer Cleaning and Packing:
   1. After unit assembly and final manufacturers proof testing each UV sterilizer shall be wiped clean and dried using nitrogen gas prior to packaging for shipment.
   2. After cleaning and nitrogen gas drying, completely assembled UV equipment shall have inlet and outlet connections capped with suitable blind flanges and red silicon gaskets, be double layer packaged in plastic and wood crated for shipment.

C. RO Skid:
   1. RO skids shall be shipped to the job site complete with handling support and/or spreader bars to facilitate, if required, handling rigging and placement without damage to the RO skid, vessels, and/or piping.
   2. RO skid may be fabricated into separate mated support skids to facilitate shipment, rigging and installation. The Vendor's drawings shall clearly indicate skid connections.

D. RO and DI Water Tank Shipment:
   1. Prior to inspection and loading, all dirt and extraneous materials shall be removed from the tank interior. All exterior surface markings, special coatings, or contaminants shall be removed prior to shipment.

E. RO and DI Water Tank Packing and Loading:
   1. Tank shipped in the horizontal position shall be mounted on padded cradles at least 6 in. wide for up to 8 foot diameter and 12 in. wide for larger diameter tanks. Cradle padding will contact each tank along at least 20 percent of the exterior circumference. At least 4 in. of high density foam rubber, 2 in. of Styrofoam padding will be used to protect tanks. All tank end blocking used to prevent shifting of tank during transit shall be padded and bear only upon the knuckle radius of flat or dished heads.
   2. Flange faces shall be protected from damage by a closed-cell foam gasket and a securely fastened plywood covering.
   3. Pipe, tubing, fittings, baskets, bolts, or any other small miscellaneous parts and accessories shall be padded and packaged in a crate or box and shipped with the tank.
   4. Additional protection, such as battens, end wrapping, or other interior fastening may be necessary to ensure that the tanks are not damaged during shipment.
   5. Exterior fittings, such as nozzles and tie-down lugs, will be padded and prevented from contacting other tanks and accessories in the same shipment.
   6. Tank that is shipped on an open trailer shall be fully wrapped with plastic and completely covered with tarps to prevent contamination of the exterior and interior of the tank from road contamination and diesel soot/fumes.
   7. The tank manufacturer will obtain a Certified Weight of the tank prior to delivery. This certified weight will be used by the riggers in determining the proper methods for rigging the tank during unloading and installation. Estimated weights or calculated weights will not be acceptable.

F. Equipment, including the RO and DI Water tanks, shall be inspected upon delivery at the project site prior to unloading, for damage. Any damage occurring during shipment shall be the responsibility of the Vendor.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. RO and DI water system:
      a. Base:
         1) Agape Water Solutions.
      b. Optional:

1) Siemens Water Technologies.
2) GE Water Technologies.
3) Pure H2O Technologies

B. The RO and DI systems shall consist of completely new systems, as specified herein and as indicated on the drawings.

C. System shall be designed and guaranteed by the Vendor to produce water to meet the specifications in this section.

D. All components of the system shall be designed with maximum water quality, conservation and reuse in mind.

E. Equipment Packages:
1. Mounting Skids: Each equipment skid shall include a structural steel base such that there is an even distribution of the equipment weight on the floor and, when fully loaded, there will be no distortion or unequal stresses upon equipment or face piping. Skid piping, valving, and instrumentation shall be completely supported from structural frame or vessel to prevent distortion from the vertical and horizontal planes. Upon arrival at the jobsite, skid piping shall be level with the vertical and horizontal planes over the skid length.
2. The surface finish of the vessels, skids, pipe supports, and other ferrous metallic surfaces shall be primed with rust-inhibitive primer compatible with the paint, and painted with polyamide epoxy.
3. Skid framing fabricated from I-beam or channel steel shall have anchor bolt holes drilled through both flanges of the structural member to allow anchor holes in the floor to be drilled vertically with the skid in place. Anchoring tabs shall be welded to skids with bases fabricated from hollow structural section. In all cases, there shall be a minimum of 18 inches vertical clearance above the anchor holes to allow for floor drilling. Where this is not possible, it shall be explicitly noted and reasons given.
4. Pump bases and equipment skid frames shall be designed to allow the base or frame to be filled with grout after the equipment has been set.
5. All equipment shall be mounted sufficiently high above skid frames to allow adequate clearance to all service points when the skid frames are filled with grout. When a spring-isolated inertia base is required, provide a base designed for concrete fill and spring isolation. Spring isolators shall be provided by the installation subcontractor. Concrete shall be provided by the installation subcontractor. Subcontractor to coordinate with installation subcontractor on spring clip design.
6. Where applicable, a local control panels shall be provided installed on each skid. The panel rating shall be NEMA 4 minimum or equivalent. All instruments installed on the skid shall be wired to terminal blocks installed in the panel.

F. General:
1. In no case shall sound levels exceed 85 dB measured 3 feet from the sound source as defined by SEMI S2-91 standards or equivalent. If equipment generates sound levels in excess of this, the vendor shall provide sound insulation to attenuate the sound to less than the specified level.
2. Equipment and piping labeling shall be located in a manner such that it is easily visible and accessible to operators during normal operation of the equipment. Control components identification shall match the labels and identifiers shown on the P&IDs.
3. Instrumentation and controls shall be mounted in a manner so as to be easily visible and accessible to the operators for use, calibration, maintenance, and replacement. The top of the highest instrument on local control panels shall be less than or equal to 6.5 feet above finished floor. The minimum height of local control mounted instruments shall be 42 inches above finished floor.
4. All conduit, mechanical, and process piping shall be supported from epoxy-coated Unistrut or structural steel. FRP or PVC channel framing can be used for nonstandard applications. Galvanized metal and threaded rod are not allowed.
5. For all motors, provide local locking disconnects.

G. Piping:
   1. Piping configurations shall not block maintenance access, and shall not block operator viewing of vessel sight glasses and instrumentation.
   2. Equipment and skid piping shall be designed and fittings shall be selected to minimize System "dead legs". A dead leg is defined as minimum of four pipe diameters of stagnant liquid which occurs when a valve is closed.
   3. Instrument air tubing on equipment and skids shall be flame-retardant polyethylene.
   4. Instrument and sample ports shall be located to avoid breakage by operators. Susceptible ports shall be protected by a mechanical plate or other external mechanical shield.
   5. Resistivity, conductivity, and pH probes shall be installed in accordance with manufacturer's instructions and in such a manner to ensure the probes are continuously wetted when equipment is taken off line and drained.
   6. Manual valve centerlines located more than 7 feet above the finished floor shall be equipped with chain wheel operators. Chains shall be sized such that the bottom of the chain hangs four to five feet above finished floor.
   7. The hand wheel on gear operated manual valves shall be at least 6 inches in diameter.
   8. The use of thread lubricants and sealants for the construction of the RODI system is prohibited at all times. Teflon tape that is impregnated with metals, or dyed with coloring is prohibited at all times. Only the use of pure, unpigmented (white), teflon tape on threads is acceptable.

H. Nameplates:
   1. Attach a permanent stainless steel or self-adhesive chemically resistant plastic equipment identification label to each component. The label shall state the following minimum information:
      a. Equipment name and service.
      b. Equipment identification number.
      c. Name of manufacturer.
      d. Manufacturer serial number.
      e. Date of manufacture.
      f. Purchase order number.
      g. Nominal capacity.
      h. Design temperature and pressure.
   2. The nameplate shall be clear coated to prevent chemical corrosion.

I. Extra Stock:
   1. For each filter component, provide one full set of sacrificial filter cartridges for start up, and one full set of spare filter cartridges.
   2. Salt for brine tank: Furnish for a minimum of four (4) times original load.

2.2 WATER SOFTENER

A. Water softening system: Vertical pressure type ion exchanger system with regenerating equipment, complete with components required to insure proper operation.

B. The water softening system shall consist of one softener tank. During normal operation, the tank will have a normal service flowrate. During regeneration, the tank will be offline.

C. Softener tank: Fiberglass reinforced molded thermoplastic inner shell with dished heads, equipped with reinforced openings for piping connections:
   1. Provide hand hole at top and bottom and tank supports of structural steel.
   2. ASME Code rated at 150 PSI working pressure.

D. Internal distribution: Design underdrain system to uniformly collect softened water as well as distribute backwash laterally across entire bed:
   1. Header-lateral construction with minimum of 2 plastic strainers per 1 SF of bed area.
   2. Furnish gravel sub-fill only, not extending above strainers.

E. Upper distribution system: Header-lateral manifold type arranged for uniform distribution of both brine solution and raw waste, as well as collection of backwash:
   1. Construct both upper and lower distributors of an approved non-corrosive material.

F. Ion exchange resin: High capacity sulfonated polystyrene type requiring no chemicals other than sodium chloride to obtain specified capacity.

G. Controls:
   1. The softener tank shall be provided with a water volume initiated 5 cycle fully automatic regeneration, managed by a solid state electronic controller featuring:
      a. Fully programmable cycle times.
      b. Service and standby modes.
      c. Water volume totalizer and flow rate displays.
      d. System status indicator lights.
      e. Provisions for additional auxiliary outputs.
   2. Provide controls interface compatible with the facility control system. Provide output for connection of common trouble alarm to Owner control system.

H. Provide pressure gauges with sample cocks on inlet and outlet of each tank.

I. Regenerating tank: Rigid, molded polyethylene, or welded steel with flat bottom with bitumastic coating inside and rust inhibiting primer on exterior:
   1. Fresh make-up water shall flow downward through solid salt controlled by float valve in salt storage tank.
   2. Filter brine through 5 IN layer of graded gravel and collect by suitable collector.
   3. Provide automatic valve to control amount of brine draw.
   4. Furnish with 6 IN support legs.
   5. Provide necessary valves, educator and piping.
   6. Size: Large enough for a minimum of four (4) regenerations at full salting.

J. Provide water testing kit to make chemical tests necessary for controlling operation and adjustments of brine dosage.

K. Size and capacity as shown on drawings.

2.3 PREFILTER

A. Low velocity multi-media filter with stratified filter media designed to remove turbidity, suspended solids and heavy sediments.

B. Vessel: Welded, industrial grade, cold rolled carbon steel with dished head:
   1. Construct and stamp in accordance with ASME Code, Section VIII and U-1 (Unfired Pressure Vessels). Design vessel for a maximum operating pressure of not less than 125 psig and test hydrostatic pressure of not less than 150 psig. Sideshell height shall be designed to allow for a minimum of 50 percent expansion of filter media during backwash cycle.
   2. Filter bed media components; top layer of 1.0-1.2 MM anthracite (SP=1.5); second layer of 0.4-0.5 MM flint sand (SP=2.6); third layer of 0.35-0.45 MM garnet (SP=4.0) all of which rests upon a coarse gravel underbedding to ensure even flow distribution. Filtered water collector and backwash water distributor shall be a fine-slotted self-cleaning stainless steel or plastic manifolds with slots sized to prevent passage of filter media. Ship filter bed media separately.
   3. Furnish vessel with O-Ring seals at openings, inlet, outlet, backwash outlet, manway, top loading port, backwash sight glass, drain valves, inlet and outlet pressure gauges with isolating valves, self-adjusting flow control valves (backwash, slow rinse and fast rinse), 14-day calendar clock and controls necessary for automatic regeneration.
   4. Exterior Finish: Epoxy enamel.
   5. Interior finish: Minimum 30 mil thick monolithic, inert, non-leaching virgin polyethylene, permanently bonded by heat fusion.

C. Vessel Internal Piping and Fittings: PVC, Schedule 80.

D. Size and capacity as shown on drawings.

2.4 CARBON FILTER

A. The carbon filter shall be granular activated carbon (GAC) required in the pretreatment/makeup water system for removal of residual chlorine and the reduction of nonpolar organics (TOC) from the city inlet water.

B. The filter system shall consist of a carbon filter. During normal operation, the activated carbon filter will have a normal service flowrate. During backwash, the filter will be offline.

C. The activated carbon filter shall produce water having a residual chlorine concentration of less than 0.1 ppm when operated at the normal service conditions.

D. The activated carbon filter shall be designed for a carbon loading rate of 2 gpm per cubic foot.

E. Filter vessel: Fiberglass reinforced molded thermoplastic inner shell with dished heads, equipped with reinforced openings for piping connections:
   1. Provide hand hole at top and bottom and tank supports of structural steel.
   2. ASME Code rated at 150 PSI working pressure.

F. Distribution system: Header-lateral manifold type arranged for uniform distribution, as well as collection of backwash.
   1. Construct both upper and lower distributors of an approved non-corrosive material.

G. Controls:
   1. The filter vessel shall be provided with a water volume initiated 5 cycle fully automatic regeneration, managed by a solid state electronic controller featuring:
      a. Fully programmable cycle times.
      b. Service and standby modes.
      c. Water volume totalizer and flow rate displays.
      d. System status indicator lights.
      e. Provisions for additional auxiliary outputs.
   2. Provide controls interface compatible with the facility control system. Provide output for connection of common trouble alarm to Owner control system.

H. Provide pressure gauges with sample cocks on inlet and outlet of each tank.

I. Size and capacity as shown on drawings.

2.5 REVERSE OSMOSIS (RO) SYSTEMS

A. Design Criteria: The reverse osmosis unit shall be designed to comply with the specified performance requirements. The Vendor shall recommend the hydraulic array most closely approximating optimum performance at the lowest applied system drive pressure.

B. The reverse osmosis unit shall be supplied complete with membrane elements (not installed), pressure vessels, interconnecting piping and valves, instrumentation and controls, sample taps, pressure gauges, pump control, control panel, and support structure.

C. Feed pumps:
   1. Pump shall be an integral unit consisting of an ANSI B73.1 316 stainless steel vertical multistage centrifugal pump and motor.
   2. Pump shall be non-contaminating and designed for the high purity service intended.
   3. Single external mechanical seal model shall have silicon carbide/silicon carbide surfaces, and stainless steel metallic parts. Elastomers shall be viton.
   4. All pumps shall be sized such that the impeller required at the given maximum flow and head is midrange of the impellers available in the casing provided. Motor horsepower shall be sized to prevent motor overloading at reduced system head.
   5. Operating point shall not be to the right of the maximum efficiency on the pump curve.

6. Motor enclosures shall be TEFC. Motors shall be inverter duty rated, suitable for adjustable frequency drive operation, and 460 V, 60 Hz service.
7. No oils or grease shall be used during assembly of the volute and impeller.
8. Motors shall have a high-current motor protection switch. All RO pumps will have controlled-voltage starters or adjustable frequency drives provided by others.
9. Pumps shall be mounted on the top or side of the membrane skid, and shall be easily removable.
10. Basis of Design: ITT-Goulds SSV.

D. Vessels/tubes:
1. The RO vessels shall be filament-wound FRP.
2. The vessels shall be designed, fabricated, and tested in accordance with ASME standards.
3. Vessel exterior finish shall be a white pigmented gel coat.

E. Membrane elements:
1. Membranes shall arrive on site in the original manufacturer's packaging. Performance test data on the membranes shall be available for any membrane required to be wet packed.
2. Furnish EPDM or Viton o-rings, gaskets, and seals. Furnish interconnectors and any other hardware required for a complete system.

F. Piping and valves:
1. All valving shall be within 6 feet of the finished floor. Isolation valves shall be provided across each pump and each vessel array.
2. CAM-LOC connections (Victaulic connections in high pressure piping) shall be provided across each vessel bank within an array for membrane cleaning.
3. Sample taps shall be provided on the product line from each vessel.

G. Controls: Solid state electronic controller.
1. Flow, temperature, resistivity, and pressure transmitters and indicators shall be supplied as required for a complete and operating system
2. Flow elements and indicators are required on the feed, product, recycle and reject streams. Includes percent recovery and rejection.
3. Temperature elements and indicators are required on the feed streams.
4. Resistivity elements and indicators are required on the feed and product streams.
5. Pressure transmitters and indicators are required on the pre-filter, pump discharge, product and reject streams.
6. Provide controls interface compatible with the facility control system.

H. Size and capacity as shown on drawings.

2.6 RO AND DI WATER STORAGE TANKS

A. A water storage tanks shall be provided to allow retention time for product water distribution for each system.

B. Tanks shall be manufactured of linear, rotationally molded polyethylene with extra heavy wall construction.

C. Fabrication:
1. The tanks shall be vertical with cone bottoms and straight sides.
2. The tanks shall be provided with at least four lifting lugs evenly spaced and incorporated into the straight sides. Lifting lugs shall be of manufacturer's design, using 304 stainless steel material.
3. Cone-bottomed tanks shall be mounted on polypropylene or steel stand and basket assemblies with hold-down lugs. The hold-down lugs shall be made of 304 stainless steel.
4. Support stands and frames for conical bottom, horizontal and rectangular tanks must be reinforced to minimize bulging.
5. Support stands and frames shall be manufactured from polypropylene or carbon steel. Design shall be able to support the tank and tank contents having a specific gravity of 1.9.

6. Flanged nozzles, plate-gusseted nozzles, and bottom-drain nozzles shall be provided as required. All fittings shall be molded or seamlessly welded – gasketed bulk head fittings are not allowed. Flange diameters and drillings shall meet ANSI B16.4 150-pound standard. Compression molded, PVC long shank, double nut, high torque design flanges are acceptable. Nozzle bolt holes shall straddle natural tank center lines.
7. Manways shall be provided with all necessary gaskets, non-corrosive bolts, and covers.
8. Tank restraint system shall be supplied and the design for same certified by a structural engineer registered in the state where the project is located. Detailed instructions for installation shall be provided, along with all necessary hardware including anchor bolts. All components of the restraint system shall be stainless steel.
9. The final locations of nozzles and accessories shall be subject to change until shop drawing approval.

D. Accessories:
1. Water loop return spray ball fitting. Spray Systems 27500 or equal.
2. Hydrophobic PTFE submicron vent filter. Siemens FCVPTO6S1 or equal.
3. Non-intrusive level controls. Flowline Switch-Tek / Point or equal.
4. Tank repair kit containing all of the necessary components for small repairs.
5. Gaskets shall be Viton.
6. All flanges shall be covered with blind flanges and Viton gaskets bolted securely in place. However, the tank will be shipped in a manner that allows the tank to "breathe".

E. Finishes:
1. The tank support and basket assemblies shall be painted with corrosion-resistant epoxy paint.
2. The tank finish shall be natural polyethylene.

F. Basis of Design: Terracon, model CXC, see drawings for capacities.

2.7 REPRESSURIZATION PUMPS

A. Each pump shall be an integral unit consisting of an ANSI B73.1 316 stainless steel vertical multistage centrifugal pump and motor.

B. Pump shall be non-contaminating and designed for the high purity service intended.

C. Single external mechanical seal model shall have silicon carbide/silicon carbide surfaces, and stainless steel metallic parts. Elastomers shall be FPM (Viton®).

D. All pumps shall be sized such that the impeller required at the given maximum flow and head is midrange of the impellers available in the casing provided. Motor horsepower shall be sized to prevent motor overloading at reduced system head.

E. Operating point shall not be to the right of the maximum efficiency on the pump curve.

F. Motor enclosures shall be TEFC. Motors shall be inverter duty rated, suitable for adjustable frequency drive operation, and 460 V, 60 Hz service.

G. No oils or grease shall be used during assembly of the volute and impeller.

H. Each pump shall be supplied with matched adjustable frequency drives (AFD), provided by the Vendor. AFDs will be in accordance with Specification Section 25 23 00.

I. Basis of Design: ITT-Goulds SSV Series, with Aquavar drive, size and capacity as shown on drawings.

2.8 DEIONIZED (DI) MIXED BEDS

A. Mixed bed ion exchange vessels shall be Service Deionization (SDI) type, with quick connect fittings on inlet and outlet to facilitate removal for off-site regeneration. SDI vessels shall be Owner furnished and Owner installed.

B. Resin furnished shall be suitable for use in polish mixed bed deionizer application and for the intended application. The Vendor shall confirm with resin manufacturer the best vessel design to support the resin's unique characteristics.

C. The Vendor shall provide Owner with the mixed bed ion exchange requirements, and recommendations of local SDI companies providing off-site ion regeneration vessel supply and service.

D. Equipment – vessels:
   1. Each vessels volume shall be 3.6 cubic feet.
   2. Vessels shall be filament wound FRP, ASME code rated at 150 PSI working pressure.
   3. Underbed construction shall be dished false bottom with electropolished 316L stainless steel slotted well screen strainer inserts and tailpipes.

E. Internal distributors and collectors:
   1. The inlet distributor shall be of an electropolished 316L stainless steel high-flow header/splash-plate design.
   2. An adjustable directional spray nozzle system, with header and laterals, shall be provided for sluicing the resin from the sides and the bottom of the tank. No more than ½ liter of resin shall be left in the service vessel after each resin transfer. Nozzles shall have well screen inserts to prevent movement of resin back into the header during normal service when a constant purge will flow out of the vessel.
   3. Well screen bayonet-style nozzles shall be provided for the bottom nitrogen inlet and the drain-down connections.
   4. All internal hardware shall be electropolished 316L stainless steel.

F. Resin trap:
   1. Resin trap shall have electropolished 316L stainless steel well screen with acrylic cylinder sandwiched between line flanges. Resin trap shall be in-line type with a resin flush port.

G. Acceptable manufacturers: Siemens/USFilter, GE Water, or equal, size and capacity as shown on drawings.

2.9 ULTRAVIOLET (UV) STERILIZERS

A. Design:
   1. For Bacteria destruction the ultraviolet light wavelength shall be 254 nm.
   2. The UV dosage shall be at least 40,000 mws/cm^2 at 254 nm after 9,000 hours of operation time.

B. General: As a minimum, ultraviolet sterilizers shall each have the following:
   1. Single medium-pressure mercury vapor lamp in a quartz tube with electrical connections at both ends.
   2. Single quartz sleeve to isolate the lamp tube from the product water.
   3. UV monitor for continuous indication of UV lamp intensity.
   4. High temperature switch for automatic lamp shutoff protection.
   5. Clear labeling of each UV housing to indicate the lamp wavelength.
   6. Clear labeling of each UV control panel to indicate unit service (e.g. Polish Loop Sterilizer), housing equipment number and electrical source.
   7. An integral power-stepping function to maintain constant UV dosage during life of the UV lamp.
   8. UV sterilizers shall be designed to allow Owner to change the sterilizer purpose (operating wavelength) by changing out no more than the UV lamp and the quartz sleeve.
   9. All wetted elastomers for the UV units shall be ozone-compatible. Solid Teflon gaskets shall not be used.

C. Construction:
   1. House high intensity ultraviolet lamps in recessed, specially fused quartz sleeves, with ozone-compatible (viton) seals, to isolate the lamp tube from the product water.

2. Wetted surfaces of the UV sterilizer chamber and other components shall be 316L stainless steel that is electropolished for a sanitary finish of less than 15 Ra microinches (36 Ra on welds). All stainless steel welds shall be full penetration and purged with inert gas, and weld radii shall be ground smooth prior to electropolish.
3. Quartz sleeves shall be watertight to allow lamp changeout without draining the chamber.
4. Inlet and outlet piping connections to the UV sterilizers shall be electropolished 316L stainless steel with a 50 Ra maximum surface roughness. As a minimum, stainless steel piping shall be used from the flanged UV sterilizer connection up to the flanged end of the inlet or outlet butterfly valve. A light trap, of at least one stainless steel 90 degree elbow and 2 feet of pipe shall be provided at each connection.
5. Rate sterilizers at 150 PSI and test to 180 PSI.
6. Fabricate the ultraviolet chamber with a helical baffle for proper water passage through the unit for maximum germicidal and organic destruct efficiency, with a minimum 3X flow potential.
7. Electrical supply shall be single phase 120V, 60 HZ.

D. Power Panels:
1. The sterilizer power panels shall be controlled and powered, and at a minimum, provide local indication of the following:
   a. Lamp ON/OFF status.
   b. Lamp intensity.
   c. Lamp run time.
   d. Alarm status lights.
   e. HAND/OFF/AUTO hand switches for lamp operation.
   f. Provide integral waterstop in conduit between the quartz sleeve and the power panel.
2. The UV sterilizers shall be configured such that, if power to the UV sterilizer is interrupted or lost, the UV sterilizers automatically restart once the power source is regained.

E. Controls: Provide each sterilizer with a NEMA 4X stainless steel status display panel, optical sensor, intensity meter, lamp status indicator, temperature safety controls, and running time meter:
1. Provide controls interface compatible with the facility control system. Provide output for connection of common trouble alarm to Owner control system.

F. Basis of Design: Aquafine SL or CSL series, size and capacity as shown on drawings.

2.10 FINAL FILTERS

A. High purity cartridge filter housings and elements for DI water final filtration.

B. Filter housings:
1. Housing shall be designed and manufactured in accordance with ASME Code Section VIII, Division I.
2. All filter housings shall be pressure tested in accordance with ASME pressure vessel code.
3. Filter housings shall be of passivated 316L stainless steel construction. Elastomers shall be viton.
4. Housings shall have a flanged side inlet and a flanged bottom outlet.
5. The filter housing vent connection shall be a ¼-inch FNPT fitting located at the top of the dome lid.
6. All flanges shall be welded to the housing surface such that the flange face surface is parallel to the normal tangent at the point of connection within 1 degree (1/32 inch per 12 inches).
7. The axis of any flange or connection shall be located with a bilateral tolerance of 1 degree around the perimeter of the housing relative to the axis of an opposing flange or connection.
8. For vessel heads greater than 10 pounds, provide spring assisted or manual screw jack type of head lifting system.
9. All filter housings shall be designed in a manner which minimizes the dead space above the cartridges (no domed top plates).

10. The support rods and hold-down plate shall be designed to allow filter elements from multiple high-purity cartridge manufacturers.

C. Filter elements:
   1. Filter elements shall be high surface area filter cartridges, constructed of pleated glass microfiber media and polypropylene core, providing absolute particle retention and long on-stream life cycles.
   2. Materials of construction shall provide a wide chemical compatibility, with no leachables or extractables, for intended service.
   3. Final-filters shall have a rating of 0.2 micron absolute.

D. Basis of Design: Millipore Corp., Size and capacity as shown on drawings

2.11 INSTRUMENTATION

A. The Vendor shall supply all control devices required for a complete and operating system, including (but not limited to) the following:
   1. Conductivity monitor:
      a. Transmitter:
         1) 4 line back-lit display.
         2) UL listed and CE compliant approvals, with NEMA 4X and IP 65 enclosure.
         3) Power supply shall be 115V AC, 5 A.
         4) Output shall be 4-20 mA.
         5) Ambient operating environment shall be -10 to 50 degC, 0-95% relative humidity.
         6) Measurement shall be 0.02 to 2000 uS/cm, with an accuracy of +/- 0.5%.
      b. Probe:
         1) 3/4 IN MNPT match probe, with patch cord as required.
      c. Basis of Design: Thornton.

2.12 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 INSTALLATION REQUIREMENTS – GENERAL

A. Vendor shall furnish onsite factory trained permanent employees as necessary to fully inspect the received equipment and supervise the entire installation of the RO and DI systems (in accordance with all written Vendor instructions and specifications). Final acceptance of the RO and DI systems shall be subject to satisfactory completion of the performance specifications detailed herein. Vendor's onsite employees shall supervise and document in real time any adjustments necessary and required for satisfactory operation.

B. Vendor's Responsibility and Services:
   1. The Vendor's employee(s) shall be prepared as necessary to assist the Mechanical and Electrical Contractors during installation and to provide written certification that the equipment has been installed as specified and in accordance with Vendor's requirements.
   2. The Vendor's employee(s) shall provide the initial start up of equipment in the presence of the Commissioning Authority and Owner:
      a. Provide a pre-start check of all piping, valves, control devices, control panels, and equipment.
      b. Perform final calibrations and adjust equipment and controls for operation at the specified design conditions.
      c. Provide a record of all start-up events noting problems and their resolution.
      d. Provide a record of all set points for operational controls and devices.

e. Review the functional operating sequence associated with programmed PLC software and correct to comply with O&M manual documentation requirements and update the Vendor generated sequence of operations submitted before equipment shipment.

3. Upon the completion of equipment startup, provide up to 40 hours of instructional time with Owner's personnel to review the operations and maintenance manuals and perform each step necessary for start up, shut down, troubleshooting, and routine maintenance. The instructional times shall be scheduled through Owner.
4. Upon completion of all inspection, start up, testing, check out, and validation procedures, the Vendor shall submit written notice to the Commissioning Authority and Owner that the RO and DI systems areis ready for use by Owner.

3.2 EQUIPMENT

A. Vendor shall furnish equipment installation instructions in the form of drawings and written instruction as part of the Operation and Maintenance Manuals. Installation of factory-assembled equipment skids, loose equipment, interconnecting piping and accessories, control panels, interconnecting wiring, and instrumentation shall be by the Mechanical and Electrical Contractors under the Vendor's supervision.

B. Mechanical and Electrical Contractors shall be responsible for installation of equipment base pads for equipment skids, pumps, vessels, panels, etc. Typical base pad details are provided on the Drawings.

3.3 TANK INSTALLATION

A. After inspection and acceptance by Owner, the RO and DI tanks shall be unloaded, stored and subsequently installed by the installer. Tanks shall be stored on a smooth, padded (as described for shipping) surface until installation. Care will be taken during storage to prevent flexing of the nozzles, brackets, or lugs and impacts and rolling.

B. The Mechanical Contractor shall verify field conditions prior to installation.

C. The Mechanical Contractor shall install the tank per the manufacturer's written instructions, this specification, and the drawings.

D. Prior to final placement of tanks, the Mechanical Contractor shall submit tank installation drawings to Owner for approval of tank location, elevation, and orientation.

E. Prior to placing into service, all interior surfaces including nozzle interiors and manway cover of the tank shall be wiped down with isopropanol using a lint-free cloth and rinsed with deionized water. After rinsing and drying, all openings shall be capped and sealed with clean rigid materials to prevent contamination of the tank.

3.4 FILTER INSTALLATION

A. Filter elements: The sacrificial and operational filter element sets shall be installed in the filter housings by the RO and DI water systems Vendor.

B. All filter elements shall be shipped to the job site in the filter manufacturer's original, unopened shipping containers by the vendor just prior to installation in the filter housings.

3.5 INSTRUMENTATION AND CONTROLS INSTALLATION

A. Electrical Contractor shall install, connect, and calibrate field-mounted instrumentation and control devices in accordance with the drawings provided by the Vendor.

B. Panels and wiring shall be installed in accordance with applicable sections in Special Construction Divisions and Electrical Divisions.

C. Vendor shall be responsible for installation, startup, debugging, and demonstration of PLC program software.

3.6 SYSTEMS PRESSURE TESTING

A. Test RO and DI systems equipment and piping in accordance with applicable sections of this specification and Mechanical Specifications, when directed by Owner.

END OF SECTION

SECTION 22 90 00
COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description
B. Responsibilities
C. Related Work
D. Test Equipment
E. Submittals
F. Startup
G. Functional Performance Tests
H. Testing Documentation, Non-Conformance and Approvals
I. Operation and Maintenance Manuals
J. Training of Owner Personnel
K. Deferred Testing
L. Written Work Products

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 22 responsibilities in the commissioning process.

B. The systems to be commissioned are listed in Section 01 91 00.

C. Commissioning requires the participation of Division 22 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 22 Contractor shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Plumbing Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 22 are as follows (all references apply to commissioned equipment only):

1. Construction and Acceptance Phases

a. Include and itemize the cost of commissioning in the contract price.
b. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.
c. Attend a commissioning scoping meeting and other meetings necessary to facilitate the commissioning process.
d. Contractors shall provide the CA with normal cut sheets and shop drawing submittals of commissioned equipment.
e. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.

1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all

responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

2) The Commissioning Agent may request further documentation necessary for the commissioning process.

3) This data request may be made prior to normal submittals.

f. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CA for review and approval.

g. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

h. Provide limited assistance to the CA in preparing the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

i. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CA for all commissioned equipment. Submit to CA for review and approval prior to startup. Refer to Section 01 91 00 for further details on start-up plan preparation.

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

k. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.

l. Address current punch list items before functional testing. Water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective water-related systems.

m. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

n. Provide skilled technicians to perform functional performance testing under the direction of the CA for specified equipment in Section 01 91 00. Assist the CA in interpreting the monitoring data as necessary.

o. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, GC and Design Engineer and retest the equipment.

p. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

q. During construction, maintain as-built red-line drawings for all drawings. Update after completion of commissioning (excluding deferred testing).

r. Provide training of the Owner's operating staff using expert qualified personnel, as specified.

s. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period

a. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Plumbing Mechanical Contractor. The responsibilities of the Plumbing Mechanical Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Provide startup for all Plumbing equipment, except for the building automation control system.
2. Assist and cooperate with the TAB contractor and CA by:

    a. Putting all Plumbing equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
    b. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

3. Install a P/T plug at each water sensor that is an input point to the control system.
4. Prepare a preliminary schedule for Division 22 pipe system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
5. Notify the GC or CA depending on protocol, when pipe system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the GC or CA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CA has the scheduling information needed to efficiently execute the commissioning process.

C. Controls Contractor. The commissioning responsibilities of the Controls Contractor, during construction and acceptance phases in addition to those listed in (A) are to be identical to those outlined in 23 08 00 1.3 (C).

D. TAB Contractor. The duties of the TAB Contractor, in addition to those listed in (A), are to be identical to those listed in 23 08 00 1.3(D).

1.4 RELATED WORK

A. Refer to Section 01 91 00 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 01 91 00 for systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 00 for additional Division 22 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. The Contractor shall provide submittal documentation relative to commissioning as required in this section and Section 01 91 00.

3.2 STARTUP

A. The HVAC Mechanical and Controls Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities List in this section and in Section 01 91 00. The Contractor has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3 CONTRACTOR TESTS

A. Subcontractors/installers shall forward to the Commissioning Authority, through the GC, a list and schedule of specified contractor tests. The tests shall include at least the following:

Section 22 10 16	Plumbing Piping	3.2,H 3.2,I 3.3,I	Hydrostatic Testing Sterilization Drainage leak testing

B. Unless specified otherwise, provide a minimum one week prior notice to the Commissioning Authority through the GC for each specified Contractors' test.

C. Submit Contractors' test reports to the Commissioning Authority, through the GC within one week of the successful completion of each test. Contractors shall document and issue a test report for each required test. The test report shall contain all information required by the respective specification section including the test date, start time, stop time, test duration, initial values, final values, expected result, and acceptable test values (per individual specification sections). The person(s) conducting each test and the local code authority (if applicable) shall sign and date each test report indicating that the test has been successfully completed and the results are within acceptable parameters.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 00 for a list of systems to be commissioned.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01 91 00 for specific details on non-conformance issues relating to prefunctional checklists and tests.

B. Refer to Section 01 91 00 for issues relating to functional performance tests.

3.6 OPERATION AND MAINTENANCE (O&M) MANUALS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.

B. The Contractor shall compile and prepare documentation for all equipment and systems covered in Division 22 and deliver this documentation to the GC for inclusion in the O&M manuals, according to this section and Section 01 91 00, prior to the training of Owner personnel.

C. The CA shall receive an electronic copy of the O&M manuals for review.

D. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the Owner Advocate and by the CA. Refer to Section 01 91 00 for details.

3.7 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.

B. The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems. Refer to Section 01 91 00 for additional details.

C. Plumbing Mechanical Contractor. The Mechanical Contractor shall have the following training responsibilities:

1. Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00.

2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of mechanical equipment including, but not limited to, pumps, hot water heaters, controls and water treatment systems, etc.

3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The Controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

8. Training shall include:

   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation

in all modes possible, shut-down, seasonal changeover and any emergency procedures.

c. Discussion of relevant health and safety issues and concerns.

d. Discussion of warranties and guarantees.

e. Common troubleshooting problems and solutions.

f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.

g. Discussion of any peculiarities of equipment installation or operation.

h. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

10. The Plumbing Mechanical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

12. Duration of Training. The Mechanical Contractor shall provide training on each piece of equipment according to Section 22 05 00.

3.8 DEFERRED TESTING

A. Refer to Section 01 91 00 for requirements of deferred testing.

3.9 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the start-up and initial checkout plan described in Section 01 91 00 and the filled out start-up, initial checkout and prefunctional checklists.

END OF SECTION

SECTION 23 21 13
HYDRONIC PIPING SYSTEMS (Revised AD-1)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Systems:
      a. Chilled water piping.
      b. Coil header piping.
      c. Condensate and cooling coil drain piping.
      d. Process cooling water piping.
      e. Heating water piping.
      f. Glycol water piping.
      g. Make-up water piping.
      h. Radiant panel crossover piping.
      i. Water treatment system piping.
      j. Glycol and glycol feed system.
   2. Products:
      a. Air vents.
      b. Expansion tanks.
      c. Flow switch wells.
      d. Pressure and temperature test stations, combination.
      e. Strainers.
      f. Valves.
      g. Water flow measurement devices.

B. Work installed but not furnished:
   1. Automatic valves: Furnished in Section 25 50 00:
      a. Provide fittings and reducers required for installation of automatic valves.

1.2 QUALITY ASSURANCE

A. Piping: ASTM labeled for rating specified.

B. Piping standards: Section 20 11 00.

C. Manual valve standards: Section 20 05 23 (for valves with "V" prefix).

1.3 SUBMITTALS

A. Shop and field coordination drawings:
   1. Piping layouts at 1/4 IN/FT scale.

B. Product data:
   1. Air vents.
   2. Coils, duct mounted.
   3. Expansion tanks.
   4. Pressure and temperature test stations, combination.
   5. Strainers.
   6. Valves, manual.
   7. Valves, pressure reducing.
   8. Valves, pressure relief.
   9. Valves, triple duty.
   10. Valves, constant flow control.
   11. Water flow measurement devices.

12. Water treatment system.
13. Glycol water make-up system.
14. Process cooling water filters.

C. Contract closeout information:
1. Operating and maintenance data.
2. Field test reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
1. Air vents, manual:
   a. Base:
      1) Crane Valves.
   b. Optional:
      1) Jenkins.
      2) Johnston.
      3) OIC.
      4) Powell.
      5) Stockham Valves & Fittings.
      6) Walworth.
2. Expansion tanks:
   a. Base:
      1) Bell & Gossett, ITT.
   b. Optional:
      1) Thrush.
      2) Armstrong Pumps.
      3) Taco.
      4) Amtrol.
3. Pressure/temperature test stations, combination (P/T plug):
   a. Base:
      1) Peterson Equipment Company (Pete's plug).
   b. Optional:
      1) Sisco P/T Plugs & Flex Connectors.
      2) Super Seal.
      3) Fairfax.
4. Strainers, in-line wye strainer and valve combination:
   a. Base:
      1) Griswold Controls.
   b. Optional:
      1) Autoflow.
5. Strainers, single-basket and tee:
   a. Base:
      1) Hoffman Specialty, ITT.
   b. Optional:
      1) Armstrong International.
      2) Gustin-Bacon.
      3) Keckley, OC.
      4) Metraflex.
      5) Mueller Steam Specialty.

6) Spence Engineering.
7) Spirax Sarco Type AT.
8) Tate.
9) Victaulic of America.

6. Strainers, duplex basket:
   a. Base:
      1) Eaton.
   b. Optional:
      1) Hayward.
      2) Kraissl.
7. Valves, pressure reducing (water and glycol):
   a. Base:
      1) Bell & Gossett, ITT.
   b. Optional:
      1) Watts Control Valves.
      2) Armstrong Pumps.
      3) Conbraco.
      4) Taco.
      5) Thrush.
8. Valves, pressure relief (water and glycol):
   a. Base:
      1) Bell & Gossett, ITT.
   b. Optional:
      1) Farris.
      2) Armstrong Pumps.
      3) Taco.
      4) Teledyne Farris Engineering.
      5) Thrush.
9. Valves, triple duty:
   a. Base:
      1) Bell & Gossett, ITT.
   b. Optional:
      1) Gustin-Bacon.
      2) Victaulic of America.
      3) Armstrong.
10. Process cooling water filters:
   a. Base:
      1) PALL
      2) Filterite.
   b. Optional:
      1) Claude Laval/Lakos Separators.
      2) Osmonics.
11. Valves, constant flow control:
   a. Base:
      1) FDI Flow Design, Inc.
   b. Optional:
      1) Griswold Controls.
      2) Presco.
12. Water flow measurement devices:
   a. Base:
      1) Barco USA.
   b. Optional:
      1) Data Industrial.
      2) Dynasonics.
      3) Gerand Engineering.
      4) Victaulic of America.

13. Water treatment system cleaning chemicals:
    a. Base:
        1) Oakite Products.
    b. Optional:
        1) Mitco.
        2) Diversey Water Technologies.
14. Water treatment system chemical feeders:
    a. Base:
        1) Nalco.
    b. Optional:
        1) Mitco.
        2) Calgon-Vestal.
        3) Diversey Water Technologies.
15. Glycol water make-up system:
    a. Base:
        1) Nalco.
    b. Optional:
        1) Mitco.
        2) Calgon.
16. Glycol water:
    a. Base:
        1) Dow Chemical Co.
    b. Optional:
        1) Olin Corporation.
        2) Ashland Chemical Co.

2.2 PIPE AND FITTINGS

A. Clean steam generator blowdown piping: Seamless black steel with welded joints.
   1. For 2 IN and less: Schedule-80 and 3000 PSI socket weld fittings.
   2. For 2-1/2 IN and larger: Schedule-40 and steel butt welding fittings.

B. Chilled water piping:
   1. Copper, type L, with soldered joints, and wrought copper or cast brass fitting; or T-drilled with brazed joints:
      a. Mechanical rolled groove-end fittings and couplings may be used for sizes 3 IN and larger.
      b. Pipes 2 IN and less ProPress System by Ridge Tool Company is acceptable.
   2. Black steel, Schedule 40:
      a. 2 IN and smaller: Threaded joints, with cast iron or malleable iron threaded fittings.
      b. 2-1/2 IN and larger: Welded joints.
      c. Rolled groove couplings and fittings may be used for chilled water and process chilled water piping.
   3. Inside fan plenums (and piping from coil connections to piping headers inside and outside of plenums):
      a. Copper, type L, with soldered joints, and wrought copper or cast brass fittings.
      b. Black steel, with rolled groove couplings and fittings.
      c. Galvanized steel, with rolled groove couplings and fittings.

C. Coil header piping:
   1. Fabricate of black steel pipe with weld-o-lets for tees.
   2. Copper, type L, with soldered joints, and wrought copper or cast brass fittings.
   3. T-drilled Type L copper with brazed joints.
   4. For pipes 2 IN and less, ProPress System by Ridge Tool Company is acceptable.

D. Condensate and cooling-coil-drain piping:
   1. Copper, type M or L, and soldered joints.
   2. Galvanized steel with cast iron drainage type fittings.

E. Glycol-water piping:
   1. Black steel, with welded joints:
      a. For 2-1/2 IN and larger: Use forged butt welding fittings.
      b. For 2 IN and less: Use socket welding fittings, 2000 or 3000 PSI class.
      c. Threaded pipes and nipples may be used at equipment connections.
      d. Weld-o-let or thread-o-let type of fittings may be used in lieu or tees for branch connections, provided main is one size larger than takeoff:
         1) Couplings or half couplings are not acceptable except for non-flow connections such as thermometers or gauges.
      e. Rolled groove type couplings and fittings may be used for glycol-water piping.
   2. T-drilled Type L copper with brazed joints.

F. Heating water piping, above grade:
   1. Copper, type L, with soldered joints, and wrought copper or cast brass fittings; or T-drilled with brazed joints:
      a. Mechanical rolled groove-end couplings and fittings may be used for sizes 3 IN and larger.
      b. For pipes 2 IN and less, ProPress System by Ridge Tool Company is acceptable.
   2. Black steel, with welded joints:
      a. For 2-1/2 IN and larger: Use butt welding fittings.
      b. For 2 IN and less: Use socket welding fittings, 2000 PSI class, or cast iron threaded fittings.
      c. 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.
      d. Rolled groove type couplings and fittings may be used for heating water piping.

G. Make-up water piping:
   1. Same as system served.

H. Radiant panel cross-over piping:
   1. Copper tubing, type L.

I. Water treatment system piping:
   1. Same as system served.

2.3 AIR VENTS

A. Air vents, manual:
   1. Vent valves: 1/4 IN 125 PSI globe angle valve with XH nipple connecting to pipe.

2.4 COILS, DUCT MOUNTED

A. Coils, general: ARI Standard 410-72.
   1. Each coil to bear ARI certification label.

B. Coils, heating:
   1. Heating coils continuous plate or spiral fin type, for 200 PSI operating pressure.
   2. Capacity: As scheduled.
   3. Headers: Cast iron, copper or brass.
   4. Fins:
      a. Aluminum.
   5. Tubes: Copper, arrange for counter-flow of air and water.
   6. Water velocity: 8 FPS maximum with head loss not greater than scheduled.
   7. Provide 16 ga galvanized steel angle frames for bolting coils to ductwork.
   8. Provide air vent and system drain at high and low points, respectively, of each coil. See Section 20 05 19.
   9. Coils guaranteed to drain.

2.5 EXPANSION TANKS

A. Tanks, expansion (air-elimination system):
   1. Pre-pressurized diaphragm type.
   2. Size: As scheduled.
   3. Rated pressure: 125 PSIG.
   4. Rated operating temperature: 240 degF, minimum.
   5. Precharge pressure: Same as scheduled minimum operating pressure.
   6. Bladder: Heavy duty butyl, removable for inspection.
   7. ASME constructed and stamped.

2.6 FLOW SWITCH WELLS

A. Flow switch wells:
   1. Install 1 IN thread-o-let for flow switch installation.
   2. Provide 1 IN nipple and cap.

2.7 PRESSURE AND TEMPERATURE TEST STATIONS, COMBINATION

A. Pressure/temperature test station, combination:
   1. Station to receive either a 1/8 IN OD temperature or pressure probe.
   2. 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).
   3. Provide extension at locations with pipe insulation. Extension length shall match or exceed insulation thickness.
   4. Provide with color coded and marked cap with gasket, rated at 1000 PSI at 140 degF.

B. Pressure and temperature test kit:
   1. Range: 0-100 PSI, 0-230 FT WG.
   2. 1/8 IN OD probe and 5 IN stem pocket testing thermometers:
      a. Provide 1 for chilled water: 25-125 degF.
      b. Provide 1 50-500 degF for hot water.
   3. No. 500 gauge adapter with 1/8 IN OD probe.
   4. Protective carrying case.

2.8 STRAINERS

A. Strainers, in-line wye strainer and valve combination:
   1. One piece configuration consisting of O-ring union, P/T plug, blow down and ball valve with handle.
   2. Strainer valves 1-1/4 IN and smaller: Limit passage of particles larger than 500 microns.
   3. Strainer valves 1-1/2 IN and larger: Limit passage of particles 1000 microns and larger.
   4. Bronze body construction with threaded or sweat connections:
      a. Internal parts: Brass and stainless steel.
   5. Provide valves with unions to allow field exchange of internal components without removing valve body from pipeline.
   6. Provide metal ID taps permanently marked to show direction of flow, strainer mesh and model number.

B. Strainers, single-basket type:
   1. Screwed or flanged.
   2. Body: Cast iron, flanged ends, bolted access cover.
   3. Coating: Rust inhibiting.
   4. Working pressure, non shock: 150 PSIG.
   5. Screens: Bronze, monel or stainless steel:
      a. 2 IN and less: 3/64 IN perforations.
      b. 2-1/2 IN and larger: 1/8 IN perforations.

C. Strainer, tee-pattern type:
   1. Grooved ends.

2. Body: One-piece ductile iron casting conforming to ASTM-A536 or malleable iron conforming to ASTM-A47.
3. Coating: Rust inhibiting.
4. Working pressure rating: 300 PSI.
5. Basket screen: 304 stainless steel 0.041 IN wire in a woven No.6 mesh wire screen with 0.126 IN opening.
6. Vertical down flow or horizontal flow.
7. Cleaning access through blank end cap.

D. Strainers, wye:
1. See Section 20 05 19, Piping Specialties.

E. Strainers, duplex:
1. Ductile iron construction, 125 LB flange connections.
2. Butterfly valves, synchronized, high quality.
3. Stainless steel basket with 3/64 IN perforations.
4. Buna N seals.
5. With integral drain and vent valves.

2.9 PROCESS COOLING WATER FILTERS

A. Manufacturers:
1. Base:

AD-1: Section 23 21 13: Revise paragraph 2.9.A.1.a.

a. Pall.
2. Optional:
a. Filterite.

AD-1: Section 23 21 13: Revise paragraph 2.9.A.2.b.

b. Purolator.

B. Filter shall have particulate polypropylene filter assembly, 150 LB, type 304 stainless steel oil-free housing.

C. Size cartridges for a maximum flow rate of 3 GPM per 10 IN length.

AD-1: Section 23 21 13: Revise paragraph 2.9.D.

D. Initial filter cartridge rating shall be 100 micron but housing shall be suitable for a future cartridge rating of down to 5 micron.

AD-1: Section 23 21 13: Revise paragraph 2.9.E.

E. Filter housing shall be suitable for a 500 GPM flow rate.

AD-1: Section 23 21 13: Delete paragraphs 2.9.F through 2.9.G.6.

F. Deleted

G. Deleted

2.10 VALVES

A. Constant flow control valves:
1. Factory calibrated, direct acting, automatic pressure compensating:
2. Control flow rates within 4 percent of flow rating over operating pressure differential range.
a. Set flow rating to match the maximum flow required by device served.
3. Pressure differential range:
a. 2-32 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 valve model number, rated GPM, direction of flow, and differential pressure range.

6. Provide with integral unions and integral ball valve. Y configuration to allow field exchange of flow cartridge without removing valve body from pipeline.
7. Provide as indicated.
8. Pressure and temperature taps.
9. For flow rates, see drawings.

B. Manual valves:
1. Angle valves:
   a. 2 IN and smaller: V-17.
   b. 2-1/2 IN and larger: V-18.
2. Balancing valves:
   a. 2 IN and smaller: V-64.
   b. 2-1/2 IN to IN: V-65.
   c. 8 IN and larger:
      1) Plug valve: V-37 with memory stop.
      2) Provide venturi waterflow measuring device.
   d. Ball type balancing valves/circuit setters shall not be used.
3. Isolation valves (Ball valves):
   a. 2 IN and smaller: V-13 or V-14.
4. Isolation valves (Butterfly valves):
   a. 2 IN and smaller: not used.
   b. 2-1/2 IN and larger: V-33, V-34 or V-35.
5. Check valves, pump discharge:
   a. 2 IN and smaller: V-25 or V-26.
   b. 2-1/2 IN and larger: V-28, V-29, or V-30.
6. Check valves, other:
   a. 2 IN and smaller: V-25.
   b. 2-1/2 IN and larger: V-28 or V-29.
7. Isolation valves (Gate valves):
   a. 2 IN and smaller: not used.
   b. 2-1/2 IN and larger: V-3.
8. Globe valves:
   a. 2 IN and smaller: V-6 or V-7.
   b. 2-1/2 IN and larger: V-8.
9. Plug valves:
   a. 2 IN and smaller: V-36.
   b. 2-1/2 IN and larger: V-37.

C. Electric valve operators:
1. Provide electric valve operators on CWS valve at chilled water entrance.
2. Valves are to be operable from the building control system.

D. Pressure reducing valves:
1. Water type, diaphragm operated with low inlet pressure check valve and built-in strainer.
2. Construction:
   a. Body: Brass.
   b. Diaphragm: EPT.
   c. Check valve: Rubber.
   d. Seat: Brass.
   e. Stem: Brass with Buna N insert.
   f. Strainer: Brass.
3. Maximum working pressure: 100 PSIG.
4. Adjustable pressure range: 25-60 PSIG.

E. Pressure relief valves:
1. ASME-approved, tight-shutoff, self-closing.

2. 2-1/2 IN and less: Screwed.
3. 3 IN and larger: Flanged.
4. Ten percent over pressure.
5. Test lever.
6. Capacity: Same BTUH as equipment served. See schedules.
7. Relief setting: 125 PSIG unless indicated otherwise.

F. Triple-duty valves:
1. Non-slam check valve with spring-loaded disc.
2. Calibrated adjustment feature to regulate pump discharge flow and shut-off.
3. Cast iron body.
4. 175 PSIG working pressure, 300 degF operating temperature.
5. Valves capable of being repacked under full line pressure.

2.11 WATER FLOW MEASUREMENT DEVICES

A. Differential water pressure meter for Venturi flow measuring devices:
1. Wall mounted type with 6 IN round dial, 270 degree indication.
2. Range: 0-100 IN WG or 0-50 IN as required.
3. Meter assembly rated at 250 PSI and 250 degF.
4. Arrange tubing for multi-station measurement or provide direct reading single station meter where indicated.
5. For multi-station measurement, use four measuring devices maximum.

B. Venturi waterflow measuring device:
1. Accuracy: Plus/minus 1 percent at design flow.
2. Maximum pressure drop: 0.8 FT.
3. Provide safety shut-off valves, sensing taps, nipples and quick connection couplings.
4. Identify with metal tag on chain indicating:
   a. Size.
   b. Location.
   c. GPM.
   d. Meter reading for GPM indicated.
5. Sizes 1/2 IN through 2 IN brass, screwed.
6. Sizes 2-1/2 IN and over steel, flanged or butt welded.

2.12 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.

2.13 AUTOMATIC AIR SEPARATOR/ELIMINATOR

A. Combination air separator and air eliminator in a single unit:
1. ASME “UM” Coded.
2. Body and Cover: Cast Iron.
3. Working Temperature: 240 degF.
4. Working Pressure: 2 to 150 PSIG.
5. Flow Range: 0 to 8 GPM.
6. Prevents air from entering system in vacuum conditions.
7. Amtrol Model No. 721 for heating water and chilled water.

2.14 GLYCOL-WATER MAKE-UP SYSTEM

A. Glycol-water make-up storage tank:
   1. Self-supporting polyethylene, minimum 4 mm thickness, with removable cover or black steel with 4 mm polyethylene insert.
   2. Capacity shall be 50 gallon with approximate diameter of 24 IN and height of 36 IN.
   3. Reinforced threaded pipe connections shall be provided for all connections.
   4. Provide identification for tank indicating name of the contents.

B. Glycol-water make-up pump:
   1. Bronze fitted, self-priming, high head type suitable for pumping a 25 percent to 50 percent glycol-water solution in intermittent service.
   2. Provided with a mechanical shaft seal.
   3. Flange connected to a NEMA Type C motor.
   4. Capacity: 1.5 GPM at 100 PSIG.
   5. Built-in or external relief valve set for design head of the pump, as indicated on drawings.

C. Glycol-water pressure control:
   1. Stainless steel diaphragm, positive snap-acting SPST switch mechanism, rated 10 amps, 120 volts AC.
   2. General purpose (NEMA 1) enclosure.
   3. Rated for pressure to 150 PSIG
   4. Provide first low pressure switch to make circuit on low water pressure. It shall cycle make-up pump to maintain pressure in glycol-water circuit.
   5. Provide second low pressure switch to make circuit on lower water pressure. It shall send signal for low pressure alarm.

D. Back pressure regulating valve:
   1. Spring loaded, diaphragm actuated type with bronze or steel body, stainless steel trim.
   2. Capacity to relieve 100 percent of pump flow with an allowable rise in the regulated pressure of 10 PSIG above the setpoint.
   3. Setpoint shall be above system PRV setting.

E. Low glycol water level control:
   1. Steel or cast iron float housing, stainless steel float.
   2. Positive snap-acting SPST switch mechanism, rated 10 amps, 120 volts AC, in General Purpose (NEMA 1) enclosure.
   3. Rated for pressure to 150 PSIG.
   4. Make alarm circuit on low water level.

2.15 GLYCOL-WATER

A. Industrially inhibited propylene glycol, phosphate-based:
   1. Fluid must pass ASTM-D1384.
   2. Provide free annual analysis by fluid manufacturer.
   3. Corrosion inhibitors formulated for HVAC systems to keep pipes free of corrosion without fouling.
   4. Dow Chemical Company: Dowfrost.

2.16 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 GENERAL

A. Excavation and backfilling: Section 31 23 33.

B. Install in accordance with Section 20 11 00 and Section 20 05 00.

C. Connect equipment.

D. Painting: Section 09 91 23.

3.2 PIPE AND FITTINGS

A. Threaded joints in glycol-water piping:
   1. Remove pipe cutting oil from threads by scrubbing in Portland cement.
   2. Coat dry threads with "Permatex" pipe compound prior to assembly.

B. Do not insulate or conceal piping until testing is completed.

3.3 AIR VENTS

A. Air vents, manual:
   1. Vents shall prevent air binding in systems.
   2. Pipe discharge of vent to a location where air and water may be collected in a bucket.
   3. Locations:
      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.

3.4 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. Chilled water: Dual basket, single-basket, tee, or wye type.
   2. 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.

3.5 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. Provide system drains: See Section 20 05 19.

E. Provide 3-valve manifold for each differential pressure sensor:
   1. Coordinate locations and quantities of sensors with Controls Contractor.

F. Constant flow control:
   1. Install as recommended by Manufacturers.
   2. Allow space for replacement of parts.

3.6 WATER FLOW MEASUREMENT DEVICES

A. Provide as indicated.

3.7 WATER TREATMENT SYSTEM

A. Mount chemical feeder as indicated:
   1. Chilled water system.
   2. Heating water system.

3.8 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.9 TESTING

A. Test piping upon completion of a section or of entire system:
   1. Test hydrostatically to pressure not less than 50 percent in excess of maximum pressure to which pipe will ordinarily be subjected, but in no case less than 150 PSI.
   2. Repair or replace leaks or defective pipe disclosed by tests.
   3. Repeat tests until piping indicates tight.

3.10 CLEANING OF HYDRONIC PIPING 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.
   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 and replace filter cartridges.

3.11 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. For glycol-water systems, add sufficient propylene glycol to provide 40% percent by volume of glycol to water mixture.

C. 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

SECTION 23 21 23
HVAC PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Single suction pumps.
   2. Double suction pumps.
   3. In-line pumps.

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. Operating and maintenance data.
   2. Letter stating extra material has been delivered.
   3. Field vibration test reports.

1.4 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by Owner for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

1.5 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Single suction, heating and cooling water pumps:
      a. Base:
      b. Optional:
         1) Allis-Chalmers, ITT.
         2) Armstrong Pumps.
         3) Buffalo Forge.
         4) Byron-Jackson.

5) Chicago Faucet.
6) Dunham-Bush.
7) Goulds Pumps.
8) Bell & Gossett, ITT.
9) Sulzer Pump (Paco).
10) Peerless Pump.
11) Taco.
12) Weil Pump.

2. Double suction, cooling water pumps:
   a. Base:
   b. Optional:
      1) Allis-Chalmers, ITT.
      2) Armstrong Pumps.
      3) Aurora.
      4) Buffalo Forge.
      5) Byron-Jackson.
      6) Dunham-Bush.
      7) Goulds Pumps.
      8) Ingersoll-Rand Air Compressor Group.
      9) Bell & Gossett, ITT.
      10) Sulzer Pump (Paco).
      11) Peerless Pump.
      12) Taco.
      13) Weil Pump.
3. Flexible pump couplings:
   a. Base:
      1) Dodge Regupol; "Para-flex".
      2) Wood's "Sure-flex".
4. In-line pumps:
   a. Base:
   b. Optional:
      1) Allis-Chalmers, ITT.
      2) Aurora.
      3) Buffalo Forge.
      4) Goulds Pumps.
      5) Bell & Gossett, ITT.
      6) Peerless Pump.
      7) Taco.
      8) Weil Pump.
      9) Ingersoll Dresser Pumps.

2.2 SINGLE SUCTION PUMPS

A. Pumps, heating and cooling water: Centrifugal, single stage, single suction, horizontal type, with vertically split casing, end suction and top vertical discharge with electric motor drive.
   1. Capacity: As scheduled, with continuously dropping head capacity curve from zero to maximum flow.
   2. Motor coupling: Close coupled, or flexible coupled as indicated.
   3. Provide coupling guard for flexible couplings.
   4. Mount pump and drive on common base.
   5. Base: Cast iron or steel plate with raised lip and drain connections.

B. Pumps, single suction centrifugal:
   1. Case: Cast iron, 125 LB ANSI standard flanged connections, hydrostatically tested at minimum 150 PSIG.
   2. Fit case with vent and drain valve.
   3. Impeller: Bronze, enclosed type with volute vent plug.

4. Shaft: Forged alloy steel.
5. Shaft sleeves: Stainless steel.
6. Mechanical seal: Ceramic on carbon.
7. Bearings: Grease lubricated, ball or roller type.

C. Pump motor drives: Constant speed, squirrel cage induction, 40 degC, drip-proof, AC, ball bearing, non-overloading.
   1. Nameplate horsepower ratings: Not less than maximum required pump input brake horsepower at pump capacities from zero to maximum.
   2. See Section 20 05 00.

D. Pump couplings, flexible: Dodge Para-Flex.
   1. Taper-Lock bushings keyed to shaft.

2.3 DOUBLE SUCTION PUMPS

A. Pumps, cooling water: Centrifugal, single stage, double suction, horizontal mounted, split case, with electric motor drive.
   1. Capacity: As scheduled.
   2. Deliver required head and GPM at 1750 RPM, with shut-off head not more than 25 percent over rated head.
   3. Motor coupling: Flexible type.
   4. Mount motor and pump on common base.

B. Casing: Horizontal split type.
   1. Design casing of cast or ductile iron for 150 PSI static pressure.
   2. Casting faces accurately machined and dowelled for bolting together.
   3. Provide 125 PSI flanges on suction and discharge openings.
   4. Rotating element removable without disturbing pipe connections by removing half casing and bearing caps.

C. Pump impeller: Bronze or brass, enclosed double suction type, radial flow design balanced both mechanically and hydraulically.
   1. Press impeller upon shaft over key to lock shaft sleeves in place.
   2. Provide axial adjustment by means of shaft sleeve locking nuts.

D. Pump wearing rings:
   1. Casing: Cast iron with streamlined water guiding surfaces.
   2. Impeller: Bronze.
   3. Provide clearances on wearing rings sufficient to prevent mating parts from touching under static deflection of impeller and shaft.

E. Pump shaft: High grade carbon steel, machined and accurately ground to size to ensure low working stresses under normal conditions imposed by driver.
   1. Protect against corrosion and abrasive action of liquid by means of stainless steel shaft sleeves held in place by locknuts.
   2. Make shaft long enough to permit flexible couplings to be disconnected.
   3. Design shaft so that, in starting and stopping, it will not pass through critical speed range.
   4. Make it rigid enough to meet requirements of wearing rings.

F. Pump bearings: Ball or roller bearings of deep groove or tapered type, sized to withstand axial and radial loads imposed upon pump shaft.
   1. Bearing housings: Cartridge type, designed so that entire rotating element may be removed from pump without disturbing alignment or exposing bearings to contaminants.
   2. Position housings by means of dowel pins in pump casing and securely clamp in place by covers fit on horizontal plane.

G. Pump seals: Mechanical, ceramic on carbon or hardened metal alloys on carbon.
   1. Working pressure: 150 PSI.

H. Pump base: Cast iron or steel, welded construction with intermediate ribs, closure plates and other reinforcing to provide rigid frame.
   1. Provide with raised lip for water drainage and threaded drain tapping.
   2. Provide holes for grouting.
   3. Provide drain pipe to floor drain.

I. Pump couplings, flexible: Dodge Para-Flex.
   1. Taper-Lock bushings keyed to shaft.
   2. 18 GA sheet metal coupling guard.

J. Pump motor drives: See Section 20 05 00.
   1. Balanced type.

2.4 IN-LINE PUMPS

A. In-line pumps, heating water: Centrifugal, single stage, for installation in vertical or horizontal piping.
   1. Capacity: As scheduled.
   2. Capable of being serviced without disturbing piping connections.
   3. Pump body: Class 30 cast iron, standard flange connections.
      a. Rated working pressure: 175 PSI.
      b. Provide with gauge ports at nozzles and vent and drain ports.
   4. Impeller: Non-ferrous material, enclosed type.
      a. Dynamically balanced, keyed to shaft and secured by locking capscrew or nut.
   5. Provide internally-flushed mechanical seal with ceramic seal seat.
   6. Non-ferrous shaft sleeve to cover wetted area under seal.
   7. Oil lubricated bronze journal and thrust bearings.
   8. Flexible coupling.
   9. Motor: Constant speed, squirrel cage induction, 40 degC, drip-proof, non-overloading.

B. In-line pumps, heating and cooling water: Centrifugal, close-coupled, single stage, bronze fitted, vertical mount.
   1. Capacity: As scheduled.
   2. Capable of being serviced without disturbing piping connections.
   3. Pump body: Cast iron with 125 PSI ANSI drilled flanges.
      a. Rated working pressure: 175 PSI.
      b. Provide with gauge ports.
   4. Impeller: Non-ferrous material, enclosed type.
      a. Hydraulically and dynamically balanced.
      b. Keyed to shaft and secured by locking capscrew.
   5. Provide internally-flushed mechanical seal with ceramic seal seat.
   6. Non-ferrous shaft sleeve to cover wetted area under seal.
   7. Motor: Open drip-proof enclosure with regreaseable ball bearings.

2.5 VERTICAL TURBINE PUMPS

A. Vertical turbine pumps: Vertical turbine, centrifugal type with discharge base, vertical hollow shaft, electrical motor drive, flanged column construction, cast iron bowl, bronze enclosed impeller and replaceable wearing rings on both impeller and bowl.
   1. Pump suitable for handling 85 degF water when submerged.
   2. Capacity and discharge head: As indicated.

B. Seals: Packed stuffing box or mechanical seals.

C. Motor: Full voltage starting, vertical hollow shaft and squirrel cage induction type.
   1. 460V, 3 phase, 60 cycles, 1750 RPM with a temperature rise of not more than 40 degC above ambient temperature.

D. Discharge head: Cast iron or fabricated steel.
   1. Head to match discharge pressure, column size, lineshaft diameter, discharge size and drive mounting.
   2. Provide above ground, flanged, discharge elbow outlet.

E. Column assembly: Total length of column designed to place suction bell approximately 6 IN above bottom of barrel (can) or tank.
   1. Provide interchangeable shaft sections coupled with steel couplings machined from solid bar steel.
   2. Provide bronze spiders with proper bearing materials installed at flanged column joints for line shaft bearings.
   3. Bearing lubrication from water handled.

F. Pump bowl assembly:
   1. Open impellers and open lineshaft construction.
   2. Threaded or flanged to column.

G. Barrel mounting: Can type.
   1. Barrel of fabricated steel to serve as pump suction and inlet assembly.
   2. Match head size.
   3. Flanged inlet sized for pump capacity.

H. Tank mounting without barrel: Pumps mounted on and extending into tanks.
   1. Provide baffles in tanks.
   2. Pump manufacturer shall "model test" and provide contractor with baffle locations and construction.
   3. Baffles may be provided with perforations.

2.6 EXTRA MATERIALS

A. Provide one extra mechanical pump seal with gaskets for each double suction pump.

2.7 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. For base mounted pumps, provide concrete inertia pad and spring isolators.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 VIBRATION ISOLATION

A. Vibration Isolation: Section 20 05 50.

3.3 VIBRATION TESTS

A. Each pump, 5 HP and above, shall be dynamically balanced in the factory and run tested with pump and motor fully assembled. Maximum pump vibration shall not exceed 2 mm per second rms. Vibration shall be measured in all directions at pump base. Vibration shall be measured at all frequencies at 1/3 octave bands. After installation, factory trained technicians shall re-test and verify in the field that the pumps meet the specified vibration criteria.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 22 00

STEAM DISTRIBUTION SYSTEM (Revised AD-1)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Pressure reducing valves.
   2. Safety valves.
   3. Steam and steam condensate valves.
   4. Specialties.
   5. Pipe and fittings.
   6. Pressure-powered condensate pumps and receiver.
   7. Blowdown separators.

B. Work installed but not furnished:
   1. Automatic valves: Furnished in Section 25 50 00:
      a. Provide necessary fittings and reducers.

1.2 QUALITY ASSURANCE

A. Manual valve standards: Section 20 05 23 (for valves labeled "V-__").

B. Piping standards: Section 20 11 00.

1.3 SUBMITTALS

A. Shop and field coordination drawings:
   1. Piping layouts at 1/4 IN/FT scale.

B. Product data:
   1. Pressure reducing valves.
   2. Safety valves.
   3. Steam valves.
   4. Steam condensate return valves.
   5. Traps.
   6. Pressure-powered condensate pumps/receiver.
   7. Blowdown separators.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Test reports.

1.4 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Pressure reducing valves (pilot operated):

a. Base:
   1) Spence.
   2) Spirax Sarco.

AD-1: Section 23 22 00: Add paragraph 2.1.A.1.a.3)

   3) Armstrong International.

2. Safety valves, steam:
   a. Base:
      1) Dresser, Inc.
   b. Optional:
      1) Farris (Division of Curtis-Wright Flow Control).
      2) Watts.
      3) Consolidated.
      4) Spence.
3. Steam traps:
   a. Base:
      1) Spirax Sarco.
   b. Optional:
      1) Illinois.
      2) Armstrong International.
      3) Hoffman Specialty.
      4) Mepco.
4. Pressure-powered condensate pumps/receiver:
   a. Base:
      1) Spirax Sarco.
   b. Optional:
      1) MEPCO.
      2) Nash Engineering Co.
      3) Roth.
      4) Domestic Pump ITT.
5. Blowdown separators:
   a. Base:
      1) Pennsylvania Separator Co.
   b. Optional:
      1) Adamson Co., Inc.
      2) Cleaver Brooks.
6. Flash tank:
   a. Base:
      1) Spirax Sarco.
   b. Optional:
      1) Pennsylvania Separator Co.
      2) Adamson

AD-1: Section 23 22 00: Add paragraph 2.1.A.6.b.3)

      3) Armstrong International.

2.2 PRESSURE REDUCING VALVES

A. Pressure reducing valves - general:
   1. Flow capacity and pressure range: As indicated.
   2. Provide wye strainer on inlet side of each valve.
   3. Provide noise diffuser to limit rated sound level to 85 dBA at a distance of 3 FT from the valve.
   4. Follow pressure reducing valve manufacturer installation instructions when erecting pressure reducing station.
   5. Pressure reducing valve shall be Spence Type E.
   6. Pressure regulator pilot shall be Spence Type D for reduction from HPS to MPS and Spence Type D5 for reduction from MPS to LPS.

B. Pressure reducing valves (1/2 – 4 IN): Pilot actuated diaphragm operated type:
   1. Cast iron body with raised face flanged end connections.
   2. Stainless steel seats and trim.
   3. Body rating: Class 250.
   4. Cast iron pilot with stainless steel trim.

C. Pressure reducing valves (over 4 IN): Pilot actuated diaphragm operated type:
   1. Cast iron body, raised face flanged end connections.
   2. Class 250B per ANSI/ASME-B16.1.
   3. Shutoff classification: ANSI/FCI Class V.
   4. Main valve shall be single seated.
   5. Trim: Hardened stainless steel.
   6. Pilot shall be externally mounted to regulator body.

2.3 SAFETY VALVES

A. Safety valves, steam:
   1. Sizes 3 IN and less: Threaded or flanged ends:
      a. Dresser, Inc. Consolidated Type 1511.
   2. For capacities over 3 IN use multiple valves.
   3. Valve sizing: Sized for 10 percent overpressure with a minimum of 5 PSIG overpressure on pressure reducing valve setting.
   4. ASME rated stainless steel seat & disc.
   5. Valves to have test levers.
   6. Safety valve discharge elbow: Spence Model DPE.
   7. Exhaust heads: Wright Austin Model 40 EHC.

2.4 STEAM VALVES TO 100 PSIG

A. Isolation valves (gate valves) LPS and MPS:
   1. 2 IN and smaller: V-2.
   2. 2-1/2 IN and larger: V-3.

B. Check valves, vacuum breaker, LPS and MPS, (2 IN and smaller): V-23.

C. Check valves, other LPS and MPS:
   1. 1-1/2 IN and smaller: V-25.
   2. 2 IN and larger: V-22 or V-28.

D. On clean steam systems, all wetted parts of steam valves shall be 304 stainless steel.

2.5 STEAM AND CONDENSATE VALVES 100 TO 200 PSIG

A. Shutoff and Blowdown Valves:
   1. 2 IN and Under: Bonney Forge – RP&C Gate Valve, Figure EF57D, Class 800, forged steel body, socket weld connections, “D” trim (13Cr/HF).
   2. 2-1/2 IN and Over (steam inside building, all condensate applications): Crane Figure 33, Class 300, raised face flanged gate valve, cast steel body, bolted bonnet, outside screw and yoke, one piece flexible wedge disc.

B. Bypass Valves:
   1. 2 IN and Under: Bonney Forge – RP&C Gate Valve, Figure EF57D, Class 800, forged steel body, socket weld connections, “D” trim (13Cr/HF).

C. Check Valves:
   1. 2 IN and Under: Bonney Forge – RP&C Check Valve, Figure F95D, spring loaded ball check valve, Class 800, forged steel body, socket weld connections, “D” trim (13Cr/HF).
   2. 2-1/2 IN and Over: Crane Figure 159, Class 300, cast steel swing check, flanged ends.

D. On clean steam systems, all wetted parts of steam valves shall be 304 stainless steel.

2.6 STEAM CONDENSATE RETURN VALVES TO 100 PSIG

A. Isolation valves (ball valves):
   1. 2 IN and smaller: V-13 or V-14.

B. Isolation valves (gate valves):
   1. 2-1/2 IN and larger: V-3.

C. Check valves:
   1. 2 IN and smaller: V-25.
   2. 2-1/2 IN and larger: V-28 or V-29.

D. On clean steam systems, all wetted parts of steam valves shall be 304 stainless steel.

2.7 SPECIALTIES

A. Steam traps - general:
   1. Sizes: As indicated, minimum; increase size if required to meet capacity requirements.
   2. Provide dirt pocket and wye strainer full size of trap opening.
   3. Provide shut-off valve and union on each inlet.
   4. Provide check and gate valve in discharge, at each lift leg.

B. Steam traps, low pressure (15 PSIG and less):
   1. Equipment traps: Use F & T type rated at 15 PSI working pressure. Each trap shall be sized using 1/2 PSI pressure drop and 2 times scheduled flow rate of equipment. Where two traps are shown on a single piece of equipment (e.g. heat exchanger), each trap shall be sized for 100% redundancy.
   2. End of main traps: Use F & T type. Trap sizes shall be as indicated on plans. If size is not indicated, the minimum trap size shall be 3/4 IN. The minimum capacities for each size of trap shall be as follows (based on 1/2 PSI differential):

Trap Size	Capacity
3/4 IN	550 lb/hr
1 IN	700 lb/hr
1-1/4 IN	950 lb/hr
1-1/2 IN	2100 lb/hr
2 IN	4000 lb/hr

C. Steam traps, medium and high pressure (over 15 PSIG):
   1. Steam Trap Assembly: Trap shall be Yarway Series 721 inline renewable tilting disc-type thermodynamic trap with chrome-moly body in ASME SA-182 GR.F-11 and stainless steel trim. End connections shall be ANSI Class 600 socket welded. Trap shall have an integral strainer with stainless steel screen, and integral blow-off valve.
   2. Equipment traps (16-30 PSIG): Sized using 2 PSI pressure drop and 2 times scheduled flow rate of the equipment.
   3. Equipment traps (over 30 PSIG): Sized using 1/2 of the maximum pressure differential across the trap and 3 times scheduled flow rate of the equipment.
   4. End of main traps: Trap size: as indicated on plans. If size is not indicated, the minimum trap size shall be 3/4 IN. The minimum capacities for each size of trap shall be as follows (based on 2 PSI differential):

Trap Size	Capacity
3/4 IN	1140 lb/hr
1 IN	2300 lb/hr
1-1/4 IN	3700 lb/hr
1-1/2 IN	5400 lb/hr
2 IN	10900 lb/hr

D. Steam traps on equipment: Provide traps and cooling legs, 18 IN deep minimum:
   1. Connect trap line to cooling leg 6 IN from bottom.
   2. Provide cap.
   3. Install trap above floor (elevate equipment if necessary).

E. Flash tank: Centrifugal design with stainless steel striking plate at point of inlet impingement with surfaces and baffles slanting for quick drainage and no pockets for condensate accumulation:
   1. Inlets and outlets as indicated.
   2. Cemline Corporation.

F. Strainers: See Section 20 05 19.

G. Supports, sleeves and seals: See Section 20 05 29.

H. Flashings: See Section 20 05 00.

I. Thermometers: See Section 20 05 19.

J. Pressure gauges:
   1. Weksler Type AA14C, 1/4 IN bottom connection, white dial, numerals range of 0 to 160 psig with 20 PSIG figure intervals, with Type A03B siphon, and Type A10 tee handle cock.

K. On clean steam systems, all wetted parts of steam valves shall be 304 stainless steel.

2.8 PIPE AND FITTINGS 30 PSIG AND OVER

A. Pipe:
   1. 2 IN and smaller (steam): Schedule 80 black steel, conforming to ASTM-A106 Grade B, seamless.
   2. 2-1/2 IN and larger, (steam): Schedule 40 black steel, conforming to ASTM-A53 Grade B, seamless.
   3. All condensate pipe regardless of size: Schedule 80 black steel, conforming to ASTM-A106 Grade B, seamless.

B. Fittings:
   1. 2 IN and smaller: 3000 LB socket weld.
   2. 2-1/2 IN and larger: Seamless standard class carbon steel butt welding, conforming to ASTM-A234 Grade WPB and ANSI-B16.9.

C. Unions (1/2 IN – 2 IN): 2000 LB carbon steel, socket weld, ground joint, integral seats, conforming to ASTM A105.

D. Flanges: 150 LB class carbon steel, raised face, conforming to ASTM-A105 and ANSI-B16.5. Figure numbers are Tube Turn's:
   1. 1/2 IN – 2 IN: Schedule 80 bore, socket weld.
   2. 2-1/2 IN and larger:
      a. Welding Neck Flanges: Figure 30.
      b. Slip-On Flanges: Figure 50.
      c. Blind Flanges: Figure 70.
   3. Gaskets: Ring-type, 150 LB class:
      a. For steam and condensate systems: Flexitallic 304 Stainless Steel, 1/8 IN thick, spiral wound.

4. Bolts:
    a. HPS and HPC: Alloy steel stud bolts, conforming to ASTM-A193, Grade B7, with corresponding nuts.

E. Elbolets and Thredolets: Bonney Forge, carbon steel, 3000 LB class, conforming to ASTM-A105 Grade II.

F. Weldolets: Bonney Forge, carbon steel, extra strong class butt welding end connection, conforming to ASTM-A105 Grade II.

2.9 PIPE AND FITTINGS LESS THAN 30 PSIG

A. Steam and steam vent piping: Black steel (Schedule 40), seamless piping:
1. 2-1/2 IN and larger: Use welded joints, with malleable steel fittings.
2. 2 IN and smaller: Use threaded or welded joints with malleable steel (3000 PSI) fittings.

B. Steam condensate and pumped condensate piping: Black steel (Schedule-80), seamless piping:
1. 2-1/2 IN and larger: Use welded joints, with malleable steel fittings.
2. 2 IN and smaller: Use threaded joints or welded joints with malleable steel (3000 PSI) fittings.

C. Relief vent pipe and fittings: Same as steam piping.

D. Flanges: 150 LB class carbon steel, raised face, conforming to ASTM-A105 and ANSI-B16.5. Figure numbers are Tube Turn's:
1. 1/2 IN – 2 IN: Schedule 80 bore, socket weld.
2. 3 IN and larger:
    a. Welding Neck Flanges: Figure 30.
    b. Slip-On Flanges: Figure 50.
    c. Blind Flanges: Figure 70.
3. Gaskets: Ring-type, 150 LB class:
    a. For steam and condensate systems: Flexitallic 304 Stainless Steel, 1/8 IN thick, spiral wound.
4. Bolts:
    a. All except HPS and HPC: Steel, square headed machine, or full threaded stud bolts, conforming to ASTM-A307 Grade B and ANSI-B1.1 coarse thread series Class 2A fit.

E. Elbolets and Thredolets: Bonney Forge, carbon steel, 3000 LB class, conforming to ASTM-A105 Grade II.

F. Weldolets: Bonney Forge, carbon steel, extra strong class butt welding end connection, conforming to ASTM-A105 Grade II.

G. Clean steam and condensate systems:
1. All steam and condensate piping to be 304 stainless steel, Schedule 40.
2. All fittings and valves to be 304 stainless steel.
3. Joining method shall be as above for steam and vent piping.

2.10 PRESSURE-POWERED CONDENSATE PUMPS/RECEIVER

A. Pressure Powered Pump:
1. Operated by steam, with minimum motive pressure of 5 PSIG.

AD-1: Section 23 22 00: Revise paragraph 2.10.A.2.

2. Ductile iron or cast steel construction (unless otherwise indicated) for pumping liquids of specific gravity of 0.65 and above.

AD-1: Section 23 22 00: Revise paragraph 2.10.A.3.

3. Provide float operated snap-acting mechanism with no external seals or packing, heavy duty Iconel springs, stainless steel trim, and hardened stainless steel mechanism bearing components.
4. Provide with sight glass.

5. Maximum required filling head: 6 IN.

B. Packaged Pressure Powered Pump Unit:

AD-1: Section 23 22 00: Revise paragraphs 2.10.B.1 through 2.10.B.3.

1. Triplex unit sized to handle 40,000 LB/HR at 80 PSIG motive pressure and 30 PSIG backpressure.
2. Pumps shall have maximum operating pressure of 200 PSIG. Receiver shall be ASME designed and stamped for 150 PSIG steam at 550 degF.
3. Pumps and receiver shall be pre-piped and as a package unit. Include bronze gate and steel butterfly valves.

AD-1: Section 23 22 00: Revise paragraph 2.10.B.4.

4. Pump shall have float operated, snap acting mechanism with no external seals and packing, heavy duty Iconel springs, stainless steel trim, and hardened stainless steel mechanism bearing components.
5. Provide pumps and receiver with sight glass.
6. Accessories: Pump and receiver insulation covers.

AD-1: Section 23 22 00: Add paragraph 2.10.B.7.

7. Receiver shall be provided with means for overflow and drainage.

2.11 BLOWDOWN SEPARATORS

A. Blowdown separators, steam:
1. Constructed of steel in accordance with ASME code, rated at 250 PSIG .
2. Internal stainless steel baffles and wear plates.
3. Minimum three support legs.
4. Inspection port.
5. Blowdown, vent, and drain connections.
6. Red primer finish.
7. Provide tempering assembly with drain fitting, self contained temperature regulating valve, temperature sensing bulb, bi-metal thermometer, and strainer.

2.12 FLASH TANK

A. Flash tank, steam:
1. Construction: Mild steel.

AD-1: Section 23 22 00: Revise paragraph 2.12.A.2.

2. Maximum operating pressure: 200 psig.
3. Maximum operating temperature: 450 degF.

AD-1: Section 23 22 00: Delete paragraph 2.12.A.4.

4. Deleted

PART 3 - EXECUTION

3.1 PIPING - GENERAL

A. Install in accordance with Section 20 11 00 and Section 20 05 00.

B. Provide drain piping from safety valves and valves that have test levers to floor drain.

3.2 STRAINERS

A. Provide full line size wye strainers ahead of steam control valves (motor operated), steam traps, regulating valves, pumps, and where indicated:
1. See Piping Specialties: Section 20 05 19.

3.3 JOINTS

A. Joints shall be socket welded, butt welded, and flanged.

3.4 INSTALLATION

A. Install drains at low points in mains, risers, and branch lines consisting of a tee fitting, 3/4” ball valve, and short 3/4 IN threaded nipple and cap.

B. Install branch connections to supply mains using 45 degree fittings in main with take-off out of the top of the main. Use of 90 degree tee fittings is permissible, where use of 45 degree fittings is not practical. Where the length of a branch take-off is less than 10 feet, pitch branch line down toward main, 1/2 IN per foot.

C. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

3.5 SLOPES

A. Slope of Pipes: Down in direction of flow 1 IN in 40 FT, unless otherwise specified or indicated on Drawings.

3.6 TESTING

A. Allow no piping to be insulated, concealed, or furred-in until it has been tested to satisfaction of Engineer.

B. Upon completion of a section or of entire piping systems, test pipes as follows:
   1. Steam and Condensate Systems (Vacuum to 30 psig):
      a. Test medium temperature shall not exceed 100 degF.
      b. Test system hydrostatically at 75 psig.
      c. Isolate system from source of pressure, and allow system to stand for four (4) hours during which time no drop in pressure shall occur.
   2. Steam and Condensate Systems (30 to 200 psig):
      a. Test medium temperature shall not exceed 100 degF.
      b. Test system hydrostatically at 225 psig.
      c. Isolate system from source of pressure, and allow system to stand for four (4) hours during which time no drop in pressure shall occur.

C. Repair leaks and replace defective pipe disclosed by tests and repeat tests until no drop in pressure.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.7 CLEANING

A. Cleaning of steam supply piping: Before steam supply system is placed in service either for temporary or permanent use, clean and flush as follows:
   1. For temporary use where additional piping will be added to system as construction proceeds, flush piping by "blowing down" with steam.
   2. At completion of project after piping is complete, flush piping by "blowing down" with steam until visual inspection indicates system cleaned. During "blow down" period: Waste condensate to sewer.
   3. After "blow down" period is complete, thoroughly clean strainers and traps.

B. Cleaning of condensate return piping: Before steam condensate return system is placed in service either for temporary or permanent use, clean and flush as follows:
   1. For temporary use where additional piping will be added to system as construction proceeds, and before strainers, traps, equipment, etc., are installed, flush piping by "blowing down" with steam.
   2. At completion of project after piping is complete, and steam supply mains are "Blown Down", flush steam condensate return piping by "blowing down" with steam until visual inspection indicates system cleaned.
   3. Prior to "blowing down" system remove strainers and traps from system and bypass equipment connected to system.
   4. During "blow down" period: Waste condensate to building sewer.
   5. After "blow down" period, clean strainers and traps and reinstall in piping system. Reconnect equipment previously bypassed.
   6. For steam traps and all equipment, follow manufacturer's installation recommendations.

3.8 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 31 13

AIR DISTRIBUTION SYSTEM (Revised AD-1, AD-4)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. High and low pressure ductwork, fittings and accessories.
   2. Manual dampers.
   3. Fire and smoke dampers.
   4. Backdraft and barametric dampers.
   5. Diffusers, registers and grilles.
   6. Sound attenuators.
   7. Duct access doors.
   8. Control dampers less actuators:
      a. Actuators for control dampers: See Section 25 50 00.

B. Work installed but not furnished:
   1. Automatic dampers: Furnished under Section 25 50 00.
   2. Airflow measuring stations: Furnished under Section 25 50 00.

C. Definitions:
   1. Low and high pressure ductwork: See Part 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: Piping, ductwork and equipment in walls, partitions, floors, pipe chases, pipe shafts, duct shafts and above suspended ceilings.
   4. Exposed insulated surfaces: Piping, ductwork and equipment located in mechanical rooms, tunnels and rooms without suspended ceilings.

D. Location of diffusers, registers and grilles are indicated on Architectural reflected ceiling plans.

E. Control dampers installed in air handling units: delivered to air handling unit manufacturer and factory mounted in unit. Actuators shall be field mounted under Section 25 50 00.

1.2 QUALITY ASSURANCE

A. Design and installation standards:
   1. ASHRAE Handbook - HVAC Systems and Equipment: Current chapter on duct construction.
   2. ADC Standard 1062: GRD-84, Test Code for Grilles, Registers and Diffusers.
   3. ADC Test Code FD 72-R1, Flexible Air Duct Test Code.
   4. AMCA Standard 210, Test Code for Air Moving Devices.
   5. ASHRAE Standard 70-72, Method of Testing for Rating the air flow performance of outlets and inlets.
   6. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems, current edition.
   7. SMACNA HVAC Duct Construction Standard - Metal and Flexible, Current Edition.

B. Fire and smoke rating test standards: ASTM-E84, NFPA-255 and ANSI/UL-723.

C. Duct sizes indicated are internal sizes.

1.3 SUBMITTALS

A. Shop drawings:
   1. Ductwork layout at 1/4 IN to 1 FT scale.

B. Product data:
   1. Ductwork and fittings, high pressure.
   2. Dampers, nonrated.
   3. Dampers, fire.
   4. Dampers, smoke.
   5. Diffusers, registers and grilles.
   6. Sound Attenuators.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Test reports.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Flat oval and round spiral ductwork, high pressure:
      a. Base:
         1) United McGill Airflow Corporation.
      b. Optional:
         1) Semco Incorporated.
         2) Sheet Metal Connectors, Inc.
         3) Eastern Sheet Metal, Inc.
   2. Factory fabricated duct connection systems:
      a. Base:
         1) Ductmate Industries.
      b. Optional:
         1) Nexus.
         2) Ward Industries, Inc.
   3. Sealants:
      a. Base:
         1) Hardcast.
      b. Optional:
         1) Hardcast.
         2) United McGill Airflow Corporation.
         3) Foster (Division of HB Fuller).
   4. Turning vanes:
      a. Base:
         1) Aerodyne Controls.
      b. Optional:
         1) Airsan.
         2) Tuttle & Bailey.
         3) Titus.
         4) VentProducts.
   5. Flexible fan connections:
      a. Base:
         1) Ventfabrics.
      b. Optional:
         1) Duro-Dyne.
         2) Elgin.

6. Flexible duct, preinsulated:
    a. Base:
        1) Atco.
    b. Optional:
        1) Flexible Technologies, Thermaflex.
        2) Hart and Cooley.
7. Flexible ducts, uninsulated:
    a. Base:
        1) United McGill Corp.
    b. Optional:
        1) ATCO Rubber Products, Inc.
        2) Or approved equal.
8. Access Doors, low and high pressure:
    a. Base:
        1) Ductmate.
    b. Optional:
        1) Ward Industries.
        2) United McGill Airflow Corporation.
9. Dampers(manual, backdraft, barametric):
    a. Base:
        1) Ruskin Manufacturing.
    b. Optional:
        1) Arrow.
        2) Louvers and Dampers, Inc.
        3) American Warming & Ventilating.
        4) Air Balance.
        5) Cesco Products.
10. Fire and smoke dampers:
    a. Base:
        1) Ruskin Manufacturing.
    b. Optional:
        1) Air Balance.
        2) Greenheck.
        3) Nailor-Hart Industries, Inc.
        4) Prefco Products.
        5) Safe-Air of Illinois.
        6) CESCO products.
11. Diffusers, registers and grilles:
    a. Base:
        1) Titus.
    b. Optional:
        1) Carnes.
        2) Anemostat Air Products.
        3) Tuttle & Bailey.
        4) Krueger.
        5) Price.
12. Sound Attenuators:
    a. Base:
        1) Vibro-Acoustics.
    b. Optional:
        1) AeroSonics.
        2) Dynasonics.

3) Rink Sound Control.
4) Semco Incorporated.
5) TranSonics.
6) United McGill Airflow Corporation.

13. Pressure relief doors:
    a. Base:
        1) Ruskin.
    b. Optional:
        1) Kees.

B. Sheet metal:
1. Galvanized steel (G90): ASTM-A653/A653M.
2. Stainless steel: ASTM-A167.

C. Duct sealer: NFPA rating of "Non-Combustible":
1. Flame spread rating: 25 or lower, in dry condition.
2. Smoke developed rating: 50 or lower, in dry condition.
3. Resistant to water and water vapors.
4. Pressure rupture rating: 16 IN WG , minimum.
5. 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.

D. Solder: ASTM-B23, Grade-50B.

E. Duct sealing tape: NFPA rating of "Non-Combustible":
1. Flame spread rating: 25 or lower, in dry condition.
2. Smoke developed rating: 50 or lower, in dry condition.
3. Adhesive: Specifically compounded for maximum adhesion to galvanized and stainless steel.
4. Durkee-Atwood Permatite Class I Insta-Seal; Hardcast Aluma-Grip 701 and Flange Grip 1902; or United McGill Sheet Metal Uni-Cast tape.

F. RTV foam: UL listed room temperature vulcanized silicone rubber foam.

2.2 DUCTWORK

A. Ductwork - general:
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 Owner approval.
    c. Modifications increasing aspect ratio beyond 5:1 require Owner approval.
3. Provide necessary transitions and offsets to complete systems.
4. All systems shall be constructed of G90 galvanized steel, except as follows:

AD-1: Section 23 31 13: Revise paragraph 2.2.A.4.a.

    a. Laboratory exhaust branch ducts from fume hoods and canopy hoods to horizontal duct mains: 316 stainless steel.

B. Ductwork, low pressure, sheet metal:
1. Construct in accordance with SMACNA HVAC Duct Construction Standard as follows:
    a. Rectangular duct: Table 1-6, 3 IN WG static pressure, positive or negative.
    b. Rectangular duct: Table 1-7, 4 IN WG static pressure, positive or negative.
    c. Round duct: Table 3-2A, 4 IN WG static pressure, positive or negative.
2. Low pressure ductwork, 3 IN WG static pressure includes:
    a. Outside air ductwork.
    b. Return air ductwork, unless otherwise noted.
    c. All general exhaust ductwork.
    d. All supply ductwork serving FCU'S.
3. Low pressure ductwork, 4 IN WG static pressure includes:

a. Relief ductwork.
b. All supply ductwork downstream of air terminal units.

4. Transverse joints, rectangular:
   a. Ducts with longest side 36 IN and longer:
      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.
   b. Ducts with longest side shorter than 35 IN:
      1) Flanged duct connection systems as defined above are optional.
      2) Refer to SMACNA HVAC Duct Construction Standard for proper duct construction.
5. Longitudinal seam: Use Pittsburgh lock seam only.
6. Seal low pressure ducts to Seal Class A requirements.
7. Runouts to diffusers, register and grilles: Insulated flexible ducts may be used:
   a. Exception: Flexible ducts may not pass through smoke or fire rated walls, floors or ceilings.
   b. Flexible duct length: 6 FT maximum.
   c. Minimum turning radius:
      1) As recommended by manufacturer.
      2) Do not kink, bend or restrict free area of duct as to generate additional pressure drop or noise.

C. Ductwork located outside, exposed to weather:
   1. Construct using flanged duct connection systems.
   2. Seal flanged ends with pressure sensitive, high density, closed cell, neoprene or polyurethane tape gasket.
   3. Use continuous cleat seals on top joints of ducts.

D. Ductwork, high pressure:
   1. Construct in accordance with SMACNA HVAC Duct Construction Standard as follows:
      a. Rectangular duct: Table 1-8, 6 IN WG static pressure, positive or negative.
      b. Round duct: Table 3-2A, 10 IN WG static pressure.
   2. High pressure ductwork includes:
      a. Supply ductwork serving AHU from air handling unit discharge to connection with air valves/terminal units.

AD-1: Section 23 31 13: Revise paragraph 2.2.D.2.b.

b. All exhaust ductwork serving laboratories.

3. Runouts to air terminal units: Rigid or flexible ductwork.
   a. Exceptions:
      1) Flexible ducts may not pass through smoke or fire rated walls, floors or ceilings.
      2) Flexible ducts shall not be used for connections to air terminal units for exhaust or return systems.
   b. Flexible duct length: 4 FT minimum, 6 FT maximum.
   c. Minimum turning radius:
      1) As recommended by manufacturer. Do not kink, bend or restrict free area of duct as to generate additional pressure drop or noise.
      2) Ninety degree bends are not allowed.
4. Seal high pressure duct to seal Class A requirements.

E. Duct hangers and supports: In accordance with following:
   1. High and low pressure ductwork (sheet metal): SMACNA HVAC Duct Construction Standard, Section IV.

F. Duct fittings and joints on low pressure systems:
   1. Radius elbows without vanes: Radius ratio (R/W) of 1.5 and greater.

2. 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 Figure 2-3, SMACNA HVAC Duct Construction Standards.
3. Where square elbows are indicated or required, provide with turning vanes.
4. Connections to diffusers, grilles and registers: Fitted securely to necks or collars provided behind diffuser, grille, or register face area.
5. Branch connections:
    a. Round: Factory built short cone or bellmouth type. Air scoops are not acceptable.
    b. Rectangular: 45 degree entry type or radius elbow.
6. Provide necessary transition pieces and duct collars to make connections to ductwork from neck sizes scheduled or indicated on drawings.
7. Where building walls, floor and ceilings form portions of duct or plenum, provide gasketed angles or channels at junction points, securely bolted to building structure.

G. Duct fittings and joints on high pressure systems:
1. Elbows 3-8 IN diameter: Die stamped, for minimum air friction loss, with continuous corrosion resistance welds.
2. 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.
3. Tees: "Low loss, short cone type", unless specifically detailed otherwise for space limitations.
4. "Y's" 45 degree type. 60 degree type may be used if space conditions dictate.
5. Install "Y's" as indicated.
6. Where tees are indicated, "Y's" may be substituted if space is available.
7. "Y's": Straight sided type (no cone).
8. Takeoffs from air handling unit plenums: Standard Bellmouth fittings:
    a. Construct in accordance with SMACNA HVAC Duct Construction Standards.
9. "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.

H. Turning vanes: For square elbows:
1. Velocities up to 2500 FPM: Single vane, runner Type 2, 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 degrees angle to give optimum turning.

I. 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.

J. Flexible fan and duct 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.

K. Flexible ducts, preinsulated:
   1. Low pressure construction:
      a. Liner: Steel wire helix encapsulated within a double lamination of polyester.
      b. Insulation: 1 IN x 3/4LB/CF fiberglass insulation, minimum resistance of R-4.2.
      c. Insulation: 1 IN x 3/4 LB/CF fiberglass insulation, minimum resistance of R-6. Jacket: Bi-directional metalized polyester.
   2. High pressure supply construction:
      a. Insulation: 1 IN x 3/4 LB/CF fiberglass insulation, minimum resistance of R-4.2.
      b. Jacket: Bi-directional metalized polyester.

L. Flexible ducts, uninsulated:
   1. Provide for all connections to HEPA filter diffusers and where indicated.
   2. Medium pressure construction:
      a. Heavy gauge corrugated aluminum.
      b. Aluminized mylar, wire reinforced and fabric type not permitted.
   3. Rated working pressure:
      a. Medium pressure duct: Positive 8 IN minimum.
   4. Fire resistant, self extinguishing, UL Standard 181, Class 1 with flame spread of 25 or less and smoke development not to exceed 50.
   5. Medium pressure connections:
      a. Secure duct to collar or sleeve with duct sealer and number and type of fasteners as required in SMACNA HVAC Duct Construction Standards.
   6. Duct sealer: E Moore Co., Tuff-bond No. 12; or Benjamin Foster No. 30-02.
   7. Turn radius: Not less than R/D equal to 1.0.
   8. Provide flexible duct supports in accordance with Figure 3-9 and 3-10, SMACNA HVAC Duct Construction Standards.

M. Access doors:
   1. Provide at fire dampers, smoke dampers, smoke detectors, duct mounted automatic dampers, pressure and temperature sensors, air plenums behind louvers and at other locations as required. Access doors shall be positioned to permit easy visual inspection and to allow maintenance and resetting of the device served. Increase duct dimensions at devices when necessary to accommodate required access. Wherever possible, access doors shall be installed above accessible lay-in ceilings. Where access doors are installed above gypboard ceilings or within shafts, provide access panels per Section 20 05 00.
   2. Low and high pressure ductwork:
      a. Construction: Access doors shall be removable, double wall construction with 1 IN thick fiberglass insulation, closed cell neoprene gasket and attachment bolts, to provide an air tight seal up to static pressures of 20 IN WG.
      b. Sizes shall be as follows:
         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.

2.3 DAMPERS

A. Dampers - general:
   1. Sizes and types: As indicated.
   2. Locate as indicated.
   3. Factory built and assembled dampers.

B. Dampers, control:
   1. Furnish under Section 25 50 00.
   2. Install as specified in this section.

C. Dampers, manual (rectangle and square):
   1. Opposed blade type, fitted with shank bolts, marked for direction (open/closed).
   2. Provide for double socket wrenches to fit square shank and locking hex nut.

3. Construction: Heavy black iron frames, flat or angle iron, with blades of 16 GA galvanized steel, equipped with brass pin running on stainless steel pivot for vertical axis.

D. Damper, manual (round):
1. Butterfly type with circular blade mounted to shaft.
2. Frame: Minimum 14 GA galvanized steel channel.
3. Blade: Minimum 16 GA galvanized steel.
4. Axle: 1/2 IN diameter.
5. Bearings: Self-lubricating nylon or stainless steel sleeve.

E. Dampers, backdraft, low pressure:
1. Counterbalanced, gravity operated.
2. Fabricate of aluminum.
3. Blades: Provided with common linkage rod and felt seals.

F. Dampers, barametric, low pressure:
1. Counterbalanced, static pressure operated.
2. Counterweight adjustable to hold damper blades closed until specified static pressure is reached.
3. Fabricate of aluminum.
4. Blades: Provided with common linkage rod and felt seals.

2.4 FIRE DAMPERS

A. Fire dampers - general:
1. UL labeled, 1.5 Hour 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.

AD-4: Section 23 31 13: Revise paragraph 2.4.A.6.

6. For curtain-type fire dampers, blades must be out of air stream (Style B fire damper), except for application with wall mounted prop fans at Building 223 (Style A fire damper).

B. Fire dampers in low pressure ducts:
1. Provide curtain type damper, Ruskin Model DIBD2:
   a. Rated up to 2375 FPM at 4 IN WG for vertical mounted applications.
   b. Rated up to 2520 FPM at 4 IN WG for horizontal mounted applications.

C. Fire dampers in high pressure ducts:
1. For vertical mounted applications: curtain type damper, Ruskin Model DIBDX2:
   a. Rated up to 4550 FPM at 8 IN WG.
2. For horizontal mounted applications: multiple blade dynamic damper, Ruskin Model DFD60:
   a. Rated up to 2000 FPM at 4 IN WG.

2.5 SMOKE DAMPERS

A. Smoke dampers - general:
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. Actuator shall not be inside of duct.
6. 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.
7. Frame: 16 GA galvanized steel, minimum.

8. Loss through wide open damper:
    a. Not more than 0.15 IN WG at 3000 FPM face velocity for high pressure.
    b. Not more than 0.15 IN WG at 2000 FPM face velocity for low pressure.
9. Provide factory supplied caulked sleeve.
10. Provide smoke dampers as indicated.

B. Smoke dampers, low pressure:
1. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
2. UL555S Leakage Rating: Class I (4 CFM/ SF at 1 IN WG):
    a. Ruskin Model SD37.
3. Blades: Single or double thickness type:
    a. Single thickness type: 16 GA steel, minimum.
    b. Double thickness type: 18 GA steel.
4. Blade width: Not more than 6 IN.
5. Single blade dampers may be used for up to 8 IN wide blade, or up to 12 IN round.

C. Smoke dampers, square or rectangular, high pressure:
1. Parallel or opposed blade type with linkage for automatic operation.
2. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
    a. Ruskin Model SD60 or SD50.
3. On round or flat oval ductwork:
    a. Provide dampers in an enclosure with round or oval connections on each side.

D. Smoke dampers, round or flat oval, high pressure:
1. Single blade type with encompassed blade edge seal.
2. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
    a. Ruskin Model SDRS25.

E. Damper actuator (operator): Electric type, factory installed:
1. Two-position type.
2. 120 VAC.
3. Spring return fail closed.
4. UL listed at 250 degF.

2.6 COMBINATION FIRE-SMOKE DAMPERS

A. Fire-smoke dampers, combination - general:
1. UL classified as a Leakage Rated damper under UL555S, latest edition, bearing a UL label attesting to same.
2. UL555 fire rating: 1.5 Hour.
3. Suitable for velocity and pressure of system.
4. Compressible metal jamb seals.
5. Actuator installed per UL requirements, in accessible location and visible for inspection.
6. Actuator shall not be inside duct.
7. 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.
8. Frame: 16 GA galvanized steel, minimum.
9. Loss through wide open damper based on AMCA Test Figure 5.3:
    a. 12 IN x 12 IN duct size: Not more than 1.25 IN WG at 3000 FPM face velocity.
    b. 24 IN x 24 IN duct size: Not more than 0.45 IN WG at 3000 FPM face velocity.
    c. 36 IN x 36 IN duct size: Not more than 0.3 IN WG at 3000 FPM face velocity.
10. Provide factory supplied caulked sleeve.
11. Provide fire-smoke dampers as indicated.

B. Fire-smoke dampers, combination, low pressure:
1. Parallel blade type with blades hinged together for operation in unison and bearings arranged for automatic operation.
2. May be used in lieu of separate fire and smoke dampers.

3. UL555S Leakage Rating: Class I (4 CFM/SF at 1 IN WG):
   a. Ruskin FSD37.
4. Fusible link: 165 degF melting point.

C. Fire-smoke damper, combination, high pressure:
1. Parallel blade type.
2. May be used in lieu of separate fire and smoke dampers.
3. UL555S Leakage Rating: Class I (8 CFM/ SF at 4 IN WG):
   a. Ruskin Model FSD60 .
4. Fusible link: 165 degF melting point.

D. Damper actuator (operator): Electric type, factory installed:
1. Two-position type.
2. 120 VAC.
3. Spring return fail closed.
4. UL listed at 250 degF.

2.7 DIFFUSERS, REGISTERS AND GRILLES

A. Diffusers, ceiling:
1. Square type.
2. Size, type and manufacturer: As scheduled.
3. Finish of steel units: Factory applied, baked or electrocoated enamel; color as selected by Architect/Engineer or as indicated.
4. Provide necessary screws, duct collars, transitions and air pattern deflectors.
5. Provide opposed blade dampers where indicated.

B. Diffusers, radial throw type:
1. Size, type and manufacturer: As scheduled.
2. Provide with steel housing with hinged face to allow filters to be replaced from within the room without requiring access to the ceiling.
3. Diffusers: Capable of 180 degree radial throw pattern.
4. Provide gasket material around frame body on frame face of air seal.
5. Finish: Baked, white epoxy finish.
6. Provide with HEPA filter where indicated on plans.

C. Air grilles and registers:
1. Size, type and manufacturer: As scheduled.
2. Finish of steel units: Factory applied, baked or electrocoated enamel; color as selected by Architect/Engineer or as indicated.
3. Provide necessary screws, duct collars and transitions.
4. Provide opposed blade dampers in registers where indicated.

D. Diffusers and grilles, linear slot type:
1. Size, type and manufacturer: As scheduled on drawings.
2. 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.
3. Extruded aluminum or steel ceiling linear diffuser.

2.8 SOUND ATTENUATORS

A. 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 percent thicker than steel specified.
7. Use straight through air passages.
8. Use airtight construction:

a. Make unit 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.

B. Sound attenuators, noise reduction (NR) rating:
1. Tests made in such manner as to eliminate end reflections, beaming or directivity, flanking, standing waves, and room absorptions.
2. Test method may be either "in-duct with anechoic termination" or "reverberant rooms with tunnel between".
3. Size of units tested: Not smaller than 24 IN x 24 IN rectangular or 24 IN round outside, with full size connections.
4. Submit corroborative report of tests made in nationally recognized, qualified, independent testing laboratory approved by AMCA for airflow determinations.

C. Sound attenuators, airflow pressure drop rating:
1. Do not exceed pressure drop at specified airflow(s).
2. Base rating on results of tests made in manner to provide reliable data.
3. Basic setup: Standard code method as adopted by AMCA for testing fans.

D. Sound attenuators, acoustical fill:
1. Inert, vermin and moisture proof, inorganic glass or mineral fiber.
2. Pack behind partitions or splitters under not less than 5 percent compression to provide "spring" and avoid settling.
3. Fill containment: totally encapsulated and sealed with a polymer film. Separate fill material from perforated baffle by a non-combustible, erosion resistant, acoustical stand-off. Refer to schedule for applicability.

PART 3 - EXECUTION

3.1 GENERAL

A. Install and coordinate systems and components.

B. Install air flow measuring stations furnished with Section 25 50 00 in accordance with manufacturer's installation instructions and as specified.

3.2 INSTALLATION OF DUCTWORK

A. Install generally as indicated.

B. Conceal ductwork in finished spaces unless indicated otherwise.

C. 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.

D. Exercise special care to provide tight fitting well fabricated, well braced ductwork systems.

E. Field assemble rectangular or round ductwork as follows:
1. Use duct joint sealer applied slip joints.
2. Use Ductmate Spiralmate or Ovalmate 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.

F. In high pressure round ductwork, do not use 2 piece mitered 90 degree elbows with or without vanes.

G. Fabricate duct connections for openings, fans, and other devices.

H. 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.

I. Do not bend or otherwise restrict the free area of flexible ductwork.

J. Install air terminal units for easy access from floors and from above ceiling platforms:
   1. Obtain Owner’s approval prior to proceeding with installation of air terminal units.

3.3 INSTALLATION OF FIRE AND SMOKE DAMPERS

A. Install in accordance with manufacturer's instructions and UL requirements:
   1. See Section 07 84 00.

B. Provide typical, prototype installation to include wall mounted dampers for the different wall constructions. Obtain approval of Owner's Fire Protection Authority before proceeding with the remainder of the damper installations. Submit certificate of approval to Owner's Physical Facilities prior to installation of any other fire and smoke dampers.

3.4 PERFORMANCE TESTS

A. Owner's representative to perform random visual examination of each duct section.

B. Owner to employ the services of a qualified testing agency.

C. When testing indicates that ductwork does not meet leakage class 6 as defined in SMACNA HVAC Systems Duct Design Manual for Seal Class A, discretionary judgement by Owner and the Owner will be used to determine the extent of work rejected due to failed leak tests.

D. All work rejected must have joints disassembled and remade as required to pass leakage testing at no additional cost to Owner.

3.5 CLEANING

A. At substantial completion, clean work installed under this section. Wipe ducts clean inside.

3.6 EQUIPMENT DEMONSTRATION

A. At substantial completion, inspect and test, and operate satisfactorily, in presence of Owner 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 (Revised AD-1, AD-4)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Tube axial inline fans.

AD-4: Section 23 35 00: Add paragraph 1.1.A.2 and renumber subsequent paragraphs.

   2. Propeller fans.
   3. Roof exhaust fans.
   4. Mixed-flow exhaust fans.

B. Abbreviations:
   1. AMCA: Air Moving and Conditioning Association.
   2. ADC: Air Diffusion Council.
   3. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers.

1.2 QUALITY ASSURANCE

A. Standards:
   1. ADC Standard 1062R2, Air Diffusing Equipment Test Code.
   2. AMCA Standard 210, Test Code for Air Moving Devices.
   3. ASHRAE Standard 70, Method of Testing for Rating the air flow performance of outlets and inlets.
   4. NFPA-90A, Standard for the Installation of Air Conditioning and Ventilating Systems, 1980 edition.

1.3 SUBMITTALS

A. Product data:
   1. Tube axial inline fans:
      a. Performance data.
      b. Physical dimensions.
      c. Fan curves.
      d. Sound data.

AD-4: Section 23 35 00: Add paragraphs 1.3.A.2 through 1.3.A.2.d. Renumber subsequent paragraphs.

   2. Propeller fans:
      a. Performance data.
      b. Physical dimensions.
      c. Fan curves.
      d. Sound data.
   3. Roof exhaust fans:
      a. Performance data.
      b. Physical dimensions.
      c. Fan curves.
      d. Sound data.
   4. Mixed-flow exhaust fans:
      a. Performance data.
      b. Physical dimensions.
      c. Fan curves.
      d. Sound data.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.

1.4 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by Owner for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

1.5 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Fans (General):
      a. Members of AMCA.
   2. Tube axial inline fans:
      a. Base: See schedule.
      b. Optional:
         1) Barry Blower.
         2) Cook, Loren.
         3) Penn Ventilator.
         4) Twin City Fan & Blower.
         5) Acme Engineering and Manufacturing.

AD-4: Section 23 35 00: Add paragraphs 2.1.A.3 through 2.1.A.3.b.5). Renumber subsequent paragraphs.

   3. Propeller fans:
      a. Base: See schedule.
      b. Optional:
         1) Carnes.
         2) Cook, Loren.
         3) New York Blower.
         4) Penn Ventilator.
         5) Greenheck.
   4. Roof exhaust fans:
      a. Base: See schedule.
      b. Optional:
         1) Carnes.
         2) Acme Engineering and Manufacturing.
         3) Aerovent, TCF.
         4) Cook, Loren.
         5) Jenn Industries.
         6) Penn Ventilator.
   5. Mixed-flow exhaust fans:
      a. Base:
         1) Strobic Air.
      b. Optional:

1) Greenheck.

6. V-belt drives:
   a. Base:
   b. Optional:
      1) Fairbanks Morse Engine.
      2) Gates.
      3) Reliance Electric.

B. Fans - General:
   1. Performance ratings: Based on laboratory tests conducted in accordance with latest edition of ASHRAE/AMCA Standard Test Codes.
   2. Ratings: As indicated.
   3. Arrangement and drive: As indicated.
   4. Provide removable belt guard.
   5. Drive sheaves:
      a. Cast iron, split tapered bushings dynamically balanced at factory.
      b. Provide wide range variable speed adjustable sheaves to be used for balancing systems.
      c. Provide final fixed pitch drive sheaves for proper RPM determined during balancing process.
   6. Fans 5 HP and less: Provide with adjustable sheaves.
   7. Finish: Applied enamel.

C. Bearings: Extra heavy duty self-aligning ball, roller, or sleeve type, grease lubricated.

D. Motors and control: As specified in Section 20 05 00.

E. Housings:
   1. Constructed of steel scroll and side sheets conforming to standard gauges of National Association of Fan Manufacturers.
   2. Continuously welded construction.
   3. Mount in heavy steel supports on both sides.
   4. For outdoor installation provide hinged weather hood that will cover both drive and motor.

F. 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.

G. Belt guards: As specified in Section 20 05 00.

H. Vibration Control:
   1. Framework shall be of sufficient rigidity to assure fan and motor meet vibration requirements specified in Section 20 05 50. Fan shaft shall be steel, solid and totally ground and polished. Fan shall be keyed to the shaft and locked in place with set screws. Shaft shall have grounding system for protection from static and AFD induced currents.
   2. Fans shall be dynamically balanced and run tested at the factory as a complete fan assembly (fan wheel, motor, and drive) to achieve maximum fan vibration, measured on fan bearings, of 2 mm per second rms. Fan vibration readings shall be taken in accordance with ANSI S2.19 grade G6.3. Fan shaft shall not exceed 75 percent of its first critical speed at any cataloged rpm.

2.2 TUBE AXIAL INLINE FANS

A. Tube axial inline:
   1. Fans shall be UL/cUL listed for emergency heat and smoke removal. Fan shall be rated for 300 degF maximum temperature for a minimum of 5 hours of operation.
   2. Base fan performance at standard conditions (density 0.075 LB/FT^3).
   3. Fans selected shall be capable of accommodating static pressure and flow variations of +/- 15 percent of scheduled values.
   4. Each fan shall be belt driven in AMCA arrangement 9 with propeller secured to the motor shaft.
   5. Fans are to be equipped with lifting lugs.
   6. After fabrication all carbon steel components shall be cleaned and chemically treated by a phosphatizing process to insure proper removal of grease, oil, scale, etc. Fan shall then be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be industrial gray. Coating must exceed 1,000-hour salt spray under ASTM B117 test method.
   7. Fan housing shall be constructed of continuously welded steel and include an integral punched inlet and outlet flange to prevent air leakage.
   8. Fans shall incorporate universal mounting system to allow for vertical base mount configuration.
   9. Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings.
   10. Belts, bearings and drives shall be protected from the airstream by heavy gauge steel belt tubes and bolted bearing covers.
   11. An OSHA compliant belt guard shall be included to completely cover the motor pulley and belt(s).
   12. The fan propeller shall be fabricated steel available in two levels of construction and include "Low and High" pressure blade pitch angles. Airfoil blades shall be continuously welded to heavy duty hubs to ensure long life in the harshest applications.
   13. A standard square key or tapered bushing shall lock propeller to the fan shaft. Hubs shall be two piece aluminum castings that securely lock the blades in place.
   14. Wheels shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.
   15. Aluminum propeller parts shall not require protective coatings.
   16. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.
   17. Motors shall meet or exceed EPACT (Energy Policy ACT) efficiencies. Motors to be NEMA T-frame, 1800 or 3600 RPM, Open Drip Proof (ODP) or Totally Enclosed Fan Cooled (TEFC) with a 1.15 service factor.
   18. Drive belts and sheaves shall be sized for 150 percent of the fan operating brake horsepower, and shall be readily and easily accessible for service, it required.
   19. Fan shaft to be turned and polished steel that is sized so the first critical speed is at least 25 percent over the maximum operating speed for each pressure class.
   20. Fan shaft bearings shall be Air Handling Quality, bearings shall be heavy-duty grease lubricated, self-aligning or roller pillow block type.
   21. Air Handling Quality bearings to be designed with low swivel torque to allow the outer race of the bearing to pivot or swivel within the cast pillow block. Bearings shall be 100 percent tested for noise and vibration by the manufacturer. Bearings shall be 100 percent tested to insure the inner race diameter is within tolerance to prevent vibration.
   22. Bearings shall be selected for a basic rating fatigue life (L-10) of 40,000 hours at maximum operating speed for vertical mount.
   23. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed.
   24. Bearings shall have Zerk fittings to allow for lubrication.

AD-4: Section 23 35 00: Add article 2.3 in its entirety and renumber subsequent articles.

2.3 PROPELLER FANS

A. Propeller fans, wall mounted:
   1. Belt drive, AMCA labeled.
   2. Fan capacity and RPM: As indicated.
   3. Wheel:
      a. Material type: Steel blades and hubs.
      b. Securely attached to fan shaft by welding or with standard square key and set screw or tapered bushing.
      c. Statically and dynamically balanced in accordance with AMCA Standard 204-05.
      d. The propeller and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.
   4. Motors:
      a. Motor enclosures: ODP or TEFC
      b. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and furnished at the specific voltage and phase.
      c. Accessible for maintenance.
   5. Shafts and bearings:
      a. Fan shaft shall be ground and polished solid steel with an anti corrosive coating.
      b. Bearing shall be cast iron pillow block with grease fittings.
      c. Bearings shall be selected for a minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
      d. Bearing shall be air handling quality and 100 percent factory tested by bearing manufacturer.
      e. Fan shaft first critical speed is at least 25 percent over maximum operating speed.
   6. Drive frame:
      a. Drive frame assemblies shall be galvanized steel, and bolted construction.
      b. Drive frame shall have formed channels and fan panels shall have prepunched mounting holes, formed flanges and a deep formed one piece inlet venturi.
   7. Drive assembly:
      a. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
      b. Belt: Static free and oil resistant.
      c. Fully machined cast iron pulley, keyed and securely attached ot the wheel and motor shafts.
      d. The motor pulley shall be adjustable for final system balancing.
      e. Readily accessible for maintenance.
   8. Options/Accessories:
      a. Dampers:
         1) Type: Gravity.
         2) Prevents outside air from entering back into the building when fan is off.
         3) Balanced for minimal resistance to flow.
         4) Galvanized frames with prepunched mounting holes.
      b. Dampers guards:
         1) Guard material: Galvanized
         2) Shall completely enclose the damper or wall opening on the discharge side of the fan.
      c. Finish:
         1) Type: Baked enamel.
      d. Wall housing:
         1) Mounting arrangement: As indicated.
         2) Construction of galvanized steel with heavy gauge mounting flanges and prepunched mounting holes.
         3) Housing shall include OSHA approved motor guard.

2.4 ROOF EXHAUST FANS

A. Roof exhaust fans:

AD-4: Section 23 35 00: Revise paragraph 2.4 (formerly 2.3) A.1.

1. Centrifugal, direct or belt driven (as scheduled), curb mounted type, AMCA labeled.
2. Capacity: As scheduled.
3. Housing: Extruded or heavy gauge sheet aluminum mounted on rigid support structure:
   a. Wind band, for upward discharge of air, welded to curb cap.
   b. Square base to match roof curb.
4. Motor and drive: Isolated from exhaust air stream:
   a. Provide overload protection.
   b. Isolate each fan motor and drive from enclosure with vibration isolators.
   c. Provide variable pitch motor pulleys for belt drive fans.
5. Bearings:
   a. Pillow block ball type minimum L10 life in excess of 100,000 hours.
6. Fan wheel: Backward curved, dynamically and statically balanced.
7. Provide factory installed and wired disconnect device outside motor compartment.
8. Provide factory prefabricated, insulated roof curbs:
   a. Curb height: 12 IN, above finished roof.
   b. Type to suit roof construction and provide water tight enclosure.
   c. Provide sound attenuating galvanized steel or aluminum baffles in curb throat.
   d. Provide level installation, regardless of roof slope.
9. Provide 1/2 IN mesh birdscreen on outlet.
10. Provide self acting backdraft damper in curb base.
11. Factory wired, solid state speed controller, on direct drive fans.

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 Automatic Temperature Contractor at start-up of the ATC 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.

AD-1: Section 23 35 00: Revise paragraph 2.4.B.4.

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. Stack extension shall be braced to wall as shown.
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 or one per every two fans on a multiple fan plenum.
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 number of fans listed on the schedule. Multiple fan plenums shall be double wall construction with structural stiffeners or shall be continuously welded, heavy gauge single wall construction.
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.

AD-4: Section 23 35 00: Add paragraph 2.5 (formerly 2.4) C.5 through C.8. Renumber subsequent paragraphs.

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 with all three fans running 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 and multiple fan plenums.

2.6 VIBRATION ISOLATION

A. Vibration isolation: Section 20 05 50.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fans, general:
   1. Install in accordance with manufacturer's recommendations and as specified.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

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 all fans in the field after they have been set in place and installation is complete. 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 the vibration specifications above, performed after system has been balanced and final fixed pitch drive sheaves installed.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 36 00

AIR TERMINAL UNITS AND AIR VALVES (Revised AD-1)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Air terminal units.
   2. Air valves.

B. Operators and controllers:
   1. Operators and controllers for air terminal units: Provided in Section 25 50 00.
   2. Operators and controllers for air valves: Provided by air valve manufacturer.

C. Definitions:
   1. Low pressure ductwork: Refer to Section 23 31 13.
   2. High pressure ductwork: Refer to Section 23 31 13.

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.

1.3 SUBMITTALS

A. Product data:
   1. Air Terminal units.
   2. Air valves.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.

1.4 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by Owner for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

1.5 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Air terminal units:
      a. Base:
         1) Titus
      b. Optional:
         1) Price.
         2) Trane.
         3) Krueger.
   2. Air Valves:
      a. Base:
         1) Phoenix.
      b. Optional:
         1) TriaTek.

2.2 AIR TERMINAL UNITS

A. Air terminal units - general: Factory assembled.
   1. Configured for pressure independent control.
   2. Capacity: As indicated.
   3. Noise level: As scheduled.
   4. DDC Controllers and Operators: Furnished under Section 25 50 00 but factory installed and wired under this section.
      a. Section 25 50 00 will furnish 120V/24V transformer and power disconnect to power all control devices in the unit.
      b. This contractor shall install and wire all devices at the factory. The air terminal units shall be configured to have a single point 120V connection to power all electrical devices in the unit.
      c. All wiring shall be plenum rated. There shall be no exposed 120 volt terminals in control cabinet.
   5. Acoustical fiberglass liner:
      a. Comply with NFPA-90A for fire resistivity and UL Standard 181 for erosion.
      b. 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.
   6. Provide multi-point velocity pressure sensors with external pressure taps.
   7. Provide static pressure tube(s).
   8. Valve adjustment: Field adjustable.
   9. Set air terminal units to air flow rates indicated.
   10. Casing leakage: 5 percent, maximum, of nominal rated capacity at 3.0 IN WG internal pressure.

B. Heating coils for air terminal units: ARI certified, continuous plate or spiral fin type, leak tested at 300 PSI.
   1. Capacity: As indicated.
   2. Headers: Copper or brass.
   3. Fins: Aluminum, maximum 8 fins per IN.
   4. Tubes: Copper, arrange for counter-flow of heating water.
   5. Water velocity: 8 FPS maximum with head loss not greater than indicated.
   6. Provide 20 GA galvanized steel casing with slip and drive construction for attachment to metal ductwork.
   7. Provide vent and drain connection at high and low point, respectively, of each coil.

C. Air terminal units, single duct, with or without coils: Constant or variable volume, unit with or without reheat coil, as indicated.

1. Construction: 22 GA galvanized steel or 0.040 IN aluminum, minimum.

AD-1: Section 23 36 00: Delete paragraph 2.2.C.2.

2. Deleted
3. Sound Attenuators: Provide where indicated on schedules.

2.3 AIR VALVES

A. Air valves, flow control:
1. All air valves shall be variable volume control type.
2. Airflow control device shall be a venturi valve.
3. Pressure independent over a 0.6 IN WG – 3.0 IN WG drop across valve.
4. Volume control accurate to plus or minus 5% of airflow over an airflow turndown range of 16 to 1. No minimum entrance or exit duct diameters shall be required to ensure accuracy or pressure independence.
5. Response time to duct static pressure change less than one second.
6. 16 gauge aluminum continuous welded seam valve body with corrosion resistant baked phenolic coatings, control device, shaft, shaft support bracket, pivot arm and internal mounting link. The control device shall have a baked on corrosion resistant phenolic coating. The shaft shall have a Teflon coating and all shaft bearing surfaces shall be made of Teflon. The pressure independent springs shall be made of stainless steel.
7. The airflow device shall have no exposed stainless steel components. The shaft support brackets, pivot arm, internal mounting link, and pressure independent springs shall have a baked-on corrosion resistant phenolic coating. Internal nuts, bolts, and rivets shall be titanium or phenolic coated stainless steel.
8. Actuator to be factory mounted to the valve.
9. Closed loop control of airflow by way of flow feedback signal with less than 120 seconds of response time.
10. Valves shall modulate from minimum to full flow in response to 0-10 vdc input signal.
11. Valves shall provide 0-10 vdc feedback signal factory calibrated to correspond to valve flow rate.
12. Valve shall be normally open type.

B. Exhaust sound performance data: As scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Sizes as scheduled on drawings.

C. Provide adequate access space for the air terminal unit control panel.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 57 00
HEAT EXCHANGERS AND CONVERTERS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Design standards: ASME and Standard of Tubular Exchanger Manufacturers Association.

B. Factory test: Test sheets and tubes at 300 PSI.

1.2 SUBMITTALS

A. Product data.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.
   3. Test reports.

1.3 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by Owner for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

1.4 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 HEAT EXCHANGERS AND CONVERTERS

A. Acceptable manufacturers:
   1. Heat exchangers, shell and tube:
      a. Base:
         1) Bell & Gossett, ITT.
         2) Taco.
         3) Armstrong.
         4) Patterson-Kelley.
         5) Adamson.
   2. Heat exchangers, plate:
      a. Base:
         1) Alfa Laval.
      b. Optional:
         1) Patterson-Kelley.
         2) Tranter.
         3) Armstrong.

B. Heat exchangers: Instantaneous, shell and U-tube type, heating liquids with steam, with removable tube bundle.

1. Capacity: As indicated, with steam in shell, water in tubes.
2. Shell working pressure: 150 PSIG.
3. Shell: Steel.
4. Heads: Cast iron.
5. Tubes: Copper, 3/4 IN OD minimum.
6. Fouling factor: 0.002 on water and steam sides.
7. Pressure loss in header coils: As indicated.
8. Maximum tube velocity: 7.5 FPS.
9. ASME code construction.

C. Heat exchangers, plate: Instantaneous flat plate and frame type with corrugated heat transfer plates, support frame, nozzles, tightening mechanism and sheet metal shroud.
   1. Capacity: As scheduled.
   2. Fouling factor: 0.002. Manufacturer shall increase the initial plate quantity to account for fouling factor impact.
   3. Plates: Stainless steel, herringbone type. Plate design and spacing shall permit passage of particulate up to 1/16 IN in diameter.
   4. Heat transfer coefficient: Greater than 1000 BTU/HR/SQFT/degF.
   5. Plate gaskets: EPDM, single piece molded construction, bonded to plates.
   6. Nozzles: 150 LB ASA rated flange type.
   7. ASME code construction.
   8. ARI Certification:
      a. If heat exchanger is not ARI certified, then the manufacturer shall provide an independent third party field performance test using the mapped ratings, limits and tolerances of ARI Standard 400 to verify performance to specification.
   9. Finish: Baked epoxy with manufacturer's standard color.
   10. The carrying bar of each heat exchanger shall be expandable 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.

B. Install so that components may be removed without disturbing piping.

C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 73 29

CUSTOM PACKAGED AIR HANDLING UNITS AND HEAT RECOVERY UNITS
(Revised AD-4)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Abbreviations:
   1. AMCA: Air Moving and Conditioning Association.
   2. ADC: Air Diffusion Council.
   3. ASHRAE: American Society of Heating, Refrigeration, and Air Conditioning Engineers.
   4. ARI: Air-Conditioning and Refrigeration Institute.

1.2 QUALITY ASSURANCE

A. Latest Version of the following Standards:
   1. ADC standard 1062R2, Air Diffusing Equipment Test Code.
   2. AMCA Standard 210, Test Code for Air Moving Devices.
   3. ASHRAE Standard 70-72, Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
   4. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating Systems.
   5. ARI Standard 410, Forced-Circulation Air-Cooling and Air-Heating Coils.
   6. ARI Standard 430 for fans.
   7. AMCA 300 – Test Code for Sound Rating Air Moving Devices
   8. AMCA 301 – Method of Publishing Sound Ratings for Air Moving Devices

1.3 SUBMITTALS (SEE DIVISION 1)

A. Submittals shall be made in accordance with the requirements of Section 01 30 00 “Submittal Procedures”. The vendor is cautioned that the requirements for deleting by marking out reference to any parts of the standard product literature that does not apply to this project will be strictly enforced.

B. Shop drawings:
   1. Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics and connection requirements.

C. Product data:
   1. Air handling units.
      a. Provide literature, which indicates dimensions, weights, capacities, ratings, fan performance, gauges and finishes of materials, electrical characteristics and connection requirements.
      b. Provide data on filter media, filter performance data, filter assembly, and filter frames.
      c. Provide fan curves with specified operating point clearly plotted.
      d. Submit sound power level data for fan unit outlet, inlet and casing radiated at rated capacity and specified pressure.
      e. Submit electrical requirements for power supply including wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring.
      f. Submit performance and vibration test results of the fan for review prior to any air handling unit shipment to the jobsite.

D. Samples: Not required.

E. Project information: Not required.

F. Contract closeout information:
   1. Operations and maintenance instructions: Operations and maintenance instructions shall be submitted in accordance with the requirements of Section 01 91 13 - Building Commissioning. The vendor is cautioned that the requirements for deleting by marking out reference to any parts of the standard product literature that does not apply to this project will be strictly enforced.
   2. On-site vibration retest reports, certified by manufacturer.
   3. On-site acoustical tests to certify that units meet specified acoustical criteria.
   4. Manufacturer's recommended spare parts list.

1.4 EXTRA STOCK

A. Air filters:
   1. Provide full compliment of scheduled filters for use during construction. Units are not to be operated during the construction phase without these filters in place.
   2. Provide new set of filters, per the equipment schedule, for test and balance and final turn over of systems to Owner.

1.5 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by Owner for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

1.6 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Custom packaged air handling units and heat recovery units:
      a. Base:
         1) Huntair.
         2) Ventrol.
         3) Governair.
      b. Optional:
         1) Trane Custom.
         2) York Custom.
         3) Racan/Carrier.
         4) Ingenia.
   2. Fans: Centrifugal.
      a. Base:
         1) Huntair.
      b. Optional:
         1) Twin City.
         2) Acme Engineering.
         3) New York Blower.
   3. Air filters:
      a. Base:

1) American Air Filter.
b. Optional:
1) Air Guard.
2) Purolator.
3) Camfil Farr.
4. Duct sealer:
a. Base:
1) Durkee-Atwood.
b. Optional:
1) Hardcast.
2) Childers.
5. Air pressure gauge:
a. Base:
1) Dwyer.
b. Optional:
1) Ashcroft.
2) Ametek.
3) Trerice.

B. Sheet metal:
1. Galvanized steel: Hot dipped G-90, ASTM-A525, F.S.QQ-I-716, minimum of 0.055 LB of zinc per FT^2.
2. Black steel: ASTM-A109, F.S.QQ-S-636.
3. 2S alloy aluminum: ASTM-B209, F.S.QQ-A-561.
4. 3S alloy aluminum: ASTM-B209, F.S.QQ-A-359.
5. Stainless steel: ASTM-A167, F.S.QQ-S-766.

C. Insulation:
1. Shall meet NFPA-90A smoke and flame spread requirements.

D. Duct sealer: NFPA rating of "Non-Combustible"
1. Flame spread rating: 25 or lower, in dry condition.
2. Smoke developed rating: 50 or lower, in dry condition.
3. Resistant to water and water vapors.
4. Pressure rupture rating: 16 IN WG.

E. Solder: ASTM-B23, grade 50B or F.S.QQ-S-571, Composition Sn50.

F. Duct sealing tape: NFPA rating of "Non-Combustible"
1. Flame spread rating: 25 or lower, in dry condition.
2. Smoke developed rating: 50 or lower, in dry condition.
3. Adhesive: Specifically compounded for maximum adhesion to galvanized and stainless steel.

G. Electrical work: Starters, wiring and accessories as specified under Division 26.

2.2 GENERAL

A. Factory assembled air handling units complete with motor, drive, fan sections, coil sections, access sections, filter sections, damper sections, sound attenuator sections, humidifier, and plenums as shown on the drawings .

B. Include all components, installed at the factory. Field fabrication of units and their components will not be accepted.

C. Ship units in modular sections as required by method of shipment or installation and rigging.

D. Provide full length perimeter angles, located inside units, at shipping splits, to allow for field bolting of modular sections. Unit manufacturer to provide necessary hardware, tape sealer and caulk, required to field join and seal modular sections.

E. See Drawing details for exact configuration of unit components and duct connections.

F. Dimensions indicated are minimum. Increase size of unit as necessary to house all components. Do not exceed any length indicated as maximum on drawings. Units shall fit into space allowed with access for maintenance.

2.3 UNIT BASE

A. Units shall be manufactured in as few sections as physically possible. Clearly indicate the requirement of cross member supports if the units are mounted on elevated perimeter curb supports. Construction shall be suitable to withstand rigors of shipping and rigging.

B. Constructed on a heavy duty full perimeter steel base supporting all components. The base shall consist of precision machined structural members. Assembly shall be accomplished with the use of high tensile strength bolt fasteners or shall consist of electrically welded structural members. Internal members shall be properly sized to allow rigging and handling of the unit. Units are supported by isolation blocks. Units shall be capable of being supported from unit base perimeter only. Formed channel bases are not acceptable.

C. After construction the base shall be cleaned and painted with rust inhibiting epoxy paint. Individual base segments shall be sand blasted prior to painting or powder coated. If sand blasted, every base element shall be processed individually.

D. Base shall include properly located lifting lugs or brackets.

2.4 AIR HANDLING UNIT CASING

A. Unit shall be double wall construction, filled with injected foam to achieve minimum thermal resistance of R-12. Casing thickness shall be as required to withstand 1.5 times working pressure ratings or deadheading of fans. All joints shall be welded or gasketed, caulked and attached using standing seam construction, nut and bolts. Air leakage shall not exceed 1/2 percent of the total design air flow at the maximum design static pressure or the cfm allowed for by SMACNA leakage class 3. The greater leakage rate is the acceptable maximum leakage.

B. Exterior wall and top panels shall be minimum 16 gauge galvanized sheet steel. Interior liner shall be 20 gauge aluminum sheet upstream of cooling coil, 20 gauge solid aluminum sheet downstream of cooling coil, except that solid 20 gauge stainless steel liner shall be used in cooling coil and humidifier sections. Discharge plenum shall include factory furnished bellmouth fittings as indicated. There shall be no metal-to-metal contact between the inner surface of the panels and the exterior skin. The base frame shall also be thermally isolated from the wall panels and floor surface.

C. Interior floor panel shall be 10 gauge galvanized sheet steel epoxy coated (2 coats) with 16 gauge galvanized sheet steel outer skin beneath insulation. Insulation material and thickness shall be as specified for wall panels. An alternate to interior floor panels may be checker plated aluminum, minimum thickness 0.090.

D. Provide unit with double wall, hinged, access doors to allow access into each section, hinged on right or left side as indicated. Access door shall be removable, have a full perimeter automotive type gasket, stainless steel hinges, and a 10 IN square sealed, tempered dual pane glass inspection window. Provide a minimum of two stainless steel or chrome plated wedge type handle latches operable from both sides. Doors to be a minimum of 24 IN wide, 6 FT high unless unit size prohibits. Provide access door or panel at fan section with adequate size for removal/replacement of fan motor. Door construction and thickness same as casing and shall have dual gaskets. Doors shall open against static pressure.

E. Provide a 3-IN. deep drain pan extending under the complete cooling coil section including headers and return bends. Capped drain connections 1-1/4 IN minimum shall be provided on each drain pan. Drain pan shall be 16 gauge stainless steel of sealed double wall construction with insulation as specified for casing, sandwiched between the pan layers, and sloped 1/4 IN per foot toward drain to be completely self draining, allowing no standing condensate in the drain pan. Extend the drain pan downstream of the cooling coil as much as necessary to ensure NO WATER CARRY-OVER. A 3 IN drain pan shall be included upstream of all cooling coils to collect residual condensate upstream of the cooling coils. Provide floor drains with removable strainers in the humidifier section and downstream of cooling coil section. All drainable sections should drain through the side of the unit just like the cooling coil sections. All drains shall exit unit on one side as shown on plans.

F. Acoustical Performance: Acoustical performance of the housing shall have been tested and certified by an independent accredited laboratory.
   1. Test methods and facilities used to establish sound transmission loss values shall conform explicitly to the ASTM designation E90-85 and E413-73.

Sound Transmission Loss dB (ASTM E-90-85 & E413-73)

	Octave Band Center Frequency (HZ)						
	125	250	500	1K	2K	4K	STC+
Construction							
Perf. Liner	22	25	37	43	53	56	39
Solid Liner	26	36	47	56	57	58	42

+ Sound Transmission Class

   2. Test methods and facilities used to establish sound absorption values shall conform explicitly with the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C423-84A and E795-83.

Sound Absorption (ASTM C423-84A & E795-83)

	Octave Band Center Frequency (Hz)						
	125	250	500	1K	2K	4K	NRC+
Construction							
Perf. Liner	0.26	0.70	0.95	0.95	0.94	0.82	0.95

+ Noise Reduction Coefficient

G. Casing panels, including blank-off panels and panels separating fan suction and discharge shall be manufactured, assembled, and spaced to eliminate panel pulsation and limit the maximum deflection to 1/200 along the panel's length centerline. All panels shall be removable. The panels shall be caulked and attached to each other, to the roof, and to the floor using nuts and bolts. Drive screw attachment is not acceptable.

AD-4: Section 23 73 29: Add paragraphs 2.4.H through 2.4.H.4.b.2)

H. Outdoor Air Handling Unit (AHU-3):
   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.
      c. Minimum 24 IN high.
      d. Nominal 2 x 4 IN wood nailer strip.
      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.

4. Supply and return openings:
   a. For supply air, provide openings with rectangular, 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 pounds.
      2) To avoid tripping hazard, grating shall be flush with the finished floor of the unit.

2.5 HEAT RECOVERY UNIT CASING

A. Unit shall be double wall construction, filled with injected foam to achieve minimum thermal resistance of R-12. Casing thickness shall be as required to withstand 1.5 times working pressure ratings or deadheading of fans. All joints shall be welded or gasketed, caulked and attached using standing seam construction, nut and bolts. Air leakage shall not exceed 1/2 percent of the total design air flow at the maximum design static pressure or the cfm allowed for by SMACNA leakage class 3. The greater leakage rate is the acceptable maximum leakage.

B. Exterior wall and top panels shall be minimum 16 gauge galvanized sheet steel. Interior liner shall be 20 gauge aluminum sheet upstream of heat recovery coil, 20 gauge solid aluminum sheet downstream of heat recovery coil, except that solid 20 gauge stainless steel liner shall be used in heat recovery coil section. There shall be no metal-to-metal contact between the inner surface of the panels and the exterior skin. The base frame shall also be thermally isolated from the wall panels and floor surface.

C. Interior floor panel shall be 10 gauge galvanized sheet steel epoxy coated (2 coats) with 16 gauge galvanized sheet steel outer skin beneath insulation. Insulation material and thickness shall be as specified for wall panels. An alternate to interior floor panels may be checker plated aluminum, minimum thickness 0.090.

D. Provide unit with double wall, hinged, access doors to allow access into each section, hinged on right or left side as indicated. Access door shall be removable, have a full perimeter automotive type gasket, stainless steel hinges, and a 10 IN square sealed, tempered dual pane glass inspection window. Provide a minimum of two stainless steel or chrome plated wedge type handle latches operable from both sides. Doors to be a minimum of 24 IN wide, 6 FT high unless unit size prohibits. Door construction and thickness same as casing and shall have dual gaskets. Doors shall open against static pressure.

E. Provide a 3-IN. deep drain pan extending under the complete coil section including headers and return bends. Capped drain connections 1-1/4 IN minimum shall be provided on each drain pan. Drain pan shall be 16 gauge stainless steel of sealed double wall construction with insulation as specified for casing, sandwiched between the pan layers, and sloped 1/4 IN per foot toward drain to be completely self draining, allowing no standing condensate in the drain pan. Extend the drain pan downstream of the coil as much as necessary to ensure NO WATER CARRY-OVER.

2.6 COILS

A. General:
   1. Coil capacity, size and type as scheduled.
   2. Seal coils to casing to prevent leakage of air around coils.
   3. Water coils shall be proof tested at 300 PSIG and leak tested at 200 PSIG air pressure under water.
   4. Coils shall be circuited for counterflow operation with supply connection at the bottom and water return at the top.
   5. Certified in accordance with ARI 410.
   6. Provide seamless copper, brass, or cast iron supply and return headers with vent and drain connections extending through casing.
   7. Provide split coils as required to permit coil removal and replacement in the space allocated for installation. Coil piping shall be arranged high inside unit to not interfere with coil removal.

8. Maximum individual coil size: 108-IN wide by 48-IN high.
9. All coils shall be fully drainable.
10. Maximum fluid velocity 8 FT/sec.

B. AHU Chilled Water Cooling Coils and Heat Recovery Unit Coils:
1. Provide 5/8-IN seamless copper tubes, minimum 0.020 IN thickness, expanded into 0.006-IN minimum thickness continuous plate aluminum fins.
2. 16 gauge 304 stainless steel casing with 16 gauge stainless steel frame for bolting to other sections.
3. Provide intermediate 0.03 IN minimum thickness stainless steel drain pan for each vertical cooling coil section with downspout to main drain pan. Pan shall extend 6 IN downstream from coil face.
4. Continuous plate fin and 200 PSIG operating pressure.

C. AHU Heat Recovery and Preheat Coils:
1. Provide 5/8-IN seamless copper tubes, minimum 0.020 IN thickness, expanded into 0.006-IN minimum thickness aluminum fins.
2. Fins may be continuous plate or spiral wound.
3. 16 gauge galvanized steel casing with 16 gauge galvanized steel frame for bolting to other sections.

2.7 FAN SECTION - FANWALL TECHNOLOGY (FWT)

A. The FANWALL® System shall consist of multiple, direct driven, arrangement of plenum fans constructed per AMCA requirements for the duty specified, (Class III). All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed. The FANWALL Array shall be selected to operate at a system Total Static Pressure that does not exceed 60% (60 HZ max) of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Each fan/motor "cube" shall include an 11 gauge, A60 Galvanized steel intake wall, 14 gauge spun steel inlet funnel, and an 11 gauge G90 Galvanized steel motor support plate and structure. All motors shall be standard pedestal mounted type, (TEAO), T-frame motors selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere. All motors shall include isolated bearings or shaft grounding. All motors shall be premium efficiency, IEEE inverter ready rated with appropriate winding insulation to meet NEMA MG 31, part 1, requirements. Each fan/motor cartridge shall be dynamically balanced to meet or exceed AMCA standard 204-96, category BV-5, to meet or exceed ISO Grade 0.55 residual unbalance, with a peak velocity of 0.022 inches/second.
1. The FWT array shall be provided with acoustical silencers that reduce the bare fan discharge sound power levels by a minimum of 15 db re 10^-12 watts throughout the eight octave bands with center frequencies of 125, 250, 500, 1000, 2000, 4000, and 8000 HZ when compared to the same unit without the silencers. The silencers shall not increase the fan total static pressure, nor shall it increase the airway tunnel length of the Air Handling Unit when compared to the same FWT unit without the silencer array.
2. The FWT array shall not have motors in excess of 15 HP installed above 4 feet off the ground for serviceability reasons.

B. The FWT array shall consist of multiple fan and motor ”cubes”, the plurality of fans spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. The FWT array shall be installed such that the optimum system operating efficiency may be achieved by manually, or automatically, enabling or disabling fans in the array to provide the minimum connected HP for the FWT array that is necessary to produce the required air flow and pressure in the system. The FWT array shall be configured such that the connected HP at reduced flow conditions may be less than the installed total HP of the entire FWT array in order to achieve optimum system efficiency. Each fan cube shall be individually wired to a control panel containing a single VFD, as specified elsewhere, for the total connected HP for all fan motors contained in the FWT array and wired to redundant VFDs, one to act as a bypass driver with catch on the fly capability. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards.

C. Each fan shall be mounted with rubber isolation between fan and supporting structure to reduce vibration. Provide a back-draft damper for each fan.

D. The FWT array shall produce a uniform air flow profile and velocity profile within the airway tunnel of the air handling unit not to exceed the specified cooling coil and/or filter bank face velocity when measured at a point 12” from the intake side of the FWT array intake plenum wall, and at a distance of 48” from the discharge side of the FWT intake plenum wall.

AD-4: Section 23 73 29: Add paragraph 2.7.E.

E. Each FWT array shall be supplied with a complete flow measuring system, which indicates airflow in Cubic Feet per Minute. The flow measuring system shall consist of a flow measuring station with four static pressure taps and four total pressure tubes located at the throat of each fan inlet cone. The flow measuring station shall not obstruct the inlet of the fan and shall have no effect on fan performance (flow or static) or sound power levels. The flow measuring system shall include a transmitter and shall sum the signals from all the fans to provide a single airflow signal. A surface mounted indicator, located on the unit exterior, shall provide a CFM readout and a 4-20 ma or 0-10 volt output control signal proportional to cfm for use in the BAS as specified elsewhere.

2.8 FAN SECTION – PLENUM FAN ARRAY

A. Plenum fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise beyond the peak efficiency to ensure quiet and stable operation.
   1. Fans shall have a non-overloading design with self limiting horsepower characteristics and shall reach a peak in the normal selection area.
   2. All fans shall be capable of operating over the minimum pressure class limits as specified in AMCA’s Standard 2408-69.
   3. Tested in accordance with AMCA 211 and AMCA 311 test codes for air moving devices.
   4. Guaranteed by the manufacturer to deliver rated published performance levels.
   5. Licensed to bear the AMCA certified ratings seal for both sound and air.
   6. Designed without a scroll type housing.
   7. Incorporate a non-overloading type backward inclined airfoil blade wheel, heavy-gauge reinforced steel inlet plate, structural steel frame, and shaft and bearings.
   8. Direct driven at 2200 RPM maximum.

B. The plenum fan array shall consist of multiple fans spaced in the air way to provide a uniform air flow and velocity profile across the entire cross section and components contained therein. The multiple plenum fans shall be installed such that the optimum system operating efficiency may be achieved by manually, or automatically, enabling or disabling fans in the array to provide the minimum connected HP for the fan array that is necessary to produce the required air flow and pressure in the system. The fan array shall be configured such that the connected HP at reduced flow conditions may be less than the installed total HP of the entire multiple fan array in order to achieve optimum system efficiency. Each fan shall be individually wired to a control panel containing a single VFD, as specified elsewhere, for the total connected HP for all fan motors contained in the plenum fan array and wired to redundant VFDs, one to act as a bypass driver with catch on the fly capability. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards.

C. Each fan shall be mounted with rubber isolation between fan and supporting structure to reduce vibration. Provide a back-draft damper for each fan.

D. Frame and inlet plates shall be of heavy-gauge reinforced steel construction.
   1. Inlet plate shall incorporate a removable spun inlet cone designed for smooth airflow into the accompanying inlet retaining ring of the fan wheel.
   2. A square, formed lip suitable for attachment of a boot connector shall surround the unit, or an optional round inlet collar can be provided.

E. Wheels shall have a spun non-tapered style blade retaining ring on the inlet side to allow higher efficiencies over the performance range of the fan.
   1. Blades shall be airfoil-shaped, of extruded aluminum or die-formed steel.
   2. All hollow blade wheels shall be continuously welded around all edges.
   3. All wheels shall be statically and dynamically balanced on precision electronic balancers to a level of G6.3 (per ANSI 2-19) or better.
   4. Up to 2 IN S.P.: Class I construction.
   5. 2 – 6 IN S.P.: Class II construction.
   6. Over 6 IN S.P.: Class III, except that next higher class shall be used as required by fan speeds or maximum allowable RPM corresponding to scheduled motor HP.

F. Shafts shall be AISI 1040 or 1045 hot rolled steel, accurately turned, ground, polished, and ring gauged for accuracy.
   1. Sized for the first critical speed of at least 1.43 times the maximum speed.
   2. Dial indicated for straightness after the keyways are cut and straightened as required.
   3. Fan and sheaves shall be keyed to the shaft and locked in place with set screws.
   4. Shaft shall have grounding system for protection from static and AFD induced currents.

G. Bearings shall be heavy duty, grease lubricated, anti-friction ball or roller, self-aligning, pillow block type.
   1. Minimum average bearing life (AFBMA L-50) in excess of 1,000,000 hours at the maximum fan RPM.
   2. All bearings shall be equipped with regreasable zerk fittings and extended lube lines for easy access for relubrication.

H. Vibration isolation:
   1. Fan and motor assembly shall be internally isolated from unit casing and supported on isolation base with isolators.
   2. Fan inlet shall be attached to the unit casing by a flexible canvas duct.
   3. Isolators and base shall be as specified in Section 20 05 50, Vibration Isolation of Mechanical Systems.

I. Noise criteria: Do not exceed sound power levels of the fans that are scheduled.

J. Motors:
   1. See Section 20 05 00.
   2. Sufficient capacity to move required amount of air at static pressure and speed indicated.
   3. Designed for AFD.

4. Power no less than indicated on schedule.

K. Entire fan assembly, excluding the shaft, shall be thoroughly degreased and deburred before application of a rust-preventative primer. After the fan is completely assembled, a finish coat of paint shall be applied to the entire assembly. The fan shaft shall be coated with a petroleum-based rust protectant. Aluminum components shall be unpainted.

L. Accessories shall be provided by fan manufacturer to maintain one source responsibility. Provide the following:
   1. Galvanized steel, OSHA, removable inlet screen.
   2. Sturdy, removable OSHA screen completely enclosing fan wheel.

M. All fans, prior to shipment from fan manufacturer's factory, shall be completely assembled and test run as a unit at the specified operating speed.
   1. Each wheel shall be statically and dynamically balanced in accordance with ANSI/AMCA 204-96 “Balance Quality and Vibration Levels for Fans” to Fan Application Category BV-3, Balance Quality Grade G6.3.
   2. Balance readings shall be taken by electronic type equipment in the axial, vertical, and horizontal directions on each of the bearings. Records shall be maintained and a written copy shall be available upon request. Fan manufacturer shall provide certificate of compliance and test data for each fan prior to shipping.

AD-4: Section 23 73 29: Add paragraphs 2.8.N through 2.8.N.1.

N. Air flow measuring stations:
   1. Factory install air flow measuring stations in the inlets of the supply and return fans. For units with multiple fans, mount stations such that back-draft dampers can be mounted and not disturb the air flow stations.

2.9 FILTER SECTION

A. Filters:
   1. Factory built and assembled.
   2. Capacity, and type as scheduled.
   3. Provide where indicated.
   4. In each filterbank, provide the maximum possible face area of filters to fill the physical size of air handling unit even if filter sizes are not listed in filter schedule.
      a. Unless indicated otherwise, provide as many 24-IN by 24-IN face dimension filter sections as possible. Where necessary, a minimum number of 24-IN by 12-IN filter sections may be used.
   5. Average filtration efficiency: As scheduled, when tested in accordance with ASHRAE Test Standard 52.1.

B. Prefilter (MERV 7):
   1. Medium efficiency pleated media, disposable panel type.
   2. Non-woven, non-fiberglass synthetic media, continuously bonded to a heavy-duty, corrosion-resistant, expanded metal support grid with a 96% open face area.
   3. Heavy duty beverage board frame with high wet strength.
   4. Grid assembly bonded to all interior surfaces of the frame with solvent-free water based glue.
   5. UL rated, Class 2.

C. High efficiency filters (MERV 14):
   1. Deep-pleated, disposable, rigid-cell type, thickness as scheduled.
   2. Dual stage non-fiberglass filter media, 100% synthetic fibers formed into a 0.25-IN thick filter blanket reinforced by an integral polypropylene backing.
   3. Filter media shall contain a fiber-bound anti-microbial agent (biocide or biostatic agent) and an adhesive dust-holding agent applied to the surface.
   4. Maximum initial resistance: Not greater than indicated at rated air flow.

5. Media continuously bonded to a heavy-duty, 28-gauge, corrosion-resistant, electrogalvanized steel, expanded metal grid with open face area not less than 95%.
6. UL rated, Class 2.
7. Enclosure frame constructed of corrosion-resistant galvanized steel to produce a rigid, durable filter.

D. Filter racks:
1. Filter racks shall be stainless steel or powder-coated galvanized steel.
2. For units 60-IN tall or greater, provide front loading filter racks. Filters individually removable from inside air handling unit.
3. For units less than 60-IN tall, provide side loading filter racks. Filters removable through access door.
4. Positive sealing filter frames welded together, structural supports welded to frames and mounted in air handler.
5. Rack shall be thoroughly caulked and sealed to minimize filter bypass.
6. Internal blank-offs as required to prevent air bypass around the filters.

2.10 ELECTRICAL

A. Electrical components, conduits, and conductors shall be in accordance with Division 26.

B. Wire fan motors to a unit mounted disconnect switch. Wiring shall be brought thru a liquid tight, flexible conduit. For units 48 IN and larger in height, disconnect switch shall be mounted inside fan section, near fan section access door, with power wiring brought to an external mounted terminal box. For units smaller than 48 IN in height, mount disconnect switch external to unit casing, near fan section access door. Disconnect switches shall be provided as specified in Division 26.
1. For units with AFD provide auxiliary control interlock switch in disconnect switch.
   a. Arranged so as to break the AFD control circuit before the main switch blades break.
   b. Switch contact rated for 30 amp, 120 volts.
   c. UL listed.
2. Provide a fan safety lockout on fan section access door.

C. Provide one wall bracket vapor proof light fixture with polycarbonate diffuser and one 120 volt, 26 watt compact florescent lamp in each section with access door. All lights shall be factory wired to one, or as many as required, 1 hour timer type switch mounted externally on the unit wall. Provide a GFI type utility outlet adjacent to the switch.

2.11 HUMIDIFIER

A. See Section 23 84 13.

2.12 SILENCERS

A. Outer casing of rectangular silencers shall be fabricated from not less than 22 gauge galvanized steel, or equivalent, in accordance with ASHRAE Guide or SMACNA recommended construction for high pressure rectangular ductwork. Seams shall be lock-formed and mastic filled. Interior casings for rectangular silencers shall be fabricated from not less than 26 gauge galvanized perforated steel, or equivalent.
1. To prevent corrosion, the perforated casing of the silencers shall be made aluminum or powder coated galvanized steel.
2. Rounded nose, bell mouth entrance and exit.
3. Size silencer bank for the scheduled airflow of the air handling units with face velocities not higher than velocities through cooling coils. Provide maximum number and sizes of silencers allowable to fill the physical size of the air handling unit even if silencer sizes are not listed in silencer schedule.

B. Silencers shall have baffles filled with inorganic mineral or glass fiber sound absorptive material packed under not less than 5% compression. Fill material shall be inert, vermin and moisture proof.

1. Fill material shall be protected by woven fiberglass cloth face installed between fill material and perforated metal liner.

C. All silencers shall have a composite fire and smoke rating, when tested in accordance with ASTM E84, NFPA 255 and UL 723, not to exceed a Flame Spread of 25, Fuel Contributed of 50 and Smoke Developed of 50.

D. Silencers shall not leak air or fail structurally when subjected to a differential air pressure of 8-IN WG inside to outside of casing.

E. Acoustical testing shall conform to ASTM E477-73 standard method of testing duct liner materials and manufactured silencers for acoustical and airflow performance. Tests shall be run both with and without air flowing through the silencer at not less than three different flow rates. All ratings shall be based on test data from nationally known qualified independent laboratory. Test methods shall eliminate effects due to end reflection, vibration, flanking transmission, and standing waves in the reverberant room. Air flow and pressure loss measurements shall be made in accordance with applicable portions of ASME, AMCS, and ADC airflow tests.

F. The dynamic insertion loss in dB for rectangular silencers shall not be less than that scheduled.

2.13 AIR PRESSURE GAUGES

AD-4: Section 23 73 29: Revise paragraph 2.13.A.

A. Magnehelic gauges mounted outside of casing to indicate differential pressure across each filter bank, supply fan, return fan, and air handling unit discharge pressure.
   1. Accuracy +/-2% of full scale.
   2. Die cast aluminum housing 4 IN diameter, clear plastic face, with metric scale:
      a. Filters, scale: 0-2 IN WG.
      b. Supply and return fans, select scale as required by fan static pressure. Reading: between 25-75% of full scale.
      c. Air handling unit discharge pressure, scale: 0-5 IN WG.

2.14 THERMOMETERS

A. Provide at outside of casing to indicate air temperature at unit discharge.

B. As specified in Section 20 05 19.

2.15 DAMPERS

A. All automatic control dampers which are mounted in air handling units will be furnished and factory mounted by air handling unit manufacturer. Electric actuators capable of developing 150 percent of the required torque to operate the dampers, shall be furnished and factory mounted by air handling unit manufacturer. Actuators shall be manufactured by Siemens, Honeywell, or Johnson Controls. Control will be provided under Section 25 50 00.

B. Dampers, automatic: Suitable for 3000 FPM velocity and 4 IN static pressure differential.
   1. Furnish and factory mount in air handling units where indicated.
   2. Parallel blade type: On mixing dampers, position blades so that outside and return air streams are directed together to promote optimum mixing.
   3. Damper frames: Galvanized steel frame, 0.12 IN minimum wall thickness, with flanges for mounting on both sides of frame.
   4. Corners reinforced with two die formed internal braces, machine staked.
   5. Blades: Not over 6 IN wide heavy gauge extruded aluminum, air foil shape.
   6. Damper bearings: Oil impregnated sintered bronze.
   7. Seals: Blade edge - Extruded vinyl; Jamb - Flexible stainless steel compression.
   8. Low leakage: Certified under AMCA certified ratings program not to exceed 6 CFM/SQ FT at 5 IN static pressure when tested in accordance with AMCA Standard 500.
   9. Linkage: Out of air stream.

a. Where necessary to mount actuator external to casing or duct, damper shalft shall extend minimum 4-IN beyond external casing wall.

10. Ruskin CD-50 or Tamco Series 1500.

C. Provide limit switch where required. Switch shall be fully enclosed, fully adjustable to make or break as necessary to perform required sequence of operation. Contacts shall have electrical rating compatible with application.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Assemble and install air handling units in accordance with manufacturer's installation drawings and instructions, and as specified.

B. Provide travel expenses for manufacturer's service engineer to instruct and supervise contractor personnel on proper installation of units.

C. Install components furnished but not mounted.

D. Touch-up abraded or damaged finish.

E. Units shall be mounted on precompressed fiberglass (PCF) blocks as specified in Section 20 05 50.

F. Unit shall rest on a curb, raised high enough to permit installation of condensate drain trap above floor as indicated on Drawings.

3.2 BALANCE AND RUN TEST

A. All fan wheels shall be dynamically balanced on precision balancers. Prior to shipment from fan manufacture, all fans shall receive a final test balance at the specified operating speed and shall ship fully assembled.

B. The unit manufacture must dynamically rebalance the fan as an assembly at the specified operating speed, complete with the motor, fan isolation base and on their isolators, to ensure the fan assembly is balanced. Measurements are taken in mils (1/1000th of inch). By adding small weights on the fan blades, the fan is balanced. Iterations of the previous step are performed until the Peak to Peak vibration displacement is below 1.5 mils. ANSI/AMCA 204 is also used in reference. Fan balance report from the fan manufacture is neither equal nor acceptable.

3.3 CLEANING

A. Remove all dirt, dust, and foreign matter from units. Vacuum all sections.

B. Wipe with clean cloth surface downstream of filters.

3.4 STARTUP

A. At final startup for Owner's use, replace filters used during construction.

B. After equipment installation is complete, provide factory trained service engineer, directly in employment of the manufacturer, to inspect the installation, supervise the start up, test equipment, and certify that all air handling units are installed in accordance with manufacturer's recommendations.

C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.5 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 82 39

HYDRONIC HEATING AND COOLING TERMINAL UNITS (Reissued AD-4)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of system:
   1. Unit heaters.
   2. Fan coil units.
   3. Radiant ceiling panels.
   4. Active chilled beams.

B. Work installed but not furnished:
   1. Control valves: Furnished under Section 25 50 00.

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.

1.3 SUBMITTALS

A. Product data:
   1. Unit heaters.
   2. Fan coil units.
   3. Radiant ceiling panels.
   4. Active chilled beams.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.

1.4 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by Owner for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

1.5 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Unit heaters:

a. Base:
   1) Trane.
b. Optional:
   1) Carrier.
   2) McQuay.
   3) Modine.

2. Fan coil units:
   a. Base:
      1) Trane.
   b. Optional:
      1) Carrier.
      2) Sterling.
      3) McQuay.
      4) Airtherm.
      5) International Environmental.
3. Radiant ceiling panels:
   a. Base:
      1) Rittling.
   b. Optional:
      1) Antex.
      2) Sterling.
      3) AeroTech.
4. Active chilled beams:
   a. Base:
      1) Trox.
   b. Optional:
      1) Krueger.
      2) SAS International.
      3) Swegon.
      4) Dadanco.

2.2 UNIT HEATERS

A. Horizontal unit heaters: Propeller type, with finned heating coil thru which air is blown, horizontal discharge.
   1. Capacity: As indicated.
   2. Casing: Sheet steel, with removable 18 GA back, with factory finish.
   3. Fan: Aluminum, mounted directly on shaft of motor, with guard.
      a. Provide fan guard.
   4. Motor: Totally enclosed:
      a. Provide thermal overload protection for motors up to 1/2 HP.
      b. Provide vibration isolated motor mounts.
   5. Heating coil: Copper tubing, non-ferrous fins; mechanically bond fins to tubes.
   6. Coil leak tested to 300 PSIG.
   7. Horizontal adjustable louvers with vertical adjustable louver fins.

2.3 FAN COIL UNITS

A. Fan coil units, horizontal concealed type: Blow thru type, heating and cooling or cooling only, as scheduled, motor driven centrifugal fans, filters, and integral internal and external auxiliary drain pans.
   1. Capacity: As scheduled.
   2. Casing construction - Horizontal ceiling mounted concealed type:
      a. Provide 18 GA galvanized steel casing and chassis.
         1) Return air plenum with flange for return air duct connection.
         2) Flange for supply air duct connection on coil outlet.

3. Fans: Double width, double inlet, forward curved, centrifugal type with heavy gauge galvanized steel housing.
4. Motors: Direct-drive type with internal thermal overload protection. See Section 20 05 00.
5. Heating and cooling coils: Copper tube mechanically bonded to configurated non-ferrous fins with continuous fin collars and sleeved end supports.
   a. Maximum working pressure 300 PSIG.
   b. Capacity certified in accordance with ARI Standard 441-70.
   c. Leak tested to maximum working pressure.
6. Filters: Permanent, cleanable aluminum mesh.
7. Drain pans: Galvanized steel with molded polystyrene foam insulating liner or noncorrosive ABS. Solderless drain connection.
   a. Provide condensate pump to handle condensate from drain pans where indicated.
8. Provide motor starters.
9. UL listed.
10. Controls: Three-speed controller with integral "on-off" switch.
11. Unit sound data to be pre-tested and rated in accordance with ARI Standard 443-70.

B. Fan coil units, horizontal: Draw thru type with heating and cooling coils, centrifugal belt-driven fan with adjustable pulley, filters, and integral internal and external auxiliary drain pans.
1. Capacity: As scheduled.
2. Casing: 16 GA galvanized steel with side access panels for maintenance and service.
3. Coils: Copper tube, aluminum plate fins.
   a. Leak tested at 300 PSIG minimum air pressure.
   b. Automatic air vent.
4. Fan: Forward curved, centrifugal type.
   a. Provide with heavy duty adjustable V-belt drive.
   b. Permanently lubricated, long life bearings.
   c. Dynamically balanced.
5. Drain pans: Integrally attached to coil casing. Galvanized steel with molded polystyrene foam insulating liner. Drain pipe connection.
   a. Provide condensate pump to handle condensate from drain pans where indicated.
6. Filters: Permanent recleanable type.
7. Motors: See Section 20 05 00.
   a. Provide with built-in thermal overload protection.
   b. Provide motor starters.
8. Provide discharge duct collar integral with casing.

C. Piping package:
1. Provide all units with piping package complete with the following for each coil:
   a. Stop valves.
   b. Balancing valve.
   c. Manual air vent.

2.4 RADIANT CEILING PANELS

A. Radiant ceiling panels: Hydronic type, smooth steel or aluminum panel.
1. Tubing: Copper tube, type L, mechanically bonded to panel with heat conductive paste or embedded in graphite layer.
2. Provide interconnecting piping between panels and to zone supply and return: Type L copper tubing and dielectric unions.
3. Performance criteria as scheduled.
4. Provide hangers, expansion joints, and hold-down clips as required and as recommended by manufacturer for mounting in grid ceiling.
5. Provide 2 IN unfaced fiberglass blanket insulation pre-cut for installation above panels.
6. Finish: Manufacturer's standard white; color selected by Architect.

2.5 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 22 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 pipe operation. The coils shall be mounted horizontally and shall be manufactured with seamless copper tubing (1/2 IN outside diameter) with minimum 0.16 IN wall thickness mechanically fixed to aluminum fins. The aluminum fins shall be limited to no more than 8 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.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 RADIANT PANEL AND CHILLED BEAM INSTALLATION

A. Install radiant panels and chilled beams in standard lay-in inverted T-ceiling grid installed by General Contractor.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 84 13
HUMIDIFIERS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.
   3. Manufacturer's approval of all installations.

1.2 WARRANTY

A. Provide a one (1) year warranty from date of acceptance by Owner for items furnished that shall cover the following:
   1. Faulty or inadequate product design.
   2. Improper assembly or erection.
   3. Defective workmanship and materials.

1.3 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 HUMIDIFIERS

A. Acceptable manufacturers:
   1. Steam grid humidifiers:
      a. Base:
         1) Armstrong.
      b. Optional:
         1) Pure Steam.
         2) Hygromatik, Spirax Sarco.
         3) Herrmidifier.
         4) Dri-Steem.

B. Humidifiers: Stainless steel steam grid type used for clean steam:
   1. All parts in contact with steam or condensate shall be 304 grade stainless steel.
   2. Control and humidistat as specified in Section 15970.
   3. The stainless steel steam control valve shall be able to control steam flow from maximum to minimum rangeability of 30:1.
   4. A steam separating chamber with baffles and mesh packing shall be provided to remove moisture particles larger than 3 microns.
   5. Temperature switch to prevent steam flow until unit is up to operating temperature.
   6. The stainless steel steam distribution manifold shall be designed for fast absorption. All vapor shall be fully absorbed by the air stream within 1.5 feet of the manifold at the design operating condition of the system based on air temperature, velocity and relative humidity.

7. Stainless steel y-strainers and steam traps. Trap manifold grid and steam separator separately when required by design.
8. Capacity and performance as scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Condensate discharge from humidifier is atmospheric. Provide adequate height between condensate discharge and condensate return pumps for proper drainage. Verify installation with humidifier manufacturer.

C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 84 23
CLEAN STEAM GENERATOR

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Factory test: In accordance with ASME code.
   1. Hydrostatically test steam generator shell at 1.5 times the design pressure.
   2. Radiograph all pressure boundary welds.
   3. Flush grind all pressure boundary welds.
   4. Generator shall bear ASME stamp indicating the pressure vessel is in conformance with ASME Code, Section VIII, Division I, for unfired pressure vessels.
   5. Stress relieve all pressure boundary welds.

B. Warranty:
   1. Manufacturer's standard warranty.

1.2 SUBMITTALS

A. Product data:
   1. Clean steam generator packaged system dimensions and general arrangement including accessories.

B. Contract Closeout Information:
   1. Product instruction and maintenance manuals for system components.
   2. Owner instruction report.
   3. Manufacturer's approval of installation.

1.3 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 CLEAN STEAM GENERATORS

A. Acceptable manufacturers:
   1. Clean steam generator(s):
      a. Base:
         1) Cemline Corp.
      b. Optional:
         1) Patterson-Kelley Co.
         2) Adamson.
   2. Automatic blowdown controller:
      a. Base:
         1) Diversey.
      b. Optional:
         1) Garret-Callahan.
         2) Betz-Dearborne.
         3) Hydac.
         4) Water Engineering.

3. Valves and specialties: As specified in referenced sections.

B. Clean steam generator: Factory assembled prepiped and wired steam to steam generator package, performance as scheduled.
   1. The pressure vessel shell shall be ASME code stamped for 50 psi gauge pressure at 300 degF. Vessels not designed for full vacuum shall be provided with vacuum breakers. The shell and all parts in contact with the boiler water shall be constructed of 316 stainless steel. Shell shall have a 18 IN diameter manway.
   2. Provide U-tube heat transfer bundle with 3/4 IN OD x 18 gauge seamless 316 stainless steel tubing on a 1 IN square pitch grid. Bundle shall be supported on stainless steel rails. Tube side shall be designed and code stamped for 150 psi gauge pressure at 400 degF.
   3. Provide full length steel skid foundation to support the generator an adequate height above floor to accomodate steam trap and piping. Provide lifting lugs with reinforcing stainless steel pads.
   4. Provide an integral steam moisture separator baffle capable of providing 99 percent quality steam at the design point.
   5. Factory insulate shell with 3 IN high density fiber insulation and zinc-plated 20 GA sheet metal jacket. Entire package shall be factory painted.

2.2 CLEAN STEAM GENERATOR TRIM, SPECIALTIES, AND APPURTENANCES

A. Output steam pressure shall be controlled by a factory mounted electric controller operating a fully modulating steam pressure control valve. Provide factory piped strainer at control valve inlet.

B. Steam pressure gauge with shut off valve on tube side and shell side. Provide two - 3/4 IN capped fittings for remote monitoring. Provide a shell side thermometer with thermowell below water line.

C. Provide factory piped steam trap and strainer to drain condensate from tube bundle. Additionally, provide steam trap and piping to drain condensate on steam supply line prior to control valve.

D. Provide shell side ASME Section 1 steam safety valve with stainless steel trim.

E. Provide magnetrol stainless steel combination water column and controller. When make-up water is required, the controller shall open a factory piped electric operated two-way valve to be provided in the make-up water line. Provide factory piped check valve and shut-off valve between two-way control valve and boiler shell. When water level is sufficient, the valve shall close. Provide gauge glass on water column controller.

F. Provide an independent steam pressure safety system to automatically shut off steam control valve if shell pressure exceeds 25 psi gauge.

G. Provide two factory piped 2 IN ASME Tandem bottom blowoff valves, one being a quick opening stainless steel ball valve and one slow opening iron body blowdown valve.

H. Provide a factory wired Diversey Solutrol B automatic boiler blowdown controller with sampling system and blowdown control valve. Unit shall control surface blowdown based on conductivity. Test interval and conductivity level shall be adjustable. When the conductivity level exceeds the setpoint, the controller shall open a motorized stainless steel ball valve allowing surface blowdown.

I. Provide tap in boiler shell for surface blowdown connection. Locate tap location as required by blowdown controller manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install steam generator(s) in accordance with ASME, local codes and manufacturer's instructions.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23 90 00
COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description
B. Responsibilities
C. Related Work
D. Test Equipment
E. Submittals
F. Startup
G. Functional Performance Tests
H. Testing Documentation, Non-Conformance and Approvals
I. Operation and Maintenance Manuals
J. Training of Owner Personnel
K. Deferred Testing
L. Written Work Products

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 23 responsibilities in the commissioning process.

B. This section also includes specification of Division 20 and Division 25 subcontractors responsibilities in the commissioning process.

C. The systems to be commissioned are listed in Section 01 91 00.

D. Commissioning requires the participation of Division 20, 23 and 25 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 20, 23 and 25 Contractors shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA, and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Divisions 20, 23 and 25 are as follows (all references apply to commissioned equipment only):

1. Construction and Acceptance Phases

a. Include and itemize the cost of commissioning in the contract price.
b. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.
c. Attend a commissioning scoping meeting and other meetings necessary to facilitate the commissioning process.
d. Contractors shall provide the CA with normal cut sheets and shop drawing submittals of commissioned equipment.
e. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.

1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
2) The Commissioning Agent may request further documentation necessary for the commissioning process.
3) This data request may be made prior to normal submittals.

f. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CA for review and approval.
g. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
h. Provide limited assistance to the CA in preparing the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
i. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CA for all commissioned equipment. Submit to CA for review and approval prior to startup. Refer to Section 01 91 00 for further details on start-up plan preparation.
j. During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment.
k. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
l. Address current punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
m. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
n. Provide skilled technicians to perform functional performance testing under the direction of the CA for specified equipment in Section 01 91 00. Assist the CA in interpreting the monitoring data as necessary.
o. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, GC and Design Engineer and retest the equipment.
p. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
q. During construction, maintain as-built red-line drawings for all drawings. Update after completion of commissioning (excluding deferred testing).
r. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
s. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period

a. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Mechanical Contractor. The responsibilities of the HVAC Mechanical Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Provide startup for all HVAC equipment, except for the building automation control system.
2. Assist and cooperate with the TAB contractor and CA by:

   a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
   b. Including cost of sheaves and belts that may be required by TAB.
   c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.
   d. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

3. Install a P/T plug at each water sensor that is an input point to the control system.
4. Prepare a preliminary schedule for Division 23 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
5. Notify the GC or CA depending on protocol, when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the GC or CA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CA has the scheduling information needed to efficiently execute the commissioning process.

C. Controls Contractor. The commissioning responsibilities of the Controls Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:

   a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
   b. All interactions and interlocks with other systems.
   c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
   d. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
   e. Start-up sequences.
   f. Warm-up mode sequences.
   g. Normal operating mode sequences.
   h. Unoccupied mode sequences.
   i. Shutdown sequences.
   j. Capacity control sequences and equipment staging.
   k. Temperature and pressure control: setbacks, setups, resets, etc.
   l. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
   m. Effects of power or equipment failure with all standby component functions.
   n. Sequences for all alarms and emergency shut downs.

o. Seasonal operational differences and recommendations.

p. Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc., that will be useful during testing and operating the equipment.

q. Schedules, if known.

r. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.

2. Control Drawings Submittal

a. The control drawings shall have a key to all abbreviations.

b. The control drawings shall contain graphic schematic depictions of the systems and each component.

c. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.

d. Provide a full points list with at least the following included for each point:

1) Controlled system
2) Point abbreviation
3) Point description
4) Display unit
5) Control point or setpoint (Yes/No)
6) Monitoring point (Yes/No)
7) Intermediate point (Yes/No)
8) Calculated point (Yes/No)
9) Key:
10) Point Description: DB temp, airflow, etc.

a) Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)

b) Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).

c) Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.

d) Calculated Point: "Virtual" point generated from calculations of other point values.

11) The Controls Contractor shall keep the CA informed of all changes to this list during programming and setup.

3. Workstation Graphics Submittal

a. Prior to the start of testing, submit screenshots of all graphics screens for review. These must be reviewed and approved at least 6 weeks prior to testing.

4. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

5. Assist and cooperate with the TAB contractor in the following manner:

   a. Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
   b. For a given area, have all required prefunctional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CA prior to TAB.
   c. Provide a qualified technician to operate the controls to assist the TAB Contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.

6. Assist and cooperate with the CA in the following manner:

   a. Using a skilled technician who is familiar with this building, execute the functional testing of the equipment and control systems. Provide two-way radios during the testing.
   b. Execute all control system trend logs required by the CA.

7. The Controls Contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, according to the process in Section 01 91 00. At a minimum, the plan shall include for each type of equipment controlled by the automatic controls:

   a. System name.
   b. List of devices.
   c. Step-by-step procedures for testing each controller after installation, including:

      1) Process of verifying proper hardware and wiring installation.
      2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
      3) Process of performing operational checks of each controlled component.
      4) Plan and process for calibrating valve and damper actuators and all sensors.
      5) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

   d. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.
   e. A description of the instrumentation required for testing.
   f. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CA and TAB contractor for this determination.

8. Provide a signed and dated certification to the CA and GC upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.

9. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified.

10. List and clearly identify on the as-built duct and piping drawings, the locations of all static and differential pressure sensors (air, water and building pressure).

D. TAB Contractor. The duties of the TAB Contractor, in addition to those listed in (A) are:

1. Six weeks prior to starting TAB, submit to the GC the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead. The Owner will approve the site technician's qualifications for this project.

2. A running log of events and issues shall be kept by the TAB field technicians. Submit handwritten reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CA and GC.

3. Communicate in writing to the Controls Contractor all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect the control system setup and operation.

4. Provide a draft TAB report within two weeks of completion. A copy will be provided to the CA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC or NEBB.

5. Provide the CA with any requested data, gathered, but not shown on the draft reports.

6. Conduct spot checks on all performed balancing for witness by the CA.

7. Provide a final electronic TAB report for the CA with details, as in the draft.

1.4 RELATED WORK

A. Refer to Section 01 91 00 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 01 91 00 for systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 00 for additional Division 20, 23 and 25 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. The Contractor shall provide submittal documentation relative to commissioning as required in this section and Section 01 91 00.

3.2 STARTUP

A. The HVAC Mechanical and Controls Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities List in this section and in Section 01 91 00. The Contractor has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3 CONTRACTOR TESTS

A. Subcontractors/installers shall forward to the Commissioning Authority, through the GC, a list and schedule of specified contractor tests. The tests shall include at least the following:

Section 23 21 13	Hydronic Piping	3.9,A	Hydrostatic Testing
		3.10	Pipe Flushing & Cleaning
		3.11	Chemical Additives
Section 23 21 23	HVAC Pumps	3.3	Vibration Tests
Section 23 22 00	Steam Piping	3.6 B	Pressure Testing
		3.7	Cleaning
Section 23 31 13	Air Distribution System	3.4	Performance Tests
Section 23 35 00	Exhaust and Ventilating Fans	3.3	Fan Dynamic Balancing
Section 23 73 29	Custom Air Handling Units	3.2	Balance & Run Test
		3.4	Manufacturer Start-Up

B. Unless specified otherwise, provide a minimum one week prior notice to the Commissioning Authority through the GC for each specified Contractors' test.

C. Submit Contractors' test reports to the Commissioning Authority, through the GC within one week of the successful completion of each test. Contractors shall document and issue a test report for each required test. The test report shall contain all information required by the respective specification section including the test date, start time, stop time, test duration, initial values, final values, expected result, and acceptable test values (per individual specification sections). The person(s) conducting each test and the local code authority (if applicable) shall sign and date each test report indicating that the test has been successfully completed and the results are within acceptable parameters.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 00 for a list of systems to be commissioned.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01 91 00 for specific details on non-conformance issues relating to prefunctional checklists and tests.

B. Refer to Section 01 91 00 for issues relating to functional performance tests.

3.6 OPERATION AND MAINTENANCE (O&M) MANUALS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.

B. The Contractor shall compile and prepare documentation for all equipment and systems covered in Divisions 20, 23 and 25 and deliver this documentation to the GC for inclusion in the O&M manuals, according to this section and Section 01 91 00, prior to the training of Owner personnel.

C. The CA shall receive a copy of the O&M manuals for review.

D. Special Control System O&M Manual Requirements. In addition to documentation that may be specified elsewhere, the Controls Contractor shall compile and organize at minimum the following data on the control system in labeled three-ring binders with indexed tabs.

1. Three copies of the controls training manuals in a separate manual from the O&M manuals.

2. Operation and Maintenance Manuals containing:

   a. Specific instructions on how to perform and apply all functions, features, modes, etc., mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.
   b. Full as-built set of control drawings (refer to Submittal article above for details).
   c. Full as-built sequence of operations for each piece of equipment.
   d. Full points list.
   e. Full print out of all schedules and set points after testing and acceptance of the system.
   f. Full as-built print out of software program.
   g. Electronic copy on disk of the entire program for this facility.
   h. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.
   i. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
   j. Control equipment component submittals, parts lists, etc.
   k. Warranty requirements.
   l. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).

3. The manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:

   a. Sequences of operation
   b. Control drawings
   c. Points lists
   d. Controller/module data
   e. Thermostats and timers
   f. Sensors and DP switches
   g. Valves and valve actuators
   h. Dampers and damper actuators
   i. Program setups (software program printouts)

4. Field checkout sheets and trend logs should be provided to the CA for inclusion in the Commissioning Record Book.

E. Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the Owner Advocate and by the CA. Refer to Section 01 91 00 for details.

3.7 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.

B. The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems. Refer to Section 01 91 00 for additional details.

C. Mechanical Contractor. The Mechanical Contractor shall have the following training responsibilities:

1. Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00.

2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of mechanical equipment including, but not limited to, pumps, chillers, cooling, air handling units, computer room air conditioning units, boilers, fans, unit heaters, controls and water treatment systems, etc.

3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The Controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

8. Training shall include:

   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.

d. Discussion of warranties and guarantees.
e. Common troubleshooting problems and solutions.
f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
g. Discussion of any peculiarities of equipment installation or operation.
h. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

10. The Mechanical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the Owner.

12. Duration of Training. The Mechanical Contractor shall provide training on each piece of equipment according to Section 23 05 00.

D. Controls Contractor. The Controls Contractor shall have the following training responsibilities:

1. Provide the CA with a training plan four weeks before the planned training according to the outline described in Section 01 91 00.

2. The Controls Contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.

3. Training manuals. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals *and* in all software displays. Manuals will be approved by the CA. Copies of audiovisuals shall be delivered to the Owner.

4. The trainings will be tailored to the needs and skill-level of the trainees.

5. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.

6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

7. Duration of Training. The Mechanical Contractor shall provide training on each piece of equipment according to Section 23 05 00.

3.8 DEFERRED TESTING

A. Refer to Section 01 91 00 for requirements of deferred testing.

3.9 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the start-up and initial checkout plan described in Section 01 91 00 and the filled out start-up, initial checkout and prefunctional checklists.

END OF SECTION

SECTION 25 22 00

LABORATORY AIR FLOW CONTROL SYSTEM (Revised AD-1, AD-4)

PART 1 - GENERAL

1.1 DESCRIPTION

AD-1: Section 25 22 00: Revise paragraph 1.1.A.

A. A laboratory airflow control system shall be furnished and installed to control the airflow into and out of each laboratory room. The exhaust flow rate of a laboratory fume hood shall be controlled precisely to maintain a constant average face velocity into the fume hood. When the presence of an operator is sensed at the hood, the system shall maintain an in-use value of 100 feet per minute (adjustable). When no operator is sensed, the system shall maintain a standby value of 60 feet per minute (adjustable). The lab airflow control system shall be digitally interfaced with the BMCS such that the BMCS can read and alarm the value of all individual points, and can manually reset all system setpoints.

1.2 PREVENTIVE MAINTENANCE

A. The laboratory airflow control system supplier shall provide at no additional cost to the owner during and after the warranty period five years of required preventive maintenance on all airflow sensors (e.g., pitot tube, flow cross, orifice ring, air bar, hot wire, vortex shedder, side wall sensors, etc.) and flow transducers provided under this section. Airflow sensors shall be removed, inspected, and cleaned annually during the five-year period to prevent inaccuracies due to long-term buildup from corrosion, lab tissues, wet or sticky particles, or other materials that foul the sensor. If impractical to remove the airflow sensors, the laboratory airflow control system supplier shall include in the proposal the cost of supplying and installing duct access doors, one for each sensor. The transducer shall be checked and recalibrated annually to ensure long-term accuracy. Note that auto-zero recalibration of transducers is not acceptable as a substitute for annual recalibration.

1.3 WARRANTY PERIOD

A. Warranty shall commence upon the date of shipment and extend for a period of 36 months, whereupon any defects in materials or laboratory airflow control system performance shall be repaired by the supplier at no cost to the Owner.

1.4 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MATERIALS – GENERAL

A. Acceptable manufacturers:
   1. Phoenix Controls Corporation.
   2. TriaTek.

B. No other manufacturers acceptable.

2.2 AIRFLOW CONTROL DEVICE – GENERAL

A. The airflow control device shall be a venturi valve.

B. The valve assembly manufacturer's Quality Management System shall be registered to ISO 9001:2000.

C. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.

D. The airflow control device shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than 16 to 1.

E. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

F. The airflow control device shall be constructed of one of the following three types:

1. **Class A –** The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of 16-gauge aluminum. The device's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, polyester or PPS (polyphenylene sulfide) composite. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.
2. **Class B –** The airflow control device for corrosive airstreams, such as fume hoods and biosafety cabinets, shall have a baked-on, corrosion-resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of a Teflon or PPS (polyphenylene sulfide) composite.

AD-1: Section 25 22 00: Delete paragraph 2.2.F.3.

3. **Deleted**

G. Actuation:

1. For electrically actuated VAV operation, an electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, normally closed-minimum position and last position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).

AD-4: Section 25 22 00: Delete paragraph 2.2.G.2.

2. Deleted

AD-4: Section 25 22 00: Revise paragraph 2.2.G.3.

3. High Speed Electric Actuators require a response from Minimum to Maximum of 1 second.

H. Certification:

1. Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of no more than ±1% of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to ±5% of signal at a minimum of 48 different airflows across the full operating range of the device.

2. Each airflow control devices shall be marked with device-specific factory calibration data. At a minimum, it should include the tag number, serial number, model number, eight-point characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

I. Airflow control devices that are not venturi valves and airflow measuring devices (e.g., pitot tube, flow cross, air bar, orifice ring, vortex shedder, etc.) shall only be acceptable, provided these meet all the performance and construction characteristics as stated throughout this specification and:
   1. The airflow control device employs transducers manufactured by Rosemount, Bailey, Bristol, or Foxboro. Accuracy shall be no less than ±0.15% of span (to equal ±5% of signal with a 15 to one turndown) over the appropriate full-scale range, including the combined effects of nonlinearity, hysteresis, repeatability, drift over a one-year period, and temperature effect. 316L stainless steel materials shall be provided for all exhaust applications. The use of 304 stainless steel materials shall be provided for all make-up air applications.
   2. Airflow sensors shall be of a multi-point averaging type, 304 stainless steel for all supply and general exhaust applications, 316L stainless steel for all fume hood, canopy, snorkel, and biosafety cabinet applications. Single point sensors are not acceptable.
   3. Suppliers of airflow control devices or airflow measuring devices requiring minimum duct diameters shall provide revised duct layouts showing the required straight duct runs upstream and downstream of these devices. Coordination drawings reflecting these changes shall be submitted by the supplier of the laboratory airflow control system. In addition, suppliers shall include static pressure loss calculations as part of their submittals. All costs to modify the ductwork, increase fan sizes and horsepower and all associated electrical changes shall be borne by the laboratory airflow control supplier.

2.3 EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER

A. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.

B. The airflow control device shall store its control algorithms in non-volatile, re-writeable memory. The device shall be able to stand-alone or to be networked with other room-level digital airflow control devices using an industry standard protocol.

C. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no room-level controller shall be required.

D. The airflow control device shall use industry standard 24 Vac power.

E. The airflow control device shall have provisions to connect a notebook PC commissioning tool and every node on the network shall be accessible from any point in the system.

F. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:
   1. Three universal inputs capable of accepting 0 to 10 Vdc, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
   2. One digital input capable of accepting a dry contact or logic level signal input.
   3. Two analog outputs capable of developing either a 0 to 10 Vdc or 4 to 20 mA linear control signal.
   4. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 Vac/Vdc.

G. The airflow control device shall meet FCC Part 15 Subpart J Class A and be UL916 listed.

2.4 FUME HOOD CONTROL EQUIPMENT

A. Fume hoods shall be variable air volume (VAV) systems. A sash sensor shall be provided to measure the height of each vertically moving fume hood sash. A sash sensor shall also be provided for horizontal overlapping sashes. Control systems employing sidewall-mounted velocity sensors shall be unacceptable.

B. The laboratory airflow control system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood's exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1.

C. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/undershoot) of required airflow. Rate of sash movement shall be from one to one and one-half feet per second.

D. A presence and motion sensor shall be provided to determine an operator's presence in front of a hood by detecting the presence and/or motion of an operator, and to command the laboratory airflow control system from an in-use operating face velocity (e.g., 100 fpm) to a standby face velocity (e.g., 60 fpm) and vice versa:
   1. The sensor shall define a detection zone that extends approximately 20" (50 cm) from the front of the fume hood. If the sensor does not detect presence and/or motion in its detection zone within five seconds, it shall command the system to the user-adjustable standby face velocity. When the sensor detects the presence and/or motion of an operator within the detection zone, it shall command the system to the in-use face velocity within one second.
   2. The sensor shall have a control circuit that adapts to its specific surroundings and adjusts automatically for inanimate objects placed within its detection zone. It shall map the area into memory and, after a period of five minutes, nullify the image of the inanimate object and return to a standby mode. When operators enter and leave the zone, the unit shall adjust automatically between in-use and standby modes. If the inanimate object is moved or taken out of the zone, the unit shall re-map the area automatically.
   3. Wide area motion detectors (on the hood or room level) shall be unacceptable.

E. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to assure flow through the fume hood even with the sash totally closed.

F. A fume hood monitor shall be provided to receive the sash sensor output and presence and/or motion signal. This same monitor shall generate an exhaust airflow control signal for the appropriate airflow control device in order to provide a constant average face velocity. Audible and separate visual alarms shall be provided for both flow alarm and emergency exhaust conditions.

G. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable.

H. Air Flow control valve for Fume hoods shall be of Class B construction. Electric actuator shall be high speed with fail safe state of normally open – maximum position. Makeup Air valves and general exhaust valves associated with the fume hood valve, shall be of Class A construction. Electric actuator shall be high speed with fail safe state of last position.

2.5 TWO-POSITION EXHAUST AIRFLOW CONTROL DEVICE

A. The airflow control device shall maintain a factory calibrated fixed maximum and minimum flow set point based on a switched signal via network or manual. The device shall generate a digital feedback signal that represents its airflow. All two-position devices shall be either networked or hard-wired into the room-level network so as to be considered under pressurization control.

B. Airflow control device that serves Canopy hoods shall be of Class A construction with Fail – safe state of last position

2.6 EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER – TRACKING PAIR

A. One controller shall be supplied for both the supply airflow control device and the corresponding exhaust air control device. The controller shall be a microprocessor-based design and use closed-loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.

B. Airflow control devices that serve both supply and exhaust shall be of Class A construction.

C. A low-speed electric actuator shall be used to modulate the airflow over the range of the specific valve size. The maximum time to modulate from minimum to maximum flow shall be less than 90 seconds. A UL or CSA listed electronic actuator shall be factory mounted to the valve. The actuator shall have sufficient torque to modulate the airflow against the maximum duct static pressure (within product specifications). Loss of main power shall cause the valve to maintain its last airflow position. This position shall be maintained until power is restored.

2.7 CONSTANT VOLUME AIRFLOW CONTROL DEVICE

A. The airflow control device shall maintain a constant airflow set point. It shall be factory calibrated and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.

AD-1: Section 25 22 00: Revise paragraph 2.7.B.

B. Laboratory airflow control systems suppliers not employing constant volume venturi airflow control valves shall provide electrical wiring as required for their devices.

2.8 CONTROL FUNCTIONS

A. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, pressurization, temperature, humidity control, as well as respond to occupancy and emergency control commands.

B. Pressurization Control:
   1. The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.
   2. The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable.
   3. The pressurization control algorithm shall consider both networked devices, as well as:
      a. Up to three non-networked devices providing a linear analog flow signal.
      b. Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.

4. Volumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means of control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.
5. The pressurization control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.

C. Temperature Control:
1. The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writeable from the BMCS, with the option of a local offset adjustment.
2. Temperature control shall be implemented through the use of independent primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with both supply and exhaust airflow devices responding simultaneously so as to maintain the desired offset. Heating shall be provided through modulating control of a properly sized reheat coil.
3. The laboratory control system shall also provide the built-in capability for being configured for hot deck/cold deck temperature control.
4. The auxiliary temperature control function shall offer the option of either heating or cooling mode and to operate as either a standalone temperature control loop, or staged to supplement the corresponding primary temperature control loop.

D. Occupancy Control:
1. The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the BMCS as a scheduled event or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to be occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over a BMCS command.

E. Fume Hood Control:
1. Airflow devices intended to control the face velocity of a fume hood shall have the ability to interface directly with the fume hood monitoring device. The airflow control device shall:
   a. Accept command inputs to regulate the flow accordingly and make this command value available to the BMCS.
   b. Accept a sash position signal and make this value available to the BMCS.
   c. Accept a Usage Based Control signal to indicate user presence and make this signal available to the BMCS.
   d. Provide a flow feedback signal to the fume hood monitor, which may be used for calculating face velocity or to confirm the airflow device has achieved the proper flow rate and make this value available to the BMCS.
   e. Provide alarm signals to the fume hood monitor in the event the airflow device is unable to achieve the proper flow rate, there is a loss of static pressure indicating improper fan operation, or there is a loss of power to the airflow control device, in order to provide a local alarm indication.
   f. The fume hood airflow control device shall respond to changes in sash position and user presence within one second, in order to provide a constant 80-feet-per-minute face velocity when the fume hood is in use.

F. The laboratory control system shall be segregated into subnets to isolate network communications to ensure room-level control functions and BMCS communications are carried out reliably. Each laboratory space or pressurization zone shall be its own subnet. Commercially available routers shall be used to provide this isolation.

G. The laboratory airflow control system shall support at least 20 networked devices in each pressurized zone.

H. All points shall be available through the interface to the BMCS for trending, archiving, graphics, alarm notification and status reports. Laboratory airflow control system performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.

I. Refer to the BMCS specification for the required input/output summary for the necessary points to be monitored and/or controlled. All points shall be available to be mapped into the BMCS system.

J. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, temperature control, humidity control, and implement occupancy and emergency mode control schemes.

2.9 INTERFACE TO BUILDING MANAGEMENT SYSTEMS

A. The laboratory airflow control system network shall have the capability of digitally interfacing with the BMCS. The required software interface drivers shall be developed and housed in a dedicated interface device furnished by the laboratory airflow control system supplier.

AD-1: Section 25 22 00: Revise paragraph 2.9.B.

B. All room-level points shall be available to the BMCS for monitoring or trending as well as total remote controllability. The gateway shall maintain a cache of all points to be read and monitored by the BMCS. The room-level airflow control devices shall update this cache continually.

AD-1: Section 25 22 00: Revise paragraph 2.9.C.

C. The building-level network shall be BACnet communications protocol. The building-level network shall support up to 100 subnets or pressurization zones, or 6000 data points.

AD-1: Section 25 22 00: Delete paragraph 2.9.D.

D. Deleted

E. A commercially available network interface card shall be provided with the gateway to interface with the BMCS. System shall interface using BACNET over IP protocol.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The automatic temperature controls (ATC) contractor shall install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood under initial supervision of the laboratory airflow control system supplier. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels. Sash interface boxes with interface cards shall be mounted in an accessible location.

B. The ATC contractor shall install all routers and repeaters in an accessible location in or around the designated laboratory room.

C. The ATC shall install an appropriately sized and fused 24 Vac transformer suitable for NEC Class II wiring.

D. All cable shall be furnished and installed by the ATC contractor. The ATC contractor shall terminate and connect all cables as required. The ATC shall utilize cables specifically recommended by the laboratory airflow controls supplier.

E. The mechanical contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.

F. The mechanical contractor shall provide and install all reheat coils and transitions.

G. The mechanical contractor shall provide and install insulation as required.

H. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

3.2 SYSTEM START-UP AND TRAINING

A. System start-up shall be provided by a factory-authorized representative of the laboratory airflow control system manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment, as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust or return), system programming and integration to BMCS (when applicable).

B. The balancing contractor shall be responsible for final verification and reporting of all airflows.

C. The laboratory airflow control system supplier shall furnish a minimum of eight hours of owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves and general troubleshooting procedures.

D. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

E. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 25 23 00
ADJUSTABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Description of systems:
   1. Adjustable frequency drives, PWM.
   2. Input fused padlockable manual disconnect.
   3. Two (2) contactor manual bypass.
   4. Minimum three (3) percent AC line or DC link reactor.
   5. Adjustable frequency drives are to be furnished under this section. They are to be mounted and wired under Division 26, Electrical.

1.2 QUALITY ASSURANCE

A. Manufacturer shall have a minimum of 7 years in manufacture and operation of PWM drives in size(s) indicated.

B. UL-508C, Standard for Power Conversion Equipment.

C. IEEE Standard 519, latest edition, "Guide for Harmonic Control and Reactive Compensation of Static Power Converters".

D. European Union Electromagnetic Compatibility Directive 89/336/EEC, EN 61800-3 Adjustable Speed Electrical Power Drive Systems, Part 3.

E. 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.

1.3 SUBMITTALS

A. Shop drawings:
   1. Dimensional drawings.
   2. Power circuit drawings.
   3. Control connection drawings.

B. Product data:
   1. AFD's maximum rated output amps.
   2. AC link and/or DC link reactor data.
   3. CE mark indicating compliance with European Union EMC Directive 89/336/EEC.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.
   3. Factory start-up and field test reports.
   4. Warranty.

1.4 WARRANTY

A. Warranty:
   1. 12 months from date of start up, not to exceed 18 months from date of shipment:
      a. Include all parts, labor, travel time and expenses.

1.5 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 ADJUSTABLE FREQUENCY DRIVES - GENERAL

A. Acceptable manufacturers:
   1. Adjustable frequency drives, pulse width modulated:
      a. Base:
         1) Allen Bradley.
      b. Optional:
         1) Asea Brown Boveri (ABB).
         2) Yaskawa.
   2. Fuses:
      a. Base:
         1) Bussmann.
         2) Shawmut.
         3) Reliance Electric.

B. General requirement for adjustable frequency drives:
   1. Adjustable frequency in proportion to output speed.
   2. Adjustable output voltage with constant volts/Hz over a variable torque output range.
   3. Supply full rated current at frequency within a variable torque output range.
   4. Develop full shaft power needed.

C. Adjustable frequency drives shall be checked against each motor's total amperage, and current limiting overload control shall be properly set.

D. Adjustable frequency drives and associated motors shall be compatible without motor deration.

E. Motor noise as a result of AFD: Limited to three dB over across the line operation, measured at three feet from motor's center line.

2.2 ADJUSTABLE FREQUENCY DRIVES (AFD'S)

A. Adjustable frequency drives (AFD): Provide rectifiers to convert three-phase, 60 Hz AC power to DC power and inverters to “invert” DC power back to a variable voltage and variable frequency, three-phase AC power:
   1. Provide input fused disconnect switch or combination circuit breaker and fuse to disconnect drive, bypass and all accessories:
      a. Fuses to be provided by AFD manufacturer.
      b. Provisions for padlock in off position.
   2. AFD shall be rated for 100,000 Amp interrupting capacity (AIC).
   3. Enclosed in NEMA 1 enclosure including accessories, completely assembled and tested; or all components provided in a single factory supplied racking system with components and accessories assembled, wired and factory tested.
   4. In applications where drives are to be mounted out-of-doors, all components shall be mounted within a NEMA 4 enclosure.
   5. Enclosure shall be of such design to assure adequate cooling at full load under ambient conditions to 104 ºF. Provide fan cooling if necessary.
   6. Harmonic mitigation: Minimum 3 percent AC line or DC link reactor mounted within the AFD enclosure.
   7. Drive efficiency: 97 percent of greater at full speed and full load.

8. Displacement power factor: 0.95 at all speeds and loads.
9. Switching frequency adjustable over minimum range of 2.0 to 12.0 kHz.

B. Rectifier section: Full wave diode bridge rectifier. Phase controlled rectifiers are unacceptable.

C. DC bus linking rectifier and inverter.

D. Inverter section: Pulse width modulated voltage source inverter (PWM):
1. Output voltage shall very with frequency using insulated gate bipolar transistors (IGBT). VVI, six-step, current source, SCR, GTO, and bipolar junction transistor (BJT or Darlington pair transistors) drives are not acceptable.

E. Printed circuit boards: Completely tested before being assembled into completed adjustable frequency drive:
1. Subject adjustable frequency drive to a preliminary functional test, and computerized final test.
2. Drive input power: Continuously cycled for maximum stress and thermal variation.

F. Environmental operating conditions:
1. 32 to 104 degF at 4 kHz switching frequency.
2. 0 to 3300 feet above sea level, less than 95 percent humidity, non-condensing.
3. Atmosphere: Standard equipment room environment.

G. Additional requirements:
1. Provide same control interface and connections regardless of horsepower rating.
2. On loss of input signal:
   a. Display a fault condition.
   b. Maintain last output speed prior to loss of signal.
3. Utilize digital display (LCD or LED).
4. Automatically restart after an overcurrent, overvoltage, under-voltage, loss of input signal protective trip or any other fault:
   a. Number of restart attempts and trial time to be programmable.
5. Capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage.
6. Provide an automatic extended power loss ride-through circuit which will utilize inertia of load to keep drive powered:
   a. Minimum power loss ride-through: One-cycle or extended time.
7. Control terminal strip: Isolated from line and ground.
8. Provide prewired 3-position Hand-Off-Auto switch, manual speed adjustment (keypad or potentiometer) and local-remote switch to control AFD:
   a. When in "Hand" position, AFD will be started at the drive location.
   b. When in "Off" position, AFD will be stopped.
   c. When in "Auto" position, AFD will start via an external contact closure.
   d. When local-remote switch is in "Local" position, speed will be controlled by manual speed adjustment.
   e. When local-remote switch is in "Remote" position, speed will be controlled by external speed reference.
   f. Operate local-remote switch independently of HOA switch for maximum flexibility:
      1) 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.

H. Provide following adjustments:
1. A minimum of 3 critical frequency lockout ranges to prevent adjustable frequency drive from continuously operating at an unstable speed:
   a. Width of each frequency range: Field adjustable.
2. Two programmable analog inputs: Accept a current or voltage signal for speed reference, or for reference and actual signals for PI controller:
   a. Provide a filter programmable from 0.01 to 10 seconds to remove any oscillation in input signal.

b. Minimum and maximum values (gain and offset): Adjustable within range of 0-20 mA and 0-10 Volts.

3. Two programmable analog outputs: Proportional to frequency, motor speed, output voltage, output current, motor torque, motor power, or DC bus voltage.
4. Relay outputs:
   a. 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.
5. Independently adjustable acceleration and deceleration rates (1-600 seconds).
6. Ramp or coast to a stop, as selected by user.
7. Provide DC hold and dynamic braking.

I. Operational information displays:
   1. Output Frequency.
   2. Motor current.
   3. Output voltage.

J. Protection circuits: In case of a protective trip, stop drive and display fault condition. Detect fault on any one or more phases:
   1. Overcurrent trip: 200 percent of AFD's variable torque current rating.
   2. Overvoltage trip: 130 percent of AFD's rated voltage.
   3. Undervoltage trip: 60 percent of AFD's rated voltage.
   4. Overtemperature: Plus 158 degF.
   5. Ground Fault.
   6. Adaptable electronic motor overload protection:
      a. Protect motor based on speed, load curve, and external fan parameter.
      b. Circuits which are not speed dependent are unacceptable.

K. Speed command input:
   1. Keypad or manual speed potentiometer.
   2. 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. Filter: Adjustable from 0.01 to 10 seconds.
      d. Able to be inverted, so that minimum reference corresponds to maximum speed, and maximum reference corresponds to minimum speed.
      e. Minimum and maximum values (gain and offset): Adjustable within range of 0-20 mA and 0-10 Volts.

L. Accessories:
   1. Interlock terminal strip:
      a. Provide separate terminal strip for connection of freeze, fire, smoke contacts, and external start command.
      b. External interlocks: Remain fully functional whether drive is in Hand, Auto or Bypass.
      c. Interlocks shall be 30 volt maximum. Provide pilot relays where required.
   2. All wires to be individually numbered at both ends for ease of troubleshooting.
   3. Door interlocked disconnect switch: Padlockable in "Off" position.
   4. Door interlocked magnetic circuit breaker: Disconnect all input power from drive and all internally mounted options:
      a. Disconnect handle: Thru-the-door type, padlockable in "Off" position.
   5. Bypass manual transfer to line power via three (3) contactors:
      a. Include motor thermal overload and fuse or circuit breaker protection while in bypass operation.
      b. Provide a three position drive/off/bypass selector switch to control bypass drive input and output contactors:
         1) Mechanically and electrically interlock bypass and drive output contactors.
         2) In "Normal" mode, bypass contactor is open while drive input and output contactors are closed.
         3) In "Off" position, all contactors are open.

4) In "Bypass" position, drive input and output contactors are open, and bypass contactor is closed.

6. Drive output contactor: Open when drive is stopped, isolating motor from drive:
   a. Start/stop signals and safety interlocks: Work in drive and bypass modes.
7. Time delay relay: 0-120 seconds field adjustable.
8. Where AFD is indicated to serve two motors not intended to run simultaneously, provide the following:
   a. Provide one set of motor overloads in the bypass and one set of interlocked contacts in each motor circuit.
   b. Provide a three position A/B/remote selector switch.
   c. In "A" or "B", motor A or motor B will be active. In "Remote", a remote contact closure signal from the Control and Instrumentation System will select the active motor.
   d. Mechanically and electrically interlock contactors to prevent both motors being activated simultaneously.
9. Where AFD is indicated to serve two or more motors intended to run simultaneously, provide the following:
   a. Include fusing and thermal overload protection for each motor circuit and one set of contacts in each motor circuit for individual on/off control.

M. 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Turn AFD's over to Div. 16 contractor for mounting and wiring. Section 25 23 00 contractor shall be responsible for testing, startup, Owner instruction, and performance verification.

B. Install in accordance with manufacturer's installation instructions and as specified.

C. Where AFD's are mounted on air handling unit casing(s), provide bracing and coordinate with air handling unit manufacturer.

D. Cover and protect units from installation dust and contamination until environment is cleaned and ready for operation.

E. Field wiring and interlocks:
   1. Output disconnects:
      a. Provide field wiring between AFD and contacts at output motor disconnect switches to shutdown AFD prior to disconnecting motor from drive.
      b. Contacts open prior to interruption of motor circuit.
      c. When there are multiple motors driven by one AFD, contacts must be interlocked in series so that if any motor is disconnected, AFD will be switched off.

3.2 TESTING AND START UP

A. Factory testing:
   1. Provide test results to confirm that adjustable frequency drive has been tested to substantiate designs according to applicable ANSI and NEMA Standards.
   2. Tests shall verify not only performance of unit and integrated assembly, but also suitability of enclosure venting and rigidity.
   3. In addition, unit shall be factory tested in accordance with ANSI Standards.
   4. Submit factory test reports.

B. 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 percent load, 50 percent load and 25 percent load, for a minimum of 1 hour at each load.
   3. Field test according to ANSI Standards.

C. Set field adjustable time delay relays. Verify delay with Division 26.

D. Drive shall be adjusted to prevent operation of motor and load at a speed less than two times the natural frequency of the vibration isolation system:

Isolator Deflection (inches)	Minimum Speed Driven Load (RPM)
1/2 IN	600
3/4 IN	430
1 1/2 IN	300
2 1/2 IN	240
3 1/2 IN	200

E. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.3 OWNER INSTRUCTIONS

A. Provide services of manufacturer's representative for 8 hours 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.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 25 50 00

BUILDING MANAGEMENT AND CONTROL SYSTEM (Revised AD-1, AD-4)

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

AD-1: Section 25 50 00: Revise paragraph 1.1.A.

AD-4: Section 25 50 00: Delete paragraphs 1.1.A through 1.1.C. Replace with paragraphs 1.1.A through 1.1.E and renumber subsequent paragraphs.

A. The existing campus system is a Johnson Controls "Metasys Extended Architecture" system.

B. The new Building Management and Control System (BMCS) shall consist of a high-speed, peer-to-peer network of DDC controllers, a web server, and a web-based operator interface. This system shall be accessible via the Argonne intranet from any PC with a standard web browser.

C. The new BMCS shall report all status and alarm information to a single existing primay Argonne operator's terminal (PC). This terminal shall be able to access and read all input points and issue commands to all output points in the new BMCS by means of a standard web browser. This Contractor shall provide all necessary hardware and software components of the new BMCS to accomplish this interface. There shall be no requirement for the Contractor to upgrade any existing systems.

D. Each mechanical system and building floor plan shall be depicted by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on the PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.

E. The system shall directly control HVAC equipment as specified. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints as specified.

AD-1: Section 25 50 00: Delete paragraph 1.1.D.

F. Deleted

G. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. Schedules, setpoints, trends, and alarms specified in paragraph Sequence of Operation and Input/Output Survey.

H. Contractor’s Responsibility: The Contractor shall furnish and install a complete direct digital control (DDC) system as hereinafter specified:
   1. The control system shall include all direct digital control modules, all sensors, transmitters, automatic valves, automatic dampers, actuators, relays, switches, wire, tubing, thermometers, gauges, and conduit external to the DDC panels and all other necessary equipment and control devices required to maintain the conditions as described and detailed in Plans and Specifications.
   2. All supply power transformers for the panel and the panel enclosures shall be provided as specified or required for the specific equipment being furnished.
   3. The Contractor shall mount the DDC panels and run the input/output wiring to the panels and the communication wiring between the panels. The Contractor shall be responsible for the coordination of his work with other Contractors for the complete installation as described in these Specifications.

I. Electrical Power: Electrical Contractor shall provide power to certain locations as indicated on the Electrical Drawings. Power shall be provided by a separately fused dedicated circuit and with an insulated ground wire from the power panel ground. All electrical power wiring shall be in conduit as described in the Electrical Section of these Specifications. Temperature control panels shall have no exposed electrical connections above 30 volts. Provide shield or other personal protection barriers. Provide wiring diagram in each panel.

J. Information on Drawings: See the Drawing set for flow diagrams, sensor locations, and temperature control diagrams.

K. Provide Building Management and Control System incorporating Direct Digital Control (DDC), energy management and equipment monitoring consisting of the following elements:
   1. Microprocessor based remote control panels interfacing directly with sensors, actuators, and environmental delivery systems to provide complete standalone DDC/EMS functionality. (i.e., HVAC equipment, etc.).
   2. Communication network to allow data exchange between remote panels and central building management computer.
   3. Personal computer (PC) based central and associated operator station(s), and software functioning as the primary operator interface for BMCS. System shall utilize a graphics front end.
   4. Electric and electronic control for all items indicated including dampers, valves, panels and electrical installation.
   5. Interface with campus control system via site Ethernet.

L. Air terminal unit damper operators and controls: DDC controllers, actuators, transformers, and disconnects shall be furnished under this section. They shall be factory installed and wired by the air terminal unit manufacturer. Provide 120V/24V transformer and power disconnect for each air terminal unit to be factory installed and wired to power all control devices in the unit. Air terminal units are to have a single 120V power connection.

M. Smoke and fire/smoke dampers and operators are furnished and installed under Specification Section 23 31 13. This Contractor shall coordinate type of operators required with that section of the specifications. Control connection and damper operation as described in the sequence of operation to be provided under this section of the specifications.

N. Control dampers: Duct mounted automatic control dampers are furnished under this section but are installed under Section 23 31 13. Actuators for all control dampers are furnished and installed by controls contractor under this section. Contractor shall coordinate exact size of damper with contractor performing work under Section 23 31 13 and shall submit all sizes for approval.

O. Duct mounted smoke detectors are furnished under Division 26. They shall be mounted under this section. Power and alarm wiring shall be furnished and installed under Division 26. All control wiring required to accomplish sequence of operation herein specified shall be furnished and installed under this section.

P. Provide submittals, installation, data entry, programming, startup, test and validation of BMCS, instruction of Owner's representative on maintenance and operation of BMCS, as-built documentation, and system warranty.

1.2 SYSTEM PERFORMANCE

A. Performance Standards: System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems):
   1. Graphic Display: A graphic with 20 dynamic points shall display with current data within 5 seconds.
   2. Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 seconds and shall automatically refresh every 8 seconds.

3. Configuration and Tuning Screens: Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 seconds.
4. Object Command: Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds.
5. Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 15 seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with the mechanical process under control.
7. Performance: Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation: Each workstation on the network shall receive alarms within 5 seconds of other workstations.

1.3 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:
   1. Graphics.
   2. Record drawings.
   3. Database.
   4. Application programming code.
   5. Documentation.

1.4 WORK BY OTHERS

A. Setting in place of valves, flow meters, water pressure and differential taps, flow switches, thermal wells, dampers, airflow stations, and current transformers.

B. This Contractor shall coordinate with other contractors as necessary to assure all pipe, duct, and wall mounted devices are properly located and installed.

AD-1: Section 25 50 00: Revise paragraph 1.4.C.

C. Certain process equipment will be furnished under other sections of these specifications or by Owner, as indicated on the Drawings, with control and monitoring systems included as part of the equipment. The contractor shall coordinate central control and/or monitoring functions for this equipment as specified in this Section with the equipment vendors.

AD-1: Section 25 50 00: Delete paragraph 1.4.D.

D. Deleted

1.5 QUALITY ASSURANCE

A. System to be installed by competent mechanics, with full responsibility for proper operation of BMCS, including debugging and proper calibration of each component in entire system.

B. Codes and approvals:
   1. Complete BMCS installation to be in strict accordance with national and local electrical codes, and Division 26 of these specifications. All devices designed for or used in line voltage applications to be UL listed.
   2. All microprocessor based remote devices: UL916 and UL864 listed.
   3. All BMCS central equipment: UL916 listed.
   4. All electrical environmental control and monitoring devices: UL429 and/or UL873 listed.
   5. Following current UL standards are applicable: UL429 Electrically Operated Valves, UL555 Fire Dampers, UL873 Temperature Indicating and Regulating Equipment, UL916 Energy Management Equipment.
   6. Following current NFPA Standards and Guides are applicable: NFPA-70 National Electric Code, NFPA-90A Air Conditioning Systems, NFPA-90B Warm Air Heating, Air Conditioning.

7. All electronic equipment shall conform to the requirements of FCC regulation Part 15, Section 15 governing radio frequency electromagnetic interference for Class A computing devices and shall be so labeled.

C. All system components shall be fault tolerant:
   1. Provide satisfactory operation without damage at 110 percent and 85 percent of rated voltage, and at ± 3-Hertz variation in line frequency.
   2. Provide static, transient, short circuit, and surge protection on all inputs and outputs. Communication lines to be protected against incorrect wiring, static transients, and induced magnetic interference. Bus connected devices to be a.c. coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.
   3. All real time clocks and data file RAM to be battery or capacitor backed with sufficient capacity to provide 24-hour backup.

D. System overall reliability requirement: The system, including all components and appurtenances, shall be configured and installed to yield a Mean Time Between Failure (MTBF) at least 1000 hours.

E. System Accuracy - Provide a DDC system, which shall display and control each system variable to the level of accuracy specified below. System shall maintain this level of accuracy for one year from date of Acceptance:
   1. Space temperature control accurate to ±1.0 ºF.
   2. Duct temperature control accurate to ±0.1 °F where indicated.
   3. Duct temperature control accurate to ±0.5 °F.
   4. Water temperature control accurate to ±0.5 ºF.
   5. Relative humidity control accurate to ±5.0 percent RH.
   6. Water differential pressure control accurate to ±5.0 percent of setpoint.
   7. Air static pressure control accurate to ±5.0 percent of setpoint.
   8. Water flow control accurate to ±5.0 percent of setpoint.
   9. Air flow control accurate to ±5.0 percent of setpoint.

F. All field equipment shall be rated for continuous operation under ambient environmental conditions of 35 to 120 °F dry bulb and 10 to 95 percent relative humidity, non-condensing. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity and vibration conditions specified or normally encountered for the installed location.

1.6 SUBMITTALS

A. Shop drawings:
   1. Data sheets of all products.
   2. Valve, damper, and well and tap schedules showing size, configuration, capacity, and location of all equipment.
   3. Data entry forms for initial parameters. All text and graphics to be approved prior to data entry.
   4. Wiring and piping interconnection diagrams, including panel and device power and sources.
   5. Equipment lists of all proposed devices and equipment.
   6. Software design data including:
      a. Flow chart of each DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.
      b. Sequence of operation relating to all flow chart functions.
   7. Control sequence.
   8. DDC installation, block diagrams, and wiring diagrams for each piece of equipment.
   9. DDC panel physical layout and schematics.
   10. Building level overview of control system architecture.
   11. Data entry forms for initial parameters. All graphics to be approved prior to data entry.
   12. Sketches of all graphics.
   13. Graphic penetration tree showing all graphics and all points.
   14. Detailed color conventions proposed for all graphics and graphic elements and states.

15. Data on any proprietary protocols to allow user to write a custom driver/interface.

B. Project information:
   1. Certification of installer qualifications.

C. Contract closeout information:
   1. Operating and maintenance manuals.
   2. Owner instruction report.
   3. Training provided by BMCS contractor.
   4. Provide digital copies of submittal items 1 through 10.

1.7 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. Acceptable manufacturer:
   1. Temperature Control System:
      a. Base:
         1) Johnson Controls.
         2) Automated Logic Corp.
         3) Honeywell.
         4) Siemens.
   2. Air flow monitoring stations:
      a. Base:
         1) Ebtron.
         2) Air Monitor Corp.
   3. Site Chilled water ultrasonic flow meter:
      a. Base:
         1) Siemens Sitrans.
      b. Alternate:
         1) Flexim
   4. Process chilled water and hot water ultrasonic flow meter:
      a. Base:
         1) Siemens Sitrans.
      b. Alternate:
         1) Flexim.
         2) Dynasonics .
   5. Dampers and electric/electronic damper actuators:
      a. Base:
         1) 1. Ruskin.
      b. Alternate:
         1) Johnson.
         2) Siemens.
   6. Control valves standard accuracy:
      a. Base:
         1) Siemens.
      b. Alternate:
         1) Johnson.
         2) Fisher.
         3) Baumann.
   7. Terminal valves:

a. Base:
    1) Neptronics.
b. Alternate:
    1) Belimo.

8. Freezestats:
    a. Base:
        1) Johnson.
    b. Alternate:
        1) Penn.
        2) Siemens T.
9. Pressure and differential Pressure transmitters:
    a. Base:
        1) Veris.
    b. Alternate:
        1) Setra.
        2) Rosemount.
10. Humidity sensors:
    a. Base:
        1) Vasala.
    b. Alternate:
        1) GE.
11. Temperature sensors:
    a. Base:
        1) Bapi.
    b. Alternate:
        1) Minco.
12. Other control devices may be of varied manufacturers whose products are capable of meeting performance requirements.
13. Contractor is responsible for quality and satisfactory operation of devices, and for overall performance of system.

B. Monitoring and control system:
    1. Include:
        a. Temperature sensors.
        b. Humidity sensors.
        c. Controllers.
        d. Switches.
        e. Relays.
        f. Valves.
        g. Dampers.
        h. Damper operators.
        i. Thermostats.
        j. Humidistats.
        k. Airflow measuring sensors.
        l. Water flow measuring sensors.
        m. Pressure transducers.
        n. Other associated controls required to maintain conditions described in detail on drawings, together with thermometers, gauges and other accessory equipment.
    2. Space temperature and humidity control.
    3. Control of air handling units.
    4. Control of exhaust systems.
    5. Control of cooling systems.
    6. Control of heating systems.
    7. Control of process systems.
    8. Control panels.

9. Provide complete system of wiring and air piping as necessary to fill intent of these specifications.
10. Control sequences indicated illustrate basic control functions only. Provide additional controls required to meet intent of these specifications and make a complete system.

2.2 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ASHRAE/ANSI Standard 135-2001, BACnet.

B. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

C. Internetwork operator interface and value passing shall be transparent to internetwork architecture:
   1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
   2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in this section. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

D. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.4 OPERATOR INTERFACE

A. Operator Interface: Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information.

B. Communication: Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ASHRAE/ANSI 135-2001, BACnet Annex J.

C. Hardware: Provide one workstation consisting of the following:
   1. Hardware Base: Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified in this section. The PC deployed in ESB for the Building Automation System must meet or exceed the performance specifications provided by the manufacturer of the Building Automation System.
      a. 1 224-6917 OptiPlex 780 MT OptiPlex 780 Minitower Base Up to 88 Percent Efficient PSU 780MTEG:
         1) OptiPlex 780 MT OptiPlex 780 Minitower Base Up to 88 Percent Efficient PSU 780MTEG

2) Operating System(s): Genuine Windows Vista® Business SP2 Downgrade,XP Professional Installed, E X33B2DE
3) Processors: Intel® Core™ 2 Duo E8400 with VT (3.0GHz, 6M, 1333MHz FSB) VE8400
4) Memory: 4GB DDR3 Non-ECC SDRAM,1066MHz, (2 DIMM) 4G3N662
5) Keyboard: Dell USB Entry Keyboard EUSB
6) Monitors: Dell Professional P2210 22in HAS Wide Monitor, VGA/ DVI/ DP P2210T
7) Video Cards: DVI (Digital) Adapter Card, Full Height ADAPTF
8) Boot Hard Drives: 320GB SATA 3.0Gb/s and 16MB DataBurst Cache™ 320S3
9) Media Card Reader: No Media Card Reader NOMEDIA
10) Mouse: Dell USB 2-Button Entry Mouse with Scroll, Black USENTRY
11) Systems Management Mode: Intel® Standard Manageability ACSMIAT
12) Hard Drive Mode: No RAID NORAID
13) Removable Media Storage Device: 16X DVD+/-RW SATA, Roxio Creator™ CyberlinkPowerDVD™ DRM16
14) Thermal Heat Sink: Mainstream, Minitower HSMMT
15) Speakers: Internal Dell Business Audio Speaker INTSPK
16) Power Supply: OptiPlex 780 Minitower Up to 88 Percent Efficient Power Supply MTPSE
17) Documentation: Opti 780 Documentation English DOCENG
18) Energy Efficiency Options: Energy Star 5.0 Cat B (<175kWh TEC),EPEAT Gold, Dell ESMART Settings ESTARB
19) Resource DVD: No Resource DVD NORCD
20) Hardware Support Services: 3 Year Basic Limited Warranty and 3 Year NBD Onsite Service U3OS
21) Federal Keep Your Hard Drive Service, 3 YEAR KHDFED3
22) Low Power Mode: 1 Watt ready low-power mode LPMODE
23) Setup and Features Information Tech Sheet Tech Sheet, English TSHENG
24) Shipping Packaging Options: Shipping Material for System, Minitower MTSHIP
25) Additional System Options: CFI,Information,MIAS, Post Bur n,Factory Install DPNNR_2469122
26) Additional System Options: CFI Titan Code for CFI FIDA or Bypass SI DPNNR_2469123
27) Additional System Options: CFI Routing SKU DPNNR_2469124
28) Additional System Options: CFI, Rollup, Asset Report Only DPNNR_2469125
29) Additional System Options: CFI, Information, CS Routing, DIRE CT,Factory Install DPNNR_2469126
30) Processor Branding: Intel Core2 Duo Desktop Sticker IC2DDT

D. Operator Functions: Operator interface shall allow each authorized operator to execute the following functions as a minimum:
   1. Log In and Log Out: System shall require user name and password to log in to operator interface.
   2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
   3. View and Adjust Equipment Properties: Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.
   4. View and Adjust Operating Schedules: Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.

5. View and Respond to Alarms: Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
6. View and Configure Trends: Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
7. View and Configure Reports: Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
8. Manage Control System Hardware: Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.
9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

E. System Software:
1. Operating System: Web server shall have an industry-standard professional-grade operating system using Microsoft Windows XP Professional.
2. System Graphics: Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint:
   a. Functionality: Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
   b. Animation: Graphics shall be able to animate by displaying different image files for changed object status.
   c. Alarm Indication: Indicate areas or equipment in an alarm condition using color or other visual indicator.
   d. Format: Graphics shall be saved in an industry-standard format such as BMP, JPEG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

F. System Tools: System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. Software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license:
1. Automatic System Database Configuration: Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Controller Memory Download: Operators shall be able to download memory from the system database to each controller.
3. System Configuration: Operators shall be able to configure the system.
4. Online Help: Context-sensitive online help for each tool shall assist operators in operating and editing the system.
5. Security: System shall require a user name and password to view, edit, add, or delete data:
   a. Operator Access: Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object.

b. Automatic Log Out: Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
c. Encrypted Security Data: Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics: System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).
7. Alarm Processing: System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Input/Output Summary. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
8. Alarm Messages: Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
9. Alarm Reactions: Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
10. Alarm Maintenance: Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.
11. Trend Configuration: Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Trends shall be BACnet trend objects.
12. Object and Property Status and Control: Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.
13. Reports and Logs: Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports: Furnish the following standard system reports:
    a. Objects: System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Alarm Summary: Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. Logs: System shall log the following to a database or text file and shall retain data for an adjustable period:
        1) Alarm History.
        2) Trend Data: Operator shall be able to select trends to be logged.
        3) Operator Activity: At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgement and deletion. System shall date and time stamp logged activity.
15. Custom Reports: Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.
16. Graphics Generation: Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.

17. Graphics Library: Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.
18. Custom Application Programming: Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
    a. Language: Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
    b. Programming Environment: Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operator shall be able to inset, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.
    c. Independent Program Modules: Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
    d. Debugging and Simulation: Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
    e. Conditional Statements: Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
    f. Mathematical Functions: Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
    g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions:
        1) Time Variables: Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
        2) System Variables: Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

G. Portable Operator's Terminal: Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

H. BACnet: Web server or workstation shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L.

AD-1: Section 25 50 00: Add Article 2.5 in its entirety and renumber subsequent Articles.

2.5 DASHBOARD MONITOR

A. Provide a Dashboard Monitor data display to be installed in the entrance lobby. It shall consist of the following:
   1. Digital Signage Monitor
      a. 47 IN widescreen digital signage monitor (TAA compliant).
      b. Input signal: VGA, HDMI, component (2), composite (1), S-video inputs (1).
      c. Contrast ratio: 1000:1
      d. Brightness (typical): 500 nits
      e. Horizontal/Vertical viewing angle (typical): 178/178 degrees
      f. Maximum power rating: 325 watts
      g. Native resolution: 1920 x 1080
      h. Response rate (typical, rise and fall): 9 ms response time (GTG)
      i. Anti-glare and anti-static.
      j. Warranty: 3-year parts, 3-year labor, 3-year onsite limited warranty.
      k. Wall mount kit.
   2. Minitower PC computer similar to that specified in this section for Operator Interface.
      a. Digital signage monitor will serve as monitor for this unit. No additional monitor required.
      b. Removable media storage device not required.
   3. Software:
      a. In addition to software specified under Operator Interface, a specialized Energy Efficiency Dashboard Display package will be installed.
   4. Data Source:
      a. PC will interface with the BMCS BACnet internetwork data trunk, with capability of downloading all building system energy consumption data.

B. Installation and connection to data trunk is to be performed by this contactor.

2.6 CONTROLLER SOFTWARE

A. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. System Security: See "Security" and "Operator Activity" under "Operator Interface".

C. Scheduling: System shall provide the following schedule options as a minimum:
   1. Weekly: Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
   2. Exception: Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.
   3. Holiday: Operator shall be able to define 24 special or holiday schedules of varying length on a scheduling calendar that repeats each year.

D. System Coordination: Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

E. Binary and Analog Alarms: See "Alarm Processing" under "Operator Interface".

F. Alarm Reporting: See "Alarm Reactions" under "Operator Interface".

G. Remote Communication: System shall automatically contact operator workstation or server on receipt of critical alarms.

H. Maintenance Management: System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in Input/Output Summary.

I. Sequencing: Application software shall sequence fans and pumps as specified.

J. PID Control: System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.

K. Staggered Start: System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

L. Energy Calculations:
   1. System shall accumulate and convert instantaneous power (kW) or flow rates (gpm) to energy usage data.
   2. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.
   3. System shall calculate a fixed-window average. Window interval start shall be defined by utility meter digital input signal to synchronize system's and utility's fixed-window averages.
   4. System shall generate monthly and annual reports that sum up energy consumption data from various meters provided to measure energy use through BTU and electrical meters.

M. Anti-Short Cycling: Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

N. On and Off Control with Differential: System shall provide direct- and revers-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.

O. Runtime Totalization: System shall provide an algorithm that can totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in Input/Output Summary.

2.7 CONTROLLERS

A. General: Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), and Smart Actuators (SA) as required to achieve performance specified in "System Performance".

B. BACnet:
   1. Building Controllers (BCs). Each BC shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L.
   2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
   3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
   4. Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.
   5. BACnet Communication:
      a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
      b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.

c. Each AAC and ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
d. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication:
1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

D. Environment: Controller hardware shall be suitable for anticipated ambient conditions:
1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -20°F to 140°F.
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32°F to 120°F.

E. Real-Time Clock: Controllers that perform scheduling shall have a real-time clock.

F. Serviceability:
1. Controllers shall have diagnostic LEDs for power, communication, and processor.
2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.
3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

G. Memory:
1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

H. Immunity to Power and Noise: Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

I. Transformer: ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.8 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection: Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

C. Binary Inputs: Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs: Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

E. Analog Inputs: Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs: Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs: Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs: Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in air terminal unit damper motors only.

I. Universal Inputs and Outputs: Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.9 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies: Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity:
   1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure:
      a. Unit shall operate between 32°F and 120°F. EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
      b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering:
   1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
      a. Dielectric strength of 1000 V minimum.
      b. Response time of 10 nanoseconds or less.
      c. Transverse mode noise attenuation of 65 dB or greater.
      d. Common mode noise attenuation of 150 dB or greater at 40-100 Hz.

2.10 PORTABLE OPERATOR'S TERMINAL

A. General:
   1. Portable Operator's Terminal (POT) for operator readout of system variables, override control, and adjustment of control parameters. The POT shall consist of a laptop computer with associated software to execute the following functions. The display and keyboard must be under password control to prevent tampering. Hand held, plug-compatible with Network Control Processors (NCP), Local Control Processors (LCP), and LCP space thermostats. Provide 1 unit.

2. Functionality:
   a. Automatically display a sequential all point summary.
   b. Allow display and/or changing of digital point state, analog point value, time and date, application and DDC parameters, analog limits, time schedules, run time counts and limits, daylight savings time changeover, time/event initiation, and programmable offset values.
   c. Allow access to initialization routines and diagnostics, and enable/disable of points, initiators and programs.
   d. Display: Minimum 14-inch.
   e. Memory: 2GB Single channel
   f. Hard drive: 250 GB
3. Complete with command keys, data entry keys, cursor control keys, and liquid crystal alphanumeric display. Access via self-prompting menu selection with next menu/previous menu, and step forward/step backward within given menu. Connection of POT to panel shall not interrupt, or interfere with normal network operation.
4. Provide access to all LCPs on respective bus. Displays to provide text via 64 character minimum screen with English descriptors.

2.11 REMOTE PANEL HARDWARE

A. General:
   1. Network control panels (NCPs) serving AHUs, exhaust fans, hot and chilled water systems, and similar systems, and local control panels (LCPs) serving air terminal units, heaters, and other individual devices, shall be compatible with BMCS system communication protocol.
   2. Microprocessor based remote panels with EPROM operating system (OS), and minimum 10 MHz operating speed. DDC programs and data files shall be in EPROM with RAM image to allow simple additions and changes. All EPROM socketed for easy replacement.
   3. EPROM/RAM DDC programs and data files to provide for instant loop recovery upon power restoration after outage beyond that which is power backed. Provide power backup of 4-hour instant recharge capacitor, or 12-hour trickle recharged batteries. RAM images, including all user additions, and changes to be up/down line loadable to central disk for backup.
   4. RAM DDC programs and data files without EPROM backup provided with 72 hours of battery backup complete with automatic monitoring, and "replace battery" alarm messaging. Upon power restoration after outage beyond that which is power or EPROM backed, all RAM to be automatically downloaded and remote panel automatically reinitialized. Systems without EEPROM or EPROM default programs shall provide automatic daily diagnostic and verification routines with historical logging and retrieval to assure that RAM based programs do not become altered or corrupted. Complete automatic download of all RAM shall occur within one hour after power restoration and battery loss.
   5. All backup power to support clocks. Clocks to be automatically synchronized upon system recovery.
   6. The panels serving air handling units, chilled, hot water, glycol, and process cooling water system shall have integral LCD display and key pad, which will allow all points to be viewed and adjusted at the panel. Panel shall have ability to display software alarms and to automatically scan all inputs/outputs with rotating display.
   7. The panels serving air handling units, exhaust fans, and pumps which are powered from generator-backed emergency power shall be powered from an emergency power source. In addition, they shall be provided with a storage battery powered uninterruptible power supply located in or adjacent to the control panel and sized to operate a minimum of 10 minutes. This is to assure that the controllers continue to function seamlessly during commercial power outage and upon transfer to generator power.
   8. Real time clock to have one hundred year calendar with automatic leap year. Provide time of day, day of week, and date.

B. Remote panels provided with capacity to accommodate maximum of 64 input/output (I/O) points. Remote panels configured with analog and digital inputs and outputs, and pulse counting totalizers as required for application, such that primary input, output, and all control logic is resident in single microprocessor for network independent standalone closed loop DDC. Provide socket for portable operator's terminal (POT).

C. Panel inputs selected for application utilizing sensor types specified.

D. Remote panel outputs to be digital for discrete control, or true variable voltage/variable current outputs for driving analog actuators and control devices. Analog outputs with minimum incremental resolution of one percent of operating range of controlled device. Output points to have manual HOA switches on control panel:
   1. NCPs: Thirty-two bit microprocessors for DDC and energy management applications, peer-to-peer communications with other NCPs and host computer, and coordination and data concentration for subnetwork of up to 150 LCPs.
   2. NCP configuration restrictions:
      a. Each air handling unit shall be on a separate controller
      b. All points for individual air handler or other major system functions shall be served from the same master panel
      c. Each DDC panel shall have a minimum of 10% of its I/O functions as spare capacity. The type of spares shall be in the same proportion as the implemented I/O functions on the panel, but in no case shall be less than two spare points of each implemented I/O type.
   3. LCPs: Sixteen bit microprocessors for DDC and terminal unit control applications, and subnetwork communications. Triac/ Tristate outputs are allowed only on air terminal unit damper controllers. Reheat valves shall be modulating from a 0 – 10 VDC signal. Use of triac/tristate outputs on central systems such as AHU's is not acceptable.

E. Panel electronics installed in finished steel enclosures. Equipment room panels with hinged doors containing all load relays, transducers, and associated equipment.

2.12 DATA COMMUNICATIONS

A. General:
   1. System shall utilize parent/child hierarchal server configuration. The building communications network shall be interfaced to a local server configured as a child server. Contractor set up and program all alarm routing of critical alarms to also be sent to the site parent server via the site Ethernet. This will allow access to all system points from any computer on site by logging in through an internet explorer. System graphics will be available as web pages from the system server.
   2. All NCPs and operator’s terminals shall be interconnected with a communications network which must utilize native BACnet communication over a high speed ARCNET 156kbps network. All devices must be configured identically.
   3. The use of a proprietary communications network (e.g. All LCPs interconnected via secondary networks managed by NCPs) with a two-way gateway between the panel network and the main network must be transparent to the system operator and approved by the engineer prior to proposal date. Proprietary network, if used, shall be as described below.

B. All NCPs interconnected via primary peer-to-peer communications network. LCPs also connected together via secondary networks managed by NCPs. All communications to be via twisted pair wires. DDC microprocessor failures shall not cause loss of communications of the remainder of any network. All networks to support sensor sharing, global application programs, and bus-to-bus communications without the presence of host PC:
   1. NCPs capable of transmitting message to any other NCP.
   2. Messages transmitted to be positively acknowledged as received, or negatively acknowledged as not received. Negative acknowledgements require retransmission of message.
   3. Bus connected devices with no messages to transmit must send "I'm Ok"(or similar) message each bus cycle.

4. Full communications sustained with as few as two operational devices on any segment of bus.
5. Each NCP provided with communications watchdog to assure that an individual NCP cannot permanently occupy bus.
6. All messages to contain CRC 16 bit checkword.
7. Error recovery and communication initialization routines resident in each bus connected device.
8. Multi bus communications capability provided allowing exchange of data, and execution of programs across individual peer buses.
9. Editing and overriding local stand-alone panel programs shall be possible remotely via modem.

C. NCP communications network to support true peer protocol so each NCP has equal rights for data transfer, and report in its predetermined time slot. Each device on bus to be capable of taking over function of bus monitor to assure that loss of any single device (controller, terminal or network server) will not cause total bus failure.

D. LCPs to be managed by NCPs via active network to provide:
1. Alarm detection and reporting.
2. Response to operator station data requests and commands.
3. POT communications from LCP to any other networked LCP, and from NCP to any connected LCP.
4. LCP program loading.

2.13 ELECTRICAL SYSTEMS AND DEVICES

A. All electric switch devices to be UL listed for application. All water thermostats and temperature sensors provided with separable copper, monel, or stainless steel well with extended neck for use on insulated piping.

B. Miscellaneous electric and mechanical devices to include:
1. Automatic dampers, duct and air handling unit mounted:
   a. Suitable for 3000 fpm velocity and 4 IN wg static pressure differential.
   b. Opposed blade type for modulating action, Parallel blade type for 2 position operation except all mixing box dampers shall be parallel blade configured to direct outside and return air together to maximize mixing.
   c. Damper frames: Extruded aluminum hat channel, 1/8 IN minimum wall thickness, with flanges for duct mounting.
   d. Blades: Not over 6-IN wide heavy gauge extruded aluminum, airfoil shape.
   e. Damper bearings: Oil impregnated sintered bronze.
   f. Blade edge seals: Extruded vinyl.
   g. Jamb seals: Flexible stainless steel compression
   h. Low leakage: A damper 24-IN wide by 24-IN high shall not have leakage greater than 25 cfm when tested at 4 IN wg in accordance with AMCA Standard 500.
   i. Linkage: Out of air stream.
2. Automatic control valves:
   a. 2-1/2 IN and smaller to be screwed type with bronze body, 3 IN and larger, flanged with cast iron body.
   b. Valves ANSI rated to withstand pressures and temperatures encountered.
   c. Valves to have stainless steel stems, and spring loaded Teflon packing with replaceable discs.
   d. Modulating straight through water valves provided with equal percentage contoured throttling plugs. All three-way valves provided with linear throttling plugs so total flow through valve remains constant regardless of valve's position. Valves sized for pressure drop equal to coil they serve, but not to exceed 5 psi. Size two-way valve operators to close valves against pump shut off head.

e. Modulating steam valves to have linear characteristics for 90 percent of closing stroke, and equal percentage for final 10 percent. Valves sized for entering steam pressure indicated with pressure drop through valves not to exceed 20 percent of main steam pressure. Provide dual valves of 1/3 - 2/3 capacity split when valve sizes are larger than 3":
   1) All valve materials in contact with steam shall be rated for 350 ºF superheated steam.
f. Terminal equipment valves:
   1) Straight through or three way type as indicated. Bronze body, brass trim. Stems polished stainless steel and packing ethylene-propylene suitable for both chilled water and 250 degree hot water service. Neptronics modulating contored V ball valve with 0-10 vdc input signal, Pressure ratings as required for intended service.

3. Electric Damper Actuators.
   a. Rating: NEMA 1 Enclosure
   b. Mounting: Direct mount
   c. Stroke: 90 seconds end to end full stroke, 15 seconds return to normal for spring return
   d. Protection: Electronic stall protection
   e. Control Input: 0-10 VDC or 0-20 mADC
   f. Power: Nominal 24 VAC
   g. Torque: Size for minimum 150% of required duty
   h. Duty cycle: rated for 65,000 cycles
   i. Modulating actuators: Output position feedback.
   j. Two position actuators: Two auxiliary contacts for actuator position.
   k. Manual override
   l. Field selectable rotational / spring return direction
   m. Field adjustable zero and span.
4. Electric Valve Actuators.
   a. Rating: NEMA 1 Enclosure
   b. Mounting: Direct mount
   c. Control Input: Continuous 0-10 VDC or 0-20 mADC
   d. Power: Nominal 24 VAC
   e. Protection: Stall protection
   f. Torque: Size for minimum 150% of required duty
   g. Modulating actuators: Output position feedback.
   h. Two position actuators: Two auxiliary contacts for actuator position.
   i. Manual override.
   j. Field selectable direction.
   k. Field adjustable zero and span.
   l. For spring return, provide field selectable spring return direction.
5. Air terminal units shall have DDC controls and shall utilize electronic actuators on volume damper and reheat valve (refer to input/output points summary and sequence of operation). Provide and program DDC controller, ship to VAV manufacturer for factory mounting. See Section 23 36 00. Provide controller with 0 – 10 VDC modulating output for reheat hot water valve.
6. Safety low limit thermostats: Snap acting, single pole, single or double throw, manual reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Minimum 20 feet length of bulb. Provide one foot of bulb length for each 1.5 square feet of coil face area. Mount thermostats using flanges and element holders. Low limit thermostats (freezestat) shall have multiple contacts or shall be installed with relay loop to allow low limit thermostats to be directly connected to the motor starter/AFD and to the BMCS.

7. Electric thermostats: Line voltage or low voltage type suitable for application. Low voltage type heating thermostats to have adjustable heat anticipation.
8. Instrument Pressure Gages: Black letters on white background, 1-1/2 inch diameter, stem mounted with suitable dial range. Install pressure gages on main and branch lines at each receiver controller, at input to each actuator, at inputs and outputs from each relay and switch, and signal lines at each transmitter.

2.14 STANDARD ACCURACY ELECTRONIC DATA INPUTS AND OUTPUTS

A. Input/output sensors and devices matched to requirements of remote panel for accurate, responsive, noise free signal output/input. Control input to be highly sensitive and matched to loop gain requirements for precise and responsive control:
   1. In no case shall computer inputs be derived from pneumatic sensors.

B. Temperature sensors:
   1. Except as indicated below, all wall mounted space temperature sensors shall be programmed to allow +/- 2 °F set point adjustment. Scale on adjustment shall indicate temperature:
      a. The following locations shall have sensor without set point adjustment:
         1) Corridors.
         2) Lobbies.
         3) Toilet rooms
         4) Storage rooms.
         5) Mechanical rooms.
         6) Electrical rooms.
         7) Elevator equipment rooms.
      b. Setpoints of all wall mounted space temperature sensors shall also be adjustable through the operator’s terminal or Portable Terminal, over-riding local control where provided.
      c. Wall mounted space temperature sensors shall be linear within ±0.5 ºF between 40 and 90ºF.
      d. Wall temperature sensors shall include an override button to bring system to occupied mode and an LCD temperature display.
      e. Wall temperature sensors shall have a communication jack to allow a laptop to talk to the VAV controller.
   2. Duct and air handling unit temperature sensors to be averaging type. Averaging sensors shall be of sufficient length (a maximum of 1.8 sq.ft. of cross sectional area per 1 lineal foot of sensing element) to insure that the resistance represents an average over the cross section in which it is installed. The sensor shall have a bendable metal sheath. Linear within ±0.5 ºF between 0 and 100 ºF.
   3. Water sensors provided with separable copper, monel or stainless steel well with extended neck when on insulated piping. Linear within ±0.5 ºF between 32 and 212 ºF.
   4. Outside air wall mounted sensors provided with sun shield. Linear within ±0.5 ºF between -20 and 120 ºF.

C. Relative humidity sensors, 0-10 VDC output, to be capacitance type with 10 percent to 90 percent range with an accuracy of plus or minus 2 percent of full scale. Relative humidity set points shall be adjustable through the operator's terminal or portable terminal, over-riding local control where provided. Duct mounted humidity sensors provided with sampling chamber:
   1. Base:
      a. Vaisala
   2. Alternate:
      a. GE GEH series

D. Differential and static pressure sensors and switches:
   1. The pressure transducer shall withstand up to 150 % of rated pressure with and accuracy of plus or minus 1 percent of full scale. The sensing element shall be capsule, diaphragm, bellows, bourdon tube, or solid state. Pressure sensors (all types) installed on liquid lines shall have drains. Pressure sensors installed on steam lines shall have drains and siphons. All pressure sensors shall have valves for isolation, venting and taps for calibration. Pressure sensors shall be verified by calibration. Differential pressure sensors shall have nulling valves.
   2. Pressure transducers:
      a. Base:
         1) Veris
      b. Alternate:
         1) Setra.
         2) Rosemount.
   3. Pressure switches shall have a repetitive accuracy of plus or minus 2 percent of their operating range and shall withstand up to 150% of rated pressure. Switch shall have a snap acting form C contact rated for the application:
      a. Pressure switches (all types installed on liquid lines shall have drains. Pressure sensors installed on steam lines shall have drains and siphons. All pressure switches shall have valves for isolation, venting and taps for calibration. Pressure switches shall be adjusted to the proper set point and shall be verified by calibration. Pressure switches shall be mounted higher than the process connection. Differential pressure switches shall have nulling valves. Switch contact ratings and duty shall be selected in accordance with NEMA ICS 1. Switches shall have visual indicator of setpoint.

AD-4: Section 25 50 00: Delete paragraphs 2.14.D.4 through 2.14.D.4.a.

   4. Deleted
   5. Differential pressure transducers:
      a. Base:
         1) Veris
      b. Alternate:
         1) Setra.
         2) Rosemount.
   6. Fan proof-of-flow sensor to be self calibrating current transducers by ACI or Veris, 0-10 VDC output.
   7. Pump proof-of-flow sensor to be self calibrating current transducers by ACI or Veris, 0-10 VDC output.
   8. Smoke exhaust fans to utilize differential pressure switch for status indication.

E. Electronic airflow measuring stations:
   1. Air Flow and Temperature Measurement:
      a. Thermal dispersion technology anemometer using instrument grade self-heated thermistor sensors with thermistor temperature sensors.
      b. Factory tested prior to shipment and shall not require calibration or adjustment over the life of the equipment when installed in accordance to manufacturer's guidelines.
      c. Manufacturer shall provide test data for accuracy performance prior to proposal date. Vortex shedding arrays are not acceptable. Pitot tube and differential pressure sensing arrays are not acceptable. Auto zeroing sensors are not acceptable.
   2. Flow Station Construction:
      a. Type: Duct Mounted.
      b. Sensors: Two glass-encapsulated thermisters at each measuring point - self heated thermistor and temperature sensor:
         1) Glass-filled polypropylene housing.
         2) Factory-calibrated at 16 airflow rates and 3 temperatures to NIST-traceable standards for both airflow and temperature.
      c. Probe construction:
         1) Gold anodized aluminum alloy tube.

2) 304 stainless steel mounting brackets.
3) Constructed as insertion, internal, or standoff mounting, depending on installation requirements.

d. Probe sensor density:

Area (sq.ft.)	Sensors
<= 1	2
>1 to< 4	4
4 to < 8	6
8 to < 12	8
12 to < 16	12
>= 16	16

e. Probe operating ranges:
1) Airflow: 0 to 5000 FPM.
2) Temperature: -20 to 160 °F.
3) Relative Humidity: 0 to 99% non-condensing.

3. Transmitter:
a. Type: Microprocessor Based, totally solid state.
b. Power Requirement: 24 VAC, isolated from other devices and not grounded. AFMS manufacturer shall furnish a 1:1 isolation transformer for each duct location.
c. Capable of processing up to 16 independent sensing points per location.
d. Output signal offset/gain adjustment.
e. Adjustable digital filter to stabilize airflow output.
f. Field configurable for either I.P.or S.I. units.
g. Local digital display on face of cabinet for indicating individual sensor airflow and temperature readings.
h. Wall-mounted NEMA 1 enclosure.

4. Performance:
a. Electronics temperature range: 30 to 120 °F.
b. Flow station temperature range: -20 to 160 °F.
c. Flow station velocity range: 0 to 5,000 ft./min.
d. Flow station pressure drop: less than 0.005 IN WC at 2000 ft/min.
e. Flow station humidity range: 0 to 99% RH (non-condensing).

5. Analog output signals: 0-10 VDC:
a. Sensor velocity accuracy: 2% reading.
b. Sensor temperature accuracy: ± 0.15°F.
c. Type: linear.

6. Ebtron Gold Series or approved equal.

F. Steam flow meter:
1. Steam flow meter shall be vortex shedding mass flow meter with temperature compensation.
2. Provision shall be made for pressure transmitters to be mounted on the retractor assembly to provide pressure signal with only one pipe penetration.
3. Body shall be 304 or 316 Stainless steel.
4. Turn down shall be minimum of 12 to 1.
5. Accuracy shall be +-1.5% of flow.
6. Unit shall have integral control logic to locally display flow rate and total. The output for flow shall be a digital pulse output.
7. Output for pressure shall be 4-20 mA with digitally adjusted span. The entire unit shall require a 24 VDC nominal power supply.
8. Suitable for 200 psi steam.
9. Rosemount 6”model 8800 DR with remote LCD display or approved equal.

G. Thermal Energy Ultrasonic Water Flow Meter:
1. Provide for chilled water system.

2. Non-intrusive ultrasonic flowmeter.
3. 1000:1 turndown ratio.
4. I/O capabilities: 0-10 volt, pulse generator, relay.
5. Measure flow rate.
6. Features:
   a. LCD display.
   b. Datalogger memory.
   c. Password protection.
   d. Programmable math functions.
7. Clamp-on flow transducers support all pipe sizes.
8. No cutting of pipe required for installation.
9. Outputs:
   a. Flow rate.
   b. Malfunction alarm.
10. Provide removable insulation blanket with vapor proof cover.
11. Siemens Sitrans.

PART 3 - EXECUTION

3.1 GENERAL

A. The Building Management and Control System (BMCS) shall be designed, installed, and commissioned in a turnkey fully implemented and operational manner including all labor not noted in paragraph "Work by Others" of Part I of this section of these specifications, and not noted in other sections of these specifications.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 SEQUENCE OF OPERATION

A. General:
   1. HVAC systems shall be controlled with Direct Digital Control (DDC) according to sequence contained in this section of specifications and on drawings. Each DDC control panel shall be stand-alone:
      a. Additional points or software programming not listed but which are required to meet following sequences of operation shall be provided.
   2. House controllers, relays, transducers, and other components required for stand-alone control in NEMA 1 enclosure with lockable door.
   3. All AFD's shall be monitored by BMCS for trouble conditions. Operator will use AFD control panel for diagnostics.
   4. Setpoints:
      a. All setpoints given in the sequence of operations or in the drawings are for system startup and are preliminary. Optimum operating setpoints must be determined by users during actual occupancy and will be affected by many factors. These may include:
         1) Weather conditions.
         2) Building occupancy.
         3) Building utilization patterns.
         4) Variations in building construction.
         5) Variations in operating characteristics of actual installed building equipment.
      b. 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.
   5. All controller inputs, outputs, and adjustable setpoints and constants shall be readable and settable from the operator’s terminal.

B. Sequences of operation are given on Drawings.

3.3 DATA CONTROL (D/C) AND GRAPHICS

A. Provide all software required to accomplish sequence of operations, including all data and control points whether or not listed on input/output points summary.

B. Graphics will be similar in appearance and function to the graphics now in use for other buildings connected to the existing campus system.

C. In addition to graphics of building systems with dynamic data points as noted in following data and control and graphic summary, and graphics required under digital system management sections, following additional graphics shall be provided:
   1. Building layouts (floor plans).
   2. Any other graphics necessary for logical penetration.
   3. Sequence of operation (window split screen view).
   4. Flow charts for critical DDC loops.
   5. Supervisor graphics.
   6. System configuration.
   7. Display Air Terminal Unit and reheat coil locations on building floor plans.
   8. Display duct mounted humidifier locations on building floor plans.
   9. Display fire and smoke damper locations on building floor plans.
   10. Display air handling unit locations and configuration (flow diagram, DDC Logic Diagram and control sequence).
   11. Display heating, and chilled water mains and valve locations with valve I.D. corresponding to valve index indicating service, size, valve type, and location.
   12. Flow diagram of chilled water system showing pumps and locations of differential pressure switches, and display all points indicated on I/O summary.
   13. Display all DDC sensors, thermostats, and humidistats on floor plan corresponding to air terminal or other controlled device locations.
   14. Display all DDC panels, indexed to correspond with system configuration.

D. Include Pseudo points for display in logical groups and graphics. Commandable pseudo points to be commandable directly from all displays.

E. Each analog point to have unique remote panel-resident dual high, and dual low limit alarm threshold engineering units. Where specified, provide floating (band above and below set point) alarm limits.

F. Each digital output to have software-associated monitored input. Any time monitored input does not track its associated command output within programmable time interval, "command failed" alarm shall be reported.

G. Where calculated points (such as CFM) are shown, they shall appear in their respective logical groups. Respective unconditioned raw data (such as logarithmic differential pressure) points to also be grouped in special group for display and observation independent of logical groups.

H. Where data or control points are required to accomplish digital control or energy management sequences specified, but not listed in I/O summary, Contractor shall provide the points necessary to accomplish the specified sequence.

I. Primary analog input and analog output of each DDC loop to be resident in single remote panel containing DDC algorithm, and shall function independent of any peer or mux communication links. Secondary (reset type) analog inputs may be received from the peer network, but approved default values and/or procedures shall be substituted in DDC algorithm for this secondary input in network communications fail or if secondary input becomes erroneous or invalid.

J. Provide the ability to plot trend graphs of any input variable for any interval.

AD-1: Section 25 50 00: Revise Article 3.4 in its entirety.

3.4 AUTOMATIC REPORT GENERATION

A. Water consumption data: Water consumption meters are specified in Section 22 10 16. Meters generate a pulse output, with each pulse representing a specific number of gallons. Contractor shall coordinate to verify specific type of meter and appropriate constants for converting output to gallons consumed.

B. Energy consumption data:
   1. All energy consumption data from hot water, chilled water, and steam usage is to be derived from flow, temperature, and pressure sensors provided by this contractor. This contractor shall provide and program all equipment necessary to integrate data from these sensors into British Thermal Units (BTU's).
   2. All electric energy consumption data is derived from kW meters provided under Division 26. This data is collected by the Power Monitoring and Control System (PMCS) specified in Section 26 09 13. The BMCS is to interface directly with the PMCS to obtain the data in kW from each meter. It shall perform the necessary time calculations to convert values to kWh and shall combine individual meters as indicated below to derive the required energy consumption of specific systems.

C. The BMCS shall continuously monitor energy usage as measured by metering systems in the building and shall totalize and store usage by day, month, and year for the systems as listed in the schedule below.
   1. Where energy source is provided in hydronic systems such as chilled water, the BMCS sensor shall measure water supply temperature and return temperature in degrees Fahrenheit, and water flow in gallons per minute. It shall multiply the temperature difference by the flow rate and a suitable constant to calculate instantaneous energy flow in BTU's per hour.
   2. Where energy source is provided by steam, the BMCS shall measure steam temperature in degrees Fahrenheit, pressure in pounds per square inch, and flow rate in pounds per hour. It shall combine these values using suitable constants and look-up tables to calculate instantaneous energy flow in BTU's per hour.
   3. Where energy source is provided by electricity, the BMCS shall interface directly with the Power Monitoring and Control System specified in Section 26 09 13. It shall obtain electric metering information to make instantaneous kW usage available for each meter location as listed on the Input/Output schedule.
   4. The BMCS shall sample and calculate each value at least once per minute. Each shall be recorded at one minute intervals, together with associated time and date, in a spread-sheet compatible format for use in user created reports.
   5. Each energy measurement point shall also be integrated over each 24-hour period to provide an energy consumption value per day in BTU (hydronic and steam sources) or kW (electric sources). Each 24-hour period shall begin and end at midnight. These values, together with their associated time and date, shall each be recorded for use in report generation as indicated below.

D. Once per month (1st day of each month (adjustable)) the BMCS shall utilize the stored daily information to generate a monthly report that sums consumption information into categories below. Once per year (1st day of each year (adjustable)) the BMCS shall generate a similar yearly report that utilizes the stored monthly information. Spreadsheet software or similar shall be used to generate a graphical representation (bar chart or other) indicating the relative consumption of energy by each end use. All input data shall be recorded in a memory location on the BMCS server for a period of one month until utilized by the monthly report. All monthly and yearly reports shall be recorded in a memory location on the BMCS server that is maintained for long-time archiving and not over-written.

REPORT CONTENT			
Item No.	Report Display Item	Units	Input Source
A	Outside air dry bulb temperature	Deg F	1
B	Outside air humidity	Percent RH	2
C	Laboratory Water Consumption	Gallons	3
D	HVAC Water Consumption	Gallons	4
E	Potable Water Consumption	Gallons	5 - 4 - 6
F	Potable Hot Water Energy	BTU	Calc by BMCS from 11, 12, 13
G	Laboratory Hot Water Energy	BTU	Calc by BMCS from 14, 15, 16
H	Total HVAC Fan Energy	kWh	Sum 29 thru 45
I	Total Building Cooling Energy	BTU	Calc by BMCS from 23, 24, 25
J	Space Cooling Energy	BTU	Calc by BMCS from 26, 27, 28
K	Process Cooling Energy	BTU	I - J
L	Total Building Heating Energy	BTU	Calc by BMCS from 8, 9, 10
M	Space Heating Energy	BTU	Calc by BMCS from 17, 18, 19
N	Clean Steam Heating Energy	BTU	Calc by BMCS from 20, 21, 22
O	Total HVAC Pumping Energy	kWh	Sum 46 thru 56
P	Total Lighting	kWh	Sum 62 + 63 +64
Q	Plug/Process/Miscellaneous	kWh	Sum 57 thru 61 + 65 thru 70

BMCS INPUT DATA		
Item No.	Measured Variable	Units
1	Outside air dry bulb temperature	Degrees F
2	Outside air humidity	Percent RH
3	Laboratory water	Gallons
4	Clean steam make-up water	Gallons
5	Potable Water	Gallons
6	Grounds Irrigation	Gallons
7	Process Cooling make-up water	Gallons
8	RO System make-up water	Gallons
9	Steam service to building - Flow	Lb/hr
10	Steam service to building – Temperature	Degrees F
11	Steam service to building - Pressure	PSI
12	Potable HW steam flow	Lbs/hr
13	Potable HW steam temperature	Degrees F
14	Potable HW steam pressure	PSI
15	Laboratory HW steam flow	Lbs/hr
16	laboratory HW steam temperature	Degrees F
17	Laboratory HW steam pressure	PSI
18	Space heating steam flow	Lbs/hr
19	Space heating steam pressure	Degrees F
20	Space heating steam temperature	PSI
21	Clean steam generator steam flow	Lbs/hr

BMCS INPUT DATA		
Item No.	Measured Variable	Units
22	Clean steam generator steam temperature	Degrees F
23	Clean steam generator steam pressure	PSI
24	Chilled water service to building – Flow	Gallons
25	Chilled water service to building – CWS Temperature	Degrees F
26	Chilled water service to building – CWR Temperature	Degrees F
27	Chilled water service to AHU's - Flow	Gallons
28	Chilled water service to AHU's – CWS Temperature	Degrees F
29	Chilled water service to AHU's – CWR Temperature	Degrees F
30	SF-1 AHU-1 supply	kWh
31	SF-2 AHU-2 supply	kWh
32	RF-1 AHU-1 return	kWh
33	RF-2 AHU2 return	kWh
34	EF-1A Lab Exhaust	kWh
35	EF-1B Lab Exhaust	kWh
36	EF-1C Lab Exhaust	kWh
37	EF-2A Lab Exhaust	kWh
38	EF-2B Lab Exhaust	kWh
39	EF-2C Lab Exhaust	kWh
40	EF-4	kWh
41	EF-5	kWh
42	EF-6	kWh
43	EF-7	kWh
44	EF-8	kWh
45	SEF-1 Smoke Exhaust Fan	kWh
46	SEF-2 Smoke Exhaust Fan	kWh
47	P-1A Chilled water circ pump	kWh
48	P-1B Chilled water circ pump	kWh
49	P-1C Chilled water circ pump	kWh
50	P-2A Process cooling water circ pump	kWh
51	P-2B Process cooling water circ pump	kWh
52	P-3A Heating water circ pump	kWh
53	P-3B Heating water circ pump	kWh
54	P-4A Preheat water circ pump	kWh
55	P-4B Preheat water circ pump	kWh
56	P-5A Heat recovery water circ pump	kWh
57	P-5B Heat recovery water circ pump	kWh
58	RO water circ pumps	kWh
59	PP-1 Domestic water booster pumps	kWh
60	PP-4 Elevator 1 pit sump pump	kWh
61	PP-4 Elevator 2 pit sump pump	kWh
62	PP-5 Duplex sump pump	kWh
63	Indoor Lighting Panel NLD4A1	kWh
64	Indoor Lighting Panel NLD4B1	kWh
65	Site Lighting Panel NHS1A	kWh
66	House Plug/Process Panel NLD4A2	kWh
67	House Plug/Process Panel NLD4B2	kWh
68	Lab Plug/Process Panel LHD4A1	kWh
69	Lab Plug/Process Panel LHD4A2	kWh
70	Lab Plug/Process Panel LHD4B1	kWh
71	Lab Plug/Process Panel LHD4B2	kWh

3.5 INSTALLATION

A. All wiring and tubing to be properly supported, and run in neat and workmanlike manner. All wiring and tubing shall run parallel to or at right angles to building structure. All piping and wiring within enclosures to be neatly bundled, and anchored to prevent obstruction to devices and terminals.

B. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and pilot lights, push buttons and switches flush on cabinet panel face. ANSI/NEMA 1, general purpose utility enclosures with enameled finished face panel. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved nameplate on cabinet face. Provide Panduit raceway with cover for wiring inside control cabinets.

C. 120V power wiring is provided under Div. 16 to certain locations as shown on the Electrical Drawings. BMCS Contractor is responsible to extend this wiring to any additional location where control system requires power. Where low voltage power is required this contractor shall provide suitable transformers and circuit.

D. BMCS Contractor shall inspect each air terminal unit and verify that all control devices furnished under this section have been properly installed and wired by the air terminal unit manufacturer before unit power supply is energized.

E. BMCS Contractor to be responsible for all electrical installation required for fully functional system, and not shown on electrical plans or required by electrical specifications. All wiring shall be in accordance to all local and national codes and requirements of Div. 16:
   1. All line voltage wiring to be installed in conduit.
   2. All low voltage and current limited electronic wiring shall be #18 AWG minimum shielded cable. Shielded cable shall be Belden New Generation Type 6300FE or approved equal.
   3. All wiring in finished spaces including central control room to be concealed.
   4. All systems to be powered from emergency power circuits.

F. Unless indicated otherwise, locate thermostats, humidistats and sensors for room monitoring and control immediately inside of door adjacent to light switch:
   1. Where light switch is in an entry way to room, locate on wall within room, at same elevation as light switch, so it is capable of sensing true space conditions.
   2. Coordinate location to avoid conflict with wall mounted casework and similar features.
   3. Prior to installation, coordinate locations with Architect/Engineer.

G. Identification:
   1. Provide laminated, engraved plastic nameplates for control panels. Other equipment devices furnished, including sensors, switches, valves, gages, actuators and all other item furnished under this section shall be identified with plastic embossed labels adhered to the device. Each nameplate shall identify the function, such as "mixed air low limit" or "cold deck temperature sensor" Laminated plastic shall be one-eighth inch thick black with white center core. Nameplates shall be a minimum of 1 inch by 3 inch with minimum one quarter inch high engraved block lettering. Nameplates for devices smaller than 1 inch by 3 inch shall be attached by a nonferrous metal chain. Submit proposed wording of each nameplate with hardware submittal.
   2. Instrumentation and Control Diagrams: Provide framed drawings including the sequence of controls, wiring and verbal description in laminated plastic showing complete diagrams for all equipment furnished and interfaces to all existing equipment, at each respective equipment location. Condensed operating instructions explaining preventive maintenance procedures methods of checking the system for normal safe operation and procedures for safely starting and stopping the system manually shall be prepared in typed form, framed as specified for the diagrams and posted beside the diagrams. Proposed diagrams, instructions and other sheets shall be submitted prior to posting.
   3. Provide labels on each control cable indicating connection points.

H. BMCS Contractor shall enter all computer programs and data files into related computers, including all control programs, initial approved parameters and settings, English descriptors, and colorgraphics complete with dynamic dispersed data. In addition, following to be user implemented, shall have samples installed for training and validation:
   1. Trend log.
   2. Alarm message (action taking message).
   3. Run time maintenance message.
   4. Trouble action message.
   5. Dynamic trend plot (6 points).

I. BMCS Contractor to maintain diskette copies of all data file, and application software for reload use in event of system crash or memory failure. One copy to be delivered to Owner during training session, and one copy archived at local software vault provided by BMCS manufacturer within 10 miles of project site.

3.6 SYSTEM VERIFICATION PROCEDURE

A. Upon completion of all wiring by the BMCS Contractor, approval shall be made by Owner's Construction Inspection Department.

B. Upon such approval being achieved, Owner shall make the necessary tie-in to the Campus Environmental Control System:
   1. Upon completion of the aforementioned, a system startup shall be conducted. See section 23 90 00 Mechanical System Commissioning for additional details.

C. Upon conclusion of the final checkout, the BMCS Contractor's responsibility reverts to standard warranty of materials and installation hereinafter specified.

D. Provide test plan and test procedures for the performance verification tests for approval. Explain in detail actions and expected results to demonstrate compliance with the requirements of this specification and the method for simulating the necessary conditions of operation to demonstrate performance of the system. Deliver Test Plans documentation for the performance verification tests to Owner's representative 30 days prior to the performance verification tests. Provide draft copy of operation and maintenance manual with performance verification test.

3.7 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing: Complete startup testing to verify operational control system before notifying Owner of system demonstration. Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing:
   1. Calibrate and prepare for service each instrument, control, and accessory equipment furnished under Section 25 50 00.
   2. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
   3. Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
   4. Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
   5. Verify that analog output devices such as actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
   6. Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
   7. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
   8. Alarms and Interlocks:
      a. Check each alarm with an appropriate signal at a value that will trip the alarm.

b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

B. Calibration shall be demonstrated by the BMCS contractor in the presence of the Architect or Owner's representative. Should random sampling indicate improper commissioning, Owner reserves the right to subsequently witness complete calibration of the system at no additional cost to Owner.

3.8 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration: Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Article 3.7 "Control System Checkout and Testing". Provide Engineer with log documenting completion of startup tests:
1. Engineer will be present to observe and review system demonstration. Notify Engineer at least 10 days before system demonstration begins.
2. Demonstrate actual field operation of each sequence of operation as specified in the "Input/Output Summary". Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
3. Demonstrate compliance with "System Performance" in Part 1 of this section.
4. Demonstrate compliance with sequences of operation through each operational mode.
5. Demonstrate complete operation of operator interface.
6. Demonstrate each of the following:
a. DDC loop response: Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25 percent of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
b. Building fire alarm system interface.
c. Trend logs for each system: Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.
7. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

B. Acceptance:
1. After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required.

C. Demonstrate to authorities that all required safeties and life safety functions are fully functional and complete.

D. Make personnel accessible to provide necessary adjustments and corrections to systems as directed by balancing agency.

E. After completion of validation procedures, contractor shall perform validation demonstration in the presence of the Architect or Owner's representative, as dictated by Owner. Witnessed validation demonstration shall consist of:
   1. Running each specified report.
   2. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
   3. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
   4. Execute digital and analog commands in graphic mode.
   5. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).
   6. Demonstrate EMS performance via trend logs and command trace.
   7. Demonstrate scan, update, and alarm responsiveness.
   8. Demonstrate spreadsheet/curve plot software, and its integration with database.
   9. Demonstrate on-line user guide, and help function and mail facility.
   10. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.
   11. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
   12. Demonstrate class programming with point options of beep duration; beep rate, alarm archiving, and color banding.

3.9 MANUALS (FOLLOWING MANUALS TO BE PROVIDED)

A. Functional design manual: The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be provided for all system operating modes.

B. Hardware manual: Furnish a hardware manual describing all equipment provided including a general description and specification, installation and checkout procedures, equipment electrical schematics and layout drawings, system schematics and I/O wiring lists, and alignment and calibration procedures.

C. Software manual: The software manual shall describe all furnished software, starting with a system overview and proceeding to a detailed description of each software module. The manual shall be oriented to enable proper integration, loading, testing and program execution. Provide flow charts or diagrams or equivalent documentation, as approved in advance by Owner’s representative, in hard copy enabling the logical step-by-step analysis of the program listings. Substitutions of different format are not acceptable.

D. Maintenance Manual: The maintenance manual shall provide descriptions of maintenance for all equipment including inspection, periodic preventative maintenance, fault diagnosis and repair or replacement of defective components.

3.10 TRAINING

A. Provide training for any new control systems provided.

B. All training to be by BMCS manufacturer and utilize specified manuals, as built documentation, and on-line help utility:
   1. Provide classroom instruction course at site:
      a. Minimum of 50 man-days. Split between number of days and number of individuals to be determined by Owner.

C. Operator training to include two initial on-site eight hour sessions encompassing:
   1. Sequence of operation review.
   2. Sign on-sign off.
   3. Selection of all displays and reports.
   4. Commanding of points, keyboard, and mouse mode.

5. Modifying English text.
6. Use of all dialog boxes and menus.
7. Modifying warning limits, alarm limits, and start-stop times.
8. System initialization.
9. Download and initialization of remote panels.
10. Purge and/or dump of historical data.
11. Use of portable operator's terminal.
12. Troubleshooting of sensors (determining bad sensors).
13. Password modification.

D. After initial training, BMCS manufacturer shall include 16 additional hours of training for miscellaneous instruction requested by Owner.

3.11 WARRANTY

A. All components, system software, parts, and assemblies supplied by BMCS manufacturer to be guaranteed against defects in materials and workmanship for two years from acceptance date.

B. Labor to troubleshoot, repair, reprogram, or replace malfunctioning system components shall be furnished by BMCS Contractor at no charge to Owner during warranty period.

C. All corrective software modifications made during warranty service periods to be updated on all user documentation, and on user and manufacturer archived software disks.

3.12 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 00 10
ELECTRICAL GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Drawings use and interpretation:
   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 superceded 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. Installation of all systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination drawings.

C. Description of systems:
   1. Provide materials to provide functioning systems in compliance with performance requirements specified.
   2. Provide modifications required by reviewed shop drawings and field coordinated drawings.

1.2 QUALITY ASSURANCE

A. Perform all work in accordance with but not limited to:
   1. All authorities having jurisdiction.
   2. Federal, state and local codes, regulations and ordinances.
   3. Underwriter's (UL) code requirements.
   4. Occupational Safety and Health Act (OSHA).
   5. Factory Mutual System (FM) requirements.
   6. Americans with Disabilities Act Accessibility Guidelines (ADAAG).
   7. National Electrical Code, NFPA 70, Current Edition.
   8. NFPA-72: Installation, maintenance and use of protective signalling systems.
   9. NFPA-30: Flammable and combustible liquids code.
   10. NFPA-45: Fire protection for laboratories using chemicals.
   11. NFPA-780: Lightning protection code.
   12. NFPA-90A: Installation of air conditioning and ventilation systems.
   13. NFPA-101: Life safety code.
   14. ANSI/ASME-A17.1: Elevator code.
   15. NFPA-13: Installation of sprinkler systems.
   16. NFPA-37: Installation and use of stationary combustion engines and gas turbines.
   17. NFPA-110: Emergency and standby power systems.

1.3 SUBMITTALS

A. Contract closeout information:
   1. Final performance test report.

B. Shop Drawings: Provide coordinated sleeve and box out layout drawing for slab and wall penetrations prior to concrete placement.

1.4 DEFINITIONS

A. Weatherproof (WP): Indicates rating suitable for wet or damp location.

1.5 PROTECTION

A. Provide covering and shielding for all 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 necessary permits, licenses, and inspections.

C. Determine and verify locations of all existing utilities on or near site:
   1. Cause as little interference or interruption of existing utilities and services as possible.
   2. Schedule work which will cause interference or interruption in advance with Owner, Architect, authorities having jurisdiction and all affected trades.
   3. Arrangements for interruptions shall be made one week in advance before proposed interruption.

D. Temporary construction power and communications (See Division 1).

E. Record drawings:
   1. Keep a complete set of all electrical drawings in job site office for indicating actual installation of electrical systems and equipment.
   2. Provide accurate record of routing of all concealed conduit.
   3. Use this set of drawings for no other purpose.
   4. Where any material, equipment, or system components are installed differently from that indicated, indicate differences clearly and neatly using ink or indelible pencil.
   5. At project completion, submit record set of drawings.

1.7 ENVIRONMENTAL CONDITIONS

A. General:
   1. Provide NEMA 1 enclosures for electrical equipment unless otherwise indicated.

B. Conduit: See Section 26 00 10.

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.

F. Hazardous locations:
   1. All equipment, wiring, devices, etc., within hazardous location(s) shall be of explosion-proof construction in strict accordance with NEC.
   2. All exposed non-current carrying parts of entire electrical system shall be grounded in hazardous location(s) in strict accordance with current NEC.
   3. Hazardous locations shall be classified NEC Class 1, Division 2, Group B, C, and D:
      a. 1033 Flammable.

1.8 TEMPORARY POWER

A. See Section 01 50 00 – Temporary Facilities.

PART 2 - PRODUCTS

2.1 MATERIALS

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

B. Material and equipment: Current and standard design of manufacturers regularly engaged in their production.

C. Use UL labeled and listed electrical materials and fabricated assemblies.

D. Structural steel for supports: ASTM-A36:
   1. Galvanize members installed in areas of high humidity or condensation.
   2. Furnish other members with shop coat of rust inhibiting primer.
   3. Shop fabricate for field assembly using bolts.
   4. Minimize field welding.
   5. Retouch primer and galvanizing after field cutting or welding.

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

F. Rain hoods and counter flashings exposed to view: As specified in Section 07 62 00.

G. Access doors, panels and frames: See Section 08 31 16:
   1. Provide access panels and/or doors at walls, and inaccessible ceilings as required to permit access to equipment, junction boxes, pull boxes, cable tray, and devices requiring service, adjustment, or inspection.
   2. Size:
      a. As required to allow access, inspection, service, and removal of items served.
      b. Minimum 18 x 18 IN.

2.2 FIRESTOPPING

A. Firestop all penetrations of fire rated walls, floors and assemblies:
   1. Penetrations shall comply with UL listing for construction or assembly.

B. Use materials and methods as specified in Section 07 84 00.

PART 3 - EXECUTION

3.1 GENERAL

A. Use only thorough, highly skilled, and experienced personnel.

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

C. Do not change indicated sizes without written approval of Architect.

D. Provide all necessary offsets and crossovers in conduits, raceways, cabletrays and ducts.

E. Install exposed conduits parallel to walls and ceilings and vertically plumb, unless otherwise indicated.

F. Where electrical items penetrate fire and/or smoke rated walls, ceilings and floors, comply with Section 07 84 00.

G. See structural drawings for spacing requirements for sleeves and openings.

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 necessary to disturb such work to permit installation of electrical work.
   2. Repair or replace existing or new work disturbed.

B. Avoid cutting by setting sleeves or frames, and by requesting openings in advance.

C. Before cutting, obtain approval of Architect:
   1. Use only approved methods.
   2. Cut all holes neatly and as small as possible to admit work.
   3. Do not weaken walls or floors; locate holes in concrete to miss structural sections.
   4. Provide verification of location of reinforcing prior to cutting. Relocate as required.

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.

3.3 EXCAVATING AND BACKFILLING

A. Excavating, trenching, and backfilling:
   1. See Section 31 23 33.

3.4 INSTALLATION OF EQUIPMENT

A. Install all equipment in accordance with manufacturer's recommendations.

B. Provide all necessary anchoring devices and supports:
   1. Use structural supports suitable for equipment.
   2. Check loadings and dimensions of equipment with shop drawings.
   3. Do not cut, or weld to, building structural members.

C. Verify that equipment will fit support layouts indicated:
   1. Where substitute equipment is used, revise indicated supports to fit at no additional cost.

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. Make all penetrations through roofs prior to installation of roofing. For penetrations required after installation of roofing:
   1. In built-up roofing (BUR), provide all curbs, cants and base flashings.
   2. In standing-seam metal roof, arrange and pay for flashing work by authorized roofer.

F. Provide rain hoods and metal counter flashing and make all penetrations of electrical work through walls and roofs water and weathertight:
   1. Furnish all clamps, waterproofing material and labor necessary.
   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. Pay for repair and replacement of roof construction, damaged by this work. Repairs shall be 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 or pads for all floor mounted electrical equipment:

1. Provide 4 IN high concrete pads.
2. Use minimum 3,000 PSI concrete in accordance with Division 3 requirements.
3. Reinforce with 6 x 6 IN - W2.9 x W2.9 mesh, with short dowels into floor at 12 IN OC around perimeter.
4. Chamfer top edges 3/4 IN.
5. Make all faces smooth.
6. Set anchor bolts for equipment.
7. Pads: 2 IN larger than equipment base on all sides.

3.5 PAINTING

A. See Section 09 06 10.

3.6 FIELD QUALITY CONTROL

A. Perform indicated tests to demonstrate workmanship, operation, and performance:
   1. Conduct tests in presence of ANL's designated representative 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 hours notice to all inspectors.
   4. Furnish or arrange for use of electrical energy, steam, water, diesel fuel, or gas required for tests.
   5. Furnish all lubricating materials required for test.
   6. Tester to provide written test results to Argonne National Lab (ANL) of tested equipment witnessed by ANL project specialist.

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 all circuits have been energized and no short circuits exist.
   3. Provide written report that the phase rotation of all distribution equipment and all three phase utilization equipment is in accordance with Argonne National Lab Standards.

3.8 ADJUST AND CLEAN

A. Inspect all equipment and put in good working order.

B. Clean all 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 all systems into satisfactory operation prior to final acceptance, at time agreed to by General Contractor, Owner and Architect.

B. Operate all systems in good working order for period of 5 working days.

3.10 DEVICE MOUNTING

A. Dimensions are to center of device unless otherwise indicated. Coordinate outlet locations with all architectural millwork and/or casework elevations.

B. Locate exit signs and fire alarm flashing lights so that all are visible from all corridor locations.

C. Relocate signs as required to resolve conflicts.

3.11 IDENTIFICATION AND LABELING

A. Nameplates: Provide indoor/outdoor, scratch proof, sunlight resistant, 4 mil flexible pressure sensitive adhesive backed vinyl labels:
   1. Label shall be suitable for ambient temperatures of – 40 degF to 176 degF and subject to continuous exposure to alcohols, detergents, grease and oil:
      a. Equal to Brother PT-9400 or Brady Handimark.
   2. Provide background and text colors as follows:
      a. Fire Alarm System: Red with black text.
      b. Normal Distribution System: Black with white text.
      c. Emergency Branch (equipment served by EATS): Yellow with black text.
      d. Optional Standby Branch (equipment served by QATS): Green with black text.
   3. Unit substation:
      a. Provide nameplate on incoming and outgoing sections. Provide 3/4 IN high text indicating:
         1) Equipment name, ie.: "ESB Unit Substation USA".
   4. Switchgear, switchboard, distribution panel and motor control center nameplates:
      a. Center nameplate near top of first section. Provide 3/4 IN high text indicating:
         1) Equipment name and branch, i.e., "Panel XXXX - Life Safety Branch".
         2) Voltage, phase and wire, i.e., "480Y/277V, 3 Phase, 4 Wire".
         3) 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. Provide 1/4 IN high text indicating:
         1) Description of load, i.e., "Load - Panelboard XXX".
   5. Panelboard nameplates:
      a. Center nameplate near top of each section. Provide 1/2 IN high text indicating:
         1) Equipment name and branch, i.e., "Panel XXXX - Life Safety Branch".
         2) Voltage, phase and wire, i.e., "480Y/277V, 3 Phase, 4 Wire".
         3) Source, i.e., "Source - Switchboard XXXX".
   6. Disconnect switches, transformers, contactors, thermal element switches, starters, etc. nameplates:
      a. Center nameplate near top of face plate or cover. Provide 1/4 IN high text indicating:
         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. Provide 1/2 IN high text indicating:
         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, security, laser entryway control, and other system control cabinet nameplates:
      a. Center nameplate near top of cover. Provide 1/2 IN high text indicating:
         1) Description of system, i.e., "Fire Alarm System Control Panel".
   9. Relays and relay cabinet nameplates:
      a. Center nameplate near top of cover. Provide 1/2 IN high text indicating:
         1) Description of item controlled, applicable system or function and type of device, i.e., "AHU-XXX FA Shut Down Relay" or "Lighting Relay Cabinet XXX".

B. Device plates: See Section 26 27 26.

C. Paint outlet boxes, junction boxes and enclosures, except switchboard and panelboard enclosures, for emergency circuits as follows:
   1. Fire Alarm System: Red.
   2. Emergency Branch (equipment served by EATS): Yellow.
   3. Optional Standby Branch (equipment served by QATS): Green.

D. Paint all fire alarm and emergency system feeder conduits with 2 IN wide band 10 FT on center as scheduled in Paragraph C above:
   1. Pressure-sensitive, color-impregnated tape will be acceptable.

E. Pull and junction boxes for feeders:
   1. Provide wrap-on wire markers on each conductor indicating source i.e., "Source – Switchboard XXXX" and load i.e., "Load – Panelboard XXXX".
   2. Indicate on cover the voltage of the feeders within pull and junction boxes using permanent marker pen.

F. Pull and junction boxes for branch circuits:
   1. Indicate, on cover, the panel, circuit number(s) and voltage using permanent marker pen.
   2. Where two or more neutrals of the same phase are provided, permanently mark each neutral with its associated phase conductor(s).

G. Conductor identification:
   1. Provide wrap-on wire markers on each conductor in panelboard, switchboard, terminal strips, etc. Marker shall indicate pole or terminal strip position. Control wire mark shall match equipment manufacturers shop drawings. Wire markers shall be Thomas and Betts Type WBC.

H. High voltage signs:
   1. All 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 – KEEP OUT".

I. Identification of working space:
   1. Provide orange hazard tape on the floor at all electrical equipment indicating the width and depth of the minimum working clearances indicated in NEC Article 110.26:
      a. Tape shall be 2 IN wide solid orange abrasion resistant high strength polyethylene with pressure sensitive adhesive back and suitable for permanent floor applications.
      b. Provide tape at all 120 volt and above electrical equipment including panelboards, relay cabinets, transformers, motor control centers, disconnect switches, starters, adjustable emergency drives, etc., which are located in any space other than the main electrical room and the exterior service yards.

END OF SECTION

SECTION 26 00 11
WIRING EQUIPMENT FURNISHED BY OTHERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide all conduit, wiring, outlet boxes, receptacles, circuit breakers, fittings, switches, starters, (with overloads) etc., to make final connections to all equipment.

B. Connect:
   1. Elevator equipment, (Division 14).
   2. Heating, ventilation, cooling and plumbing system equipment, (Division 23).
   3. Automatic door equipment, (Division 8).
   4. Projection screens, (Division 11).
   5. Fixed and/or movable equipment, (Division 11).

PART 2 - PRODUCTS

2.1 ELEVATOR

A. Provide following for each elevator:
   1. Shunt trip circuit breaker:
      a. Locate on wall near door of machine room.
      b. Provide conduit and wire from switch to controller.
   2. 30 A S/N, 120V disconnecting switch for 120V power supply for controls and signal circuit:
      a. Locate adjacent to elevator switch.
      b. Provide conduit and wire for switch to controller.
      c. Connect to shunt trip circuit breaker.
   3. 30A S/N, 120V disconnect switch for car lights and fan:
      a. Locate adjacent to elevator switch. Extend circuit to J-box at midpoint of shaft as directed by elevator installer.
   4. 120V GFCI duplex receptacle and vapor-tight fixture in each elevator pit, with switch located 48 IN above pit floor.
   5. Telephone outlet J-box with empty 3/4 IN conduit to telephone cabinet:
      a. Locate at midpoint of each shaft or at elevator controller as directed by elevator installer.

2.2 DIVISION 23 EQUIPMENT

A. Provide all conduit, wire, and connect all Division 23 Equipment.

B. Provide all motor starters except where AFD's or packaged or prewired units are indicated in Mechanical Equipment Schedule:
   1. Connect all motors.
   2. Provide starters with solid state overload protection for all motors not having such protection, except as otherwise indicated.
   3. Starters: See Section 26 24 19.

C. Coordinate solid state overload settings with installed motors.

D. Mount adjustable frequency drives furnished by Division 23:
   1. Mount AFD's in accordance with manufacturer's recommendations and instructions.
   2. Connect line and load power circuits.
   3. Provide working clearances in accordance with NEC.
   4. Mount floor mounted units on 4 IN housekeeping pad.

5. Mount wall mounted units on room walls, columns, or free standing steel supports.
6. Wall mounted units may be mounted on the air handling unit casing. Provide bracing and coordinate with air handling unit manufacturer.

2.3 AUTOMATIC DOOR EQUIPMENT

A. Provide all conduit, wiring, outlet boxes, etc., to make final connections to all motors, switches, safety mats, proximity detectors, remote control units, electric dead bolts.

B. Switches for control of automatic doors furnished by door manufacturer, installed by electrical.

C. See Section 28 31 00 for connections to fire alarm system.

2.4 PROJECTION SCREENS

A. Provide all conduit, wiring, outlet boxes, etc., to make final connections to power projection screens and associated UP/STOP/DOWN switches.

B. UP/STOP/DOWN switches furnished by door manufacturer, installed by electrical.

2.5 DIVISION 11 EQUIPMENT

A. Provide all conduit, wiring, outlet boxes, receptacles, circuit breakers, fittings, switches, etc., to make final connections to all equipment.

B. Where equipment items are to be connected using plug and receptacle, provide receptacle compatible with plug.

C. Where equipment is to be directly connected, use flexible conduit as indicated in Section 26 05 33.

D. See Division 11 and electrical plans for equipment to be connected.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Perform work in accordance with applicable Division 26 sections.

C. Wire equipment complete properly connected and energized.

D. Provide conduit and wiring as required for directly-connected switches as indicated or required.

END OF SECTION

SECTION 26 05 13
MEDIUM VOLTAGE CABLE

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. EPR insulated cable shall comply with the following:
   1. NEMA Publication No. WC 74-2000, 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.CS-6, Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 69 KV
   3. UL1072 Medium Voltage Power Cables.

B. Splices and terminations shall comply with the following:
   1. IEEE 404- 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- IEEE Standard for Separable Insulated Connector System for Power Distribution Systems above 600 V.

C. High potential testing shall comply with the following:
   1. IEEE 400-IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
   2. IEEE 510- IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing.
   3. InterNational Electrical Testing Association (NETA)- Acceptance Testing Specifications For Electrical Power Distribution Equipment and Systems.

D. Qualifications:
   1. Cable technician:
      a. Five years experience in handling, terminating and splicing medium voltage cables.
      b. Specifically trained by a factory representative on the terminations and splices to be used on the project. If not trained on the products to be used, on-site training by the factory representative shall be preformed before any terminations or splices are made.
   2. Cable testing :
      a. Cable testing may be performed by the Contractor.
      b. The cable tester shall have been engaged in full practice in the final inspection, testing, calibration, and adjusting of electrical distribution systems, for a minimum of five years.
      c. The cable tester shall have a calibration program with accuracy traceable every six months in an unbroken chain, to the National Institute of Standards and Technology (NIST).
      d. Cable testing shall be in accordance with the following safety standards:
         1) OSHA
         2) NFPA 70E
         3) IEEE 510
      e. Inspection, testing, and calibration shall be performed by an acceptable engineering technician, with a minimum of five years experience inspecting, testing, and calibrating electrical equipment, systems and devices. Qualification of engineering technician shall be submitted to the Engineer for approval prior to the start of work.

1.2 SUBMITTALS

A. Product data:
   1. Technical data on each type of cable.
   2. Technical data on each type of splice and termination.

B. Samples:
   1. Cable sample: Not to be returned. Length submitted to include all stamped on information including:
      a. Manufacturers name.
      b. Plant number or designation.
      c. Conductor size.
      d. Copper.
      e. Voltage rating.
      f. Insulation type and level.
      g. Insulation thickness.
      h. UL designation.
      i. Type MV-105.

C. Project information:
   1. Cable Technician qualifications.
   2. Engineering Technician qualifications.
   3. Cable pulling tension record from pulling rig dynamometer.
   4. 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.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Ship cable with removable watertight end seals, and store in dry place.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Medium voltage cable:
      a. Base:
         1) Okonite.
         2) Kerite.
         3) Southwire.
         4) Pirelli Cable.
         5) American Insulated Wire.
   2. Splices and terminations:
      a. Base:
         1) 3M.
         2) Raychem.
         3) Elastimold.
         4) Cooper Power Systems.
   3. High dielectric, arc proof and insulating tape:
      a. Base:
         1) 3M.

2) Okonite.

2.2 MEDIUM VOLTAGE POWER CABLE

A. Medium voltage cable: Single conductor, copper, rated 105 degC wet or dry, EPR, 133 percent insulation level, Type MV-105.
   1. 15 kV rated, 5.6 mm, 220 mil average thickness.
   2. Minimum spot thickness 90 percent of average thickness.

B. Cable shall be no more than 12 months old and each reel shall have label indications name of manufacturer and date of manufacture.

C. Conductor: Compressed concentric round, Class B, stranded, annealed base copper.

D. Conductor shield: Free stripping layer of extruded semi-conducting EPR firmly bonded to the insulation.

E. Insulation: Ethylene Propylene Rubber (EPR).

F. Insulation shield: Free stripping layer of extruded semi-conducting EPR.

G. Shield: Helically applied 0.13 mm, 5 mil uncoated copper tape overlapped a minimum of 12.5 percent.

H. Outer jacket: Oil and sunlight resistant PVC.

I. Armor: None.

J. Armor Jacket: None.

2.3 SPLICES AND TERMINATIONS

A. Splicing and terminating materials:
   1. Acceptable to and as recommended by cable manufacturer.
   2. Equal to or exceed rating of cable.

B. Splices: Hot shrink manufactured kit type in accordance with IEEE 404 and suitable for water immersion.
   1. Conductor splices: Compression type.
   2. Insulation, shield and jacket splices:
      a. In-line splices: Raychem HVS 1520S Series.
      b. Wye splices: Raychem HVSY 1520S Series.

C. Terminations:
   1. Within substation enclosures: Hot shrink manufactured kit type in accordance with IEEE 48 Class 1 terminations utilizing high dielectric constant stress control tube:
      a. Conductor termination: Compression type lug.
      b. Insulation, shield, and jacket terminations: Raychem HVT-150-SG Series.
   2. Within 15 kV pad mounted SF6 switch enclosures: Deadfront, modular, separable insulated connectors in accordance with IEEE 386.
      a. 600A deadbreak elbows with pulling eye, grounding eye and test point.
         1) Elbows shall be compatible with other manufacturers of deadbreak bushings.
         2) Refer to Section 15 kV Pad Mounted SF6 Switch for deadbreak bushings.
         3) Cooper Power Systems 600 Series.

2.4 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.

2.5 INSULATING TAPE FOR USE WITH ARC PROOF TAPE

A. Woven glass fabric with pressure-sensitive thermosetting adhesive.

B. 3M Scotch 69.

2.6 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.
   2. 0.008 LB/cm x cm for copper conductors when pulling eye is employed where cm is the circular mill area of single conductor, total area of the several conductors in a single cable, or the total area of conductors of all cables pulled at the same time.
   3. 5000 LB.

M. Tension on pulling devices not greater than the smaller of the following:
   1. Manufacturer's allowable tension.
   2. 1000 LB per grip when basket grip is employed.

N. Tension limiting side wall pressure not greater than the smaller of the following:
   1. Manufacturer's allowable tension.
   2. 300 LB per mm foot for radius of curvature.

O. 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 five 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.

3.3 ARC-PROOFING

A. Install one 1/4 IN, minimum, overlapped layer of arcproof tape on all cable exposed in manholes and pull and junction boxes. Bind with one layer of glass cloth insulating tape.

3.4 TESTING OF CABLES

A. 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:

Rated Circuit Voltage Phase-to Phase Volts	Wire Size AWG or MCM	Test Voltage kV 133 Percent Insulation Level
2001-5000	2-1000	25
5001-8000	2-1000	35
8001-15000	2-1000	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 under criteria for resistance decrease or disparity of insulation values 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

SECTION 26 05 19
LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SCOPE

A. Feeders, 600 volt and below, shall be copper conductors in conduit.

B. Branch circuits, 600 volt and below, from the branch circuit panelboards to the outlet or utilization equipment shall be copper conductor in conduit. Type MC Metal Clad cable may be used concealed above accessible ceilings and within drywall partitions. Type MC metal clad cable may be used exposed directly above branch circuit panelboards.

1.2 SUBMITTALS

A. Product data.
   1. Type MC Metal Clad cable.

B. Project information:
   1. Test report.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Splices and taps for smaller than No.6 AWG wire:
      a. Base:
         1) 3M.
         2) Ideal Electric.
         3) Heyco Molded Products.
         4) Elastimold.
         5) Buchanan Construction Products.
   2. Type MC Metal Chad cable:
      a. Base:
         1) AFC Cable Systems.
         2) Okonite.
         3) Southwire.

B. 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. For branch circuits served by GFCI circuit breakers: Type XHHW.
   4. 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.
   5. Size conductors to match over current protective device unless larger conductors are indicated.
   6. No.10 and smaller wire: Solid conductor.
      a. Provide stranded conductor between adjustable frequency drives and their motor(s) served.
   7. No. 10 AWG conductor to be used for 20 ampere, 120V circuits exceeding 100 FT.
   8. No. 10 AWG conductor to be used for 20 ampere, 277V circuits exceeding 200 FT

C. 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.

D. Splices and taps for No.6 AWG wire and larger: Use compression connectors with prestretched insulation to equal insulation of wire being spliced.

E. Splices and taps - General: Do not make splices and taps with crimp or indenter-type connectors.

F. Pulling lubricant: Water based type containing no waxes, greases, silicones or polyalkylene glycol oils or waxes. Lubricant shall be compatible with conductor and approved by conductor manufacturer.

G. 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:

	208Y/120 VOLT	480Y/277 VOLT
Phase 1	Black	Brown
Phase 2	Red	Orange
Phase 3	Blue	Yellow
Neutrals	White	Gray
Ground	Green	Green

   3. Color shall be solid and continuous throughout the entire length of the conductor. Color coding at conductor ends is not acceptable.
   4. Use following colors in single phase lighting and receptacle circuits:
      a. Separate neutral associated with 120 volt, Phase 1: White with three continuous black strips for the entire length of the conductor.
      b. Separate neutral associated with 120 volt, Phase 2: White with three continuous red strips for the entire length of the conductor.
      c. Separate neutral associated with 120 volt, Phase 3: White with three continuous blue strips for the entire length of the conductor.
      d. Neutral for 208V single phase and three phase circuits: White.
      e. Neutral for 480 volt single phase and three phase circuits: Gray.
   5. Isolated equipment grounding conductor: Green with one or more yellow stripe(s).
   6. Provide label for conductor color code at all panelboards.

H. Type MC Metal Clad cable: Multi-conductor type THHN 600 volt insulated copper conductors with a polypropylene assembly tape over all conductors and all within an interlocking galvanized steel or aluminum armor:
   1. Listed per UL 1569 Metal Clad cable.
   2. Suitable for use in environmental air handling spaces.
   3. Maximum of three phase conductors per cable.
   4. Conductors shall be color coded as specified above.
   5. Provide insulated equipment grounding conductor.
   6. Fittings shall be steel or malleable iron, clamp type with insulating throat and UL listed for use with type MC cable.
   7. AFC Cable Systems, Inc Type MC.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting and receptacle home runs indicated are for identification purposes only.

B. Install all line voltage and low voltage wiring in conduit unless otherwise indicated.

C. Install conductors per manufacturers recommendation. Do not exceed allowable pulling tension.

D. Install no more than 3 phase conductors in one conduit.

E. The neutral conductor shall be considered as a current carrying conductor.

F. Provide a separate neutral conductor for each phase conductor in all branch circuits including lighting circuits. Shared (common) neutrals in multi-circuit homeruns are unacceptable.

G. Provide secondary feeders from K-rated transformers with neutral conductors sized at 200 percent of the phase conductor size.

H. In laboratory and service galley surface metal raceways, twist the phase, neutral, and isolated equipment grounding conductors of each circuit within the surface metal raceway. Provide a minimum of three twists per foot of circuit. Conductors shall be twisted prior to placement within raceway. Tie-wrap conductors adjacent to each device and at maximum two foot increments.

I. Twist phase conductors between adjustable frequency drive (AFD) and motor in all motor circuits controlled by AFD. Provide a minimum of three twist per foot of circuit. Conductors shall be twisted prior to pulling into conduit.

J. Install no more than 30 current carrying conductors in surface raceways or any compartment within a multi-compartment wireway.

K. Provide neutral in all circuits serving lab areas including circuits to: 250V, 2P, 3W, single phase grounding receptacles; 250V, 3P, 4W, three phase grounding receptacles; junction boxes for hardwired equipment; and to all disconnect switches. Leave slack for future connection to device or equipment. Provide insulated connector at end of conductor.

L. Provide green insulated equipment grounding conductor in all circuits.

M. Provide isolated equipment grounding conductor to all isolated ground receptacles.

N. Provide conductor identification as indicated in Section 26 00 10.

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 or exposed directly above branch circuit panelboards located in electrical or mechanical rooms.

C. Cable shall be routed parallel or perpendicular to structure.

D. Cables shall be independently supported.

E. Damaged cable shall be replaced.

3.3 TESTING

A. Perform insulation resistance test on each feeder conductor.

B. Testing may be performed by the Contractor.

C. Testing shall be in accordance with conductor manufacturer's recommendations.

D. Provide test report of all tests performed.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop drawings:
   1. Ground grid.

B. Product data:
   1. Technical data on each component.

C. Project information:
   1. Test reports.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Ground rods:
      a. Base:
         1) Eritech.
      b. Optional:
         1) Blackburn.
         2) Harger.
   2. Exothermic weld kits:
      a. Base:
         1) Cadweld.
      b. Optional:
         1) Thermoweld.
         2) Harger.

B. Ground rods:
   1. Ground rods shall be two section copper-clad steel with high strength steel core and electrolytic grade copper outer sheath molten welded to core. Length and manufacturer's name shall be stamped at top. Size shall be 3/4 IN diameter and 10 FT long.

C. Conductors:
   1. Wire and cable: As specified in Section 26 05 19.
      a. Below grade conductors shall be bare copper cable.
      b. Above grade conductors shall be insulated copper cable except bare conductors which are indicated within enclosures.
   2. Ground bus shall be bare annealed copper bar minimum 1/4 IN x 4 IN x length indicated.

D. Connectors:
   1. Welded connections shall be exothermic type. Kits shall be of the proper type and size for conductors or other material being connected.
   2. Pressure and compression type connectors shall be as specified in Section 26 05 19.
   3. Conduit hubs shall be cast bronze.
   4. Pipe clamps shall be heavy duty cast bronze.
   5. Soldered connections are unacceptable.

E. Instrument reference terminal strip:
   1. Provide with three 1/4 IN copper threaded screw binding post with insulated mounting and 3/4 IN cap nut. Equal to Hampden HB series.
   2. Provide copper ground bar between binding post equivalent to #6 AWG.
   3. Provide lug for terminating #6 ground conductor.
   4. Mount binding post on cover-plate. Cut holes to prevent rotation of binding post.
   5. Binding post, ground bar, lug and grounding conductor shall be insulated and isolated from all other material.
   6. Provide label with 1/4 IN high black letters on green background "Instrument Reference Ground".
   7. Flush mount in minimum 4 gang back box with stainless steel cover-plate where indicated.
   8. Surface mount in minimum 3 IN x 2-1/4 IN x 8 IN aluminum housing with aluminum cover-plate where indicated.

F. Conduit:
   1. Conduit shall be as specified in Section 26 05 33.

G. Conduit fittings:
   1. Grounding locknuts and insulated grounding bushings shall be as specified in Section 26 05 34.

PART 3 - EXECUTION

3.1 GENERAL

A. Ground electrical system, raceway systems, enclosures, equipment, etc., in accordance with NEC and authorities having jurisdiction.

B. Where sizes and quantities indicated differ from NEC requirements, provide the larger sizes and quantities.

C. Where conductors are installed in steel conduit, bond conductor to each end of the conduit.

D. Seal conduit where direct buried conductors enter the conduit.

3.2 INSTALLATION

A. Grounding electrode system:
   1. Install ground grid with perimeter and cross conductors and ground rods as indicated on Drawings.
   2. Conductors shall be bare copper embedded in the concrete foundation or direct buried minimum 36 IN below finish grade or below slab-on-grade.
   3. Install ground rods where indicated to a depth where a minimum 6 IN from top of rod to finish grade is provided. Provide test wells where indicated on drawings.
   4. All below grade connections shall be exothermically welded.

B. Substation Grounding.
   1. Ground substation as indicated on Drawings and in accordance with IEEE Standard 80-2000 Guide for Safety in AC Substation Grounding.

C. Grounding riser.
   1. Install grounding buses where indicated and of the sizes indicated on the Drawings.
   2. Interconnecting grounding buses with insulated grounding conductors and of the sizes indicated on the Drawings.
   3. Install grounding electrode conductors, bonding jumper (when not routed with phase conductors), and instrument reference ground conductors in PVC conduit.
   4. Connect conductors to bus with two hole compression lugs.
   5. Each instrument reference ground bus shall be the single point ground for that associated lab module.

6. Interconnect instrument reference terminal strips in a radial configuration. Loops and daisy chains are unacceptable.
7. The instrument reference ground system shall be completely insulated and isolated from all other material.

D. Bonding of piping systems:
1. Provide bonding jumper from electrical equipment room ground bus to metal piping systems including but not limited to:
   a. Domestic water.
   b. Fire water.
   c. Chilled water supply.
   d. Chilled water return.
   e. Steam supply.
   f. Condensate return.
   g. Compressed air.
2. Bonding jumper shall be minimum #4/0.

E. Separately derived systems:
1. Separately derived systems include:
   a. Substation transformers.
   b. Dry type transformers.
   c. Standby generator.
2. Connect grounding electrode conductor from:
   a. Substation transformer to:
      1) Substation yard grounding electrode system.
   b. Lab dry type transformer to:
      1) Nearest building steel.
      2) Associated lab power system ground bus.
   c. Other than lab dry type transformer to:
      1) Nearest building steel.
   d. Standby generator to:
      1) Substation yard grounding electrode system.
3. Grounding electrode conductor shall be unspliced and in conduit in accordance with NEC Article 250-66 unless indicated larger on drawings.
4. Provide main bonding jumper between neutral and ground terminals.
   a. Provide mean to isolate neutral.
      1) Provide disconnecting link at main switchboard.
   b. Main bonding jumper shall be the same size as the grounding electrode conductor.

F. Equipment grounding conductor:
1. Install separate green insulated equipment grounding conductor in all feeders and in all branch circuits. Install equipment grounding conductor in the same raceway as the circuit conductors. Size shall be in accordance with NEC Article 250-122 unless indicated larger on drawings.
2. Ground raceways, enclosures, equipment, etc., to provide a complete and redundant equipment grounding conductor.
   a. Where nonmetallic conduit is used, the insulated equipment grounding conductor shall be the sole type of equipment grounding conductor.
3. Where metallic conduits terminate without mechanical connection to metallic enclosures (stub-ups at equipment enclosures) provide each conduit with a grounding type insulated bushing. Bond each bushing to the grounding bus within the enclosure with bare copper conductor.
4. Where metallic conduits connect to metallic enclosure through knockouts, bond conduit to enclosure with bonding bushing, bonding locknuts or bonding jumper.
5. Install grounding screw or grounding clip in outlet boxes. Provide bonding jumper from outlet box to ground terminal of grounding receptacles except where isolated ground receptacles are provided.

G. Isolated equipment grounding conductor:
   1. Install insulated and isolated equipment grounding conductor in 208Y/120 volt systems serving sensitive electronic lab equipment. Install isolated equipment grounding conductor in same raceway as equipment grounding conductor. Size shall be the same size as the equipment grounding conductor unless indicated larger on drawings.
   2. Isolated equipment grounding conductor shall be bonded to the equipment grounding conductor at the shielded isolation transformer. No other intentional or unintentional contact shall be made with the equipment grounding conductor.
   3. Provide insulated and isolated grounding terminal strip in electronic grade panelboards.
   4. Connect isolated equipment grounding conductor to ground terminals of isolated ground receptacles.
   5. In laboratories where direct connected equipment is indicated to have an isolated ground, provide insulating non-metallic raceway fitting at the point of attachment of the raceway to the equipment. Connect isolated equipment grounding conductor to ground terminals of equipment.

H. Instrument reference terminal strip: Install where indicated on drawings. Connect to instrument reference grounding bus with #6 in PVC conduit.

I. Hazardous locations:
   1. Provide grounding in accordance with NEC Article 501.
   2. Provide ground bus and bond #10 AWG exposed insulated conductor to all non-current carrying metallic surfaces within classified location.

3.3 TESTING

A. Provide earth resistance test of grounding electrode system. Perform test using fall of potential method in accordance with IEEE Standard 142. Perform test at least 48 hours after any precipitation.

B. Remove neutral disconnecting links and main bonding jumpers at switchgear and unit substations and provide ground megger test of neutral system. Perform test at each unit substation. Temporarily disconnect all TVSS equipment during test. Reconnect upon completion of test.

C. Remove main bonding jumper at the generator and at all dry type transformers and provide ground megger test of neutral system. Perform test at each separately derived system. Temporarily disconnect all TVSS equipment during test. Reconnect upon completion of test.

D. Remove bonding jumper from isolated equipment grounding terminal at panelboard and/or shielded isolation transformer serving electronic grade panelboards and provide ground megger test of isolated equipment grounding conductor. Perform test at each electronic grade panelboard. Temporarily disconnect all TVSS equipment during test. Reconnect upon completion of test.

E. Remove bonding jumper(s) and conductor to building ground grid from instrument reference ground bus and provide ground megger test of instrument reference ground system. Perform test at each instrument reference ground bus. Reconnect upon completion of test.

F. Provide test reports of all tests performed. For grounding electrode system resistance test provide weather observations.

END OF SECTION

SECTION 26 05 33
CONDUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Products Supplied and Installed Under This Section:
   1. Provide and install electrical conduit sleeves defined in Specification Appendix B. Coordinate with all other trades.

1.2 DESCRIPTION

A. Conduit runs are diagrammatic. Verify locations in field.

1.3 SUBMITTALS

A. Shop drawings:
   1. Conduit routing indicating: (If conductors within the conduit are twisted).
      a. Size.
      b. Elevation.
      c. Material type.

B. Product data:
   1. Sealers.

C. Contract closeout information:
   1. As-build drawings with plans and elevations indicating routing with dimensions of concealed conduit in floors and walls.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Steel conduit:
      a. Base:
         1) Allied Tube & Conduit.
         2) LTV Conduit.
         3) Republic Steel.
         4) Triangle Wire & Cable.
         5) Wheatland Tube.
         6) Youngstown.
   2. PVC coated steel conduit:
      a. Base:
         1) Robroy Industries.
         2) Occidental Coating.
         3) Schuller International.
   3. Neoprene coated flexible steel conduit:
      a. Base:
         1) Anaconda.
         2) Electri-Flex.
         3) Kellems.
   4. PVC conduit:
      a. Base:

1) Carlon Electrical Products.
2) Ethyl.
3) Cantex.
4) Condux.

B. Conduit:
1. Rigid steel conduit (RGS):
   a. Hot dipped galvanized exterior coating.
   b. Enamel or lacquer baked-on interior.
   c. In accordance with underwriter's laboratories UL 242.
2. Intermediate metal conduit (IMC): Steel:
   a. Hot dipped galvanized exterior coating.
   b. Enamel or lacquer baked-on interior.
   c. In accordance with underwriter's laboratories UL 6.
3. Thinwall electrical metallic tubing (EMT): Steel:
   a. Electro-galvanized zinc exterior coating.
   b. Lacquer coated interior.
   c. In accordance with underwriter's laboratories UL 797 and Federal Spec WWT-806V.
4. Flexible steel conduit for motor and equipment connections: Galvanized with continuous copper content or separate grounding conductor:
   a. Neoprene-coated type: With approved liquid-tight connectors; Anaconda Seal-Tite type LIA.
5. Rigid PVC conduit: High impact polyvinyl chloride, meeting minimum requirements of NEC:
   a. Concrete encased: Carlon Electric Products, Type 40.
   b. Fittings: PVC, solvent weld type, with connectors and threaded adapters as required.
6. Stamp each length with name or trade mark of manufacturer, nominal trade size, type of material, and affix UL label.
7. PVC coated steel conduit: Galvanized rigid steel conduit with 40 mils minimum coating of PVC.

2.2 SUPPORTS, SLEEVES AND SEALS

A. Conduit hangers - General: Threaded rods minimum 1/4 IN, with straps or clamp conduit holder:
1. Do not use the following to support conduit:
   a. Wire including ceiling support wires.
   b. Perforated strap hangers.
   c. Plastic or nylon tie wraps.
2. Use trapeze assemblies for multiple conduits.
3. Provide sufficient hangers for support of electrical work and equipment to limit load on single hanger to 25 LB, maximum:
   a. Conduit 1 IN and smaller shall be supported at maximum 5 FT spacing.
   b. Conduit 1-1/4 IN and larger shall be supported at maximum 8 FT spacing.
4. Hangers in metal roof deck: Do not extend above tops of ribs, or otherwise interfere with vapor retarder, insulation or roofing.

B. Hanger fasteners: Provide preset inserts, expansion anchors and beam clamps to attach hangers to structure:
1. Drill and set expansion anchors horizontally in solid masonry wall or into the side of concrete beams and joist at the neutral axis of the member.
2. Do not drill into the underside of concrete beams or joist.
3. Do not use explosive driven fasteners.
4. Do not use concrete nails in masonry walls.
5. Toggle bolts may be used in hollow masonry and gypsum board walls. Provide support backing in stud wall as required to support the load.
6. Sheet metal screws may be used in metal studs.
7. Attachments to hollow metal deck may be by means of prepunched tabs, prepunched holes or with screws it the sides of the ribs, or toggle bolts in the bottom of the rib.

C. Sleeves: Black iron pipe, RGS or IMC sized to accommodate work passing through.

D. Sealer for sleeves and openings around conduit: UL listed for assembly. See Section 07 84 00.

E. All penetrations of floor slab at mechanical rooms above grade shall be sealed off and waterproofed.

2.3 SCHEDULE OF CONDUIT APPLICATIONS

A. Use rigid steel conduit or intermediate metal conduit in following locations:
   1. Underground (RGS only).
   2. Exposed exterior locations (RGS only).
   3. In concrete.
   4. Under concrete slabs on grade.
   5. Entering or exiting slabs up to 12 IN above finish floor.
   6. In exterior masonry walls.
   7. In damp and wet locations.
   8. In explosion-proof areas (RGS only).

B. Thinwall EMT may be used for other 600 volt and below indoor dry applications.

C. Concrete encased Schedule 40 PVC conduit may be used for underground and under concrete slabs on grade:
   1. Exterior lighting: See Section 26 56 00.
   2. Underground distribution: See Section 26 05 43.
   3. Provide a green grounding conductor of proper ampacity in each PVC conduit.
   4. 45 degree and greater bends in PVC conduit runs shall be made with rigid steel conduit.

D. Use no conduit smaller than 3/4 IN.

E. Size conduit in accordance with NEC unless indicated larger.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install all conduits concealed within walls and above finished ceilings.

B. Exposed overhead conduit may be used in mechanical, electrical and other equipment rooms except conduit drops to flush mounted devices in walls.

C. Exposed conduit may be used in service galleys.

D. Exposed conduit may be used in labs serving wall mounted disconnects and other surface mounted equipment other than surface metal raceway.

E. Exposed vertical runs of conduit may be used in labs serving equipment mounted on service frames and carriers.

F. Install no conduit within concrete columns.

G. Install no conduit under or within concrete slabs on grade:
   1. Except where serving exterior circuits.
   2. Except in lengths less than 2 FT between floor trench and floor box.

H. Install no conduit in elevated floor slabs.

I. Run conduit in straight lines at right angles to or parallel with walls, beams or columns.

J. Keep conduit away from waterlines or heating duct lines. Where crossings are unavoidable, leave minimum 6 IN clearance.

K. Do not cross conduit in front of access door in walls, ceilings, duct work, AHU's etc.

L. Conduits within 1-1/2 IN of roof decking are required to be rigid steel type.

3.2 UNDERGROUND INSTALLATIONS

A. Steel conduits in contact with earth or a vapor retarder, that are not completely encased in concrete: Coat with 2 coats asphaltum before installation, or use PVC coated steel conduit.

B. Install exterior underground conduit 30 IN minimum below grade and as indicated in duct bank profiles.

C. Encase underground PVC branch circuit conduits in 3 IN minimum of concrete.

D. Encase underground PVC feeder conduits in 3 IN minimum of concrete. Provide reinforcing steel throughout the entire length of duct.

E. Where conduit enters a building and after installation of conductors or pull wires, seal conduit to prevent entry of water, gases or vapors.

3.3 CONDUIT INSTALLATION

A. No conduit or raceway shall enter or pass through a lab unless it serves that lab.

B. No feeders shall be routed within labs or in galleys adjacent to labs. Only feeders serving panels within service galleys shall be routed within service galleys.

C. Support all 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 install to prevent ready removal of equipment, piping, ducts or ceiling tiles.
   3. Do not support from ceiling or ceiling support systems.

D. Sum of angles in any conduit run shall not exceed 360 degrees:
   1. Where more bends are necessary, install condulet or pullbox.
   2. A hand conduit bender may be used on 3/4 IN RGS, IMC or EMT conduit and 1 IN EMT conduit. Use manufactured elbows or a conduit bending machine for larger sizes.

E. Cut conduit square and butt solidly in couplings.

F. 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.

G. 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.

H. Remove moisture and debris from conduit before wire is drawn into place. Tightly plug ends of conduit with tapered wood plugs or plastic inserts until wire is pulled.

I. Neatly seal openings around conduits, etc., where they pass through fire rated construction or exterior walls or roof.

3.4 CONNECTIONS AND FITTINGS

A. Above lay-in tile ceilings, make connections to lay-in type fixtures with 3/8 or 1/2 IN x 6 FT long flexible steel conduit:
   1. Include No.18 branch and grounding conductors.
   2. Arrange conduit and box systems for easy removal of lay-in ceiling.

B. Connect switch legs for narrow switches in hollow metal jamb posts using 1/2 IN flexible steel conduit.

C. Connections to vibration isolated equipment: See Section 26 05 48, Vibration Isolation:
   1. Use neoprene coated type with liquid tight connectors in damp and wet locations.

D. Install expansion joint fittings on conduit at all building expansion joints where conduit is in slab, rigidly attached to structure, or where otherwise necessary to compensate for thermal expansion and contraction.

E. Use sealing fittings on rigid galvanized conduit in hazardous areas. Install in accordance with NEC.

F. Use only compression type fittings for all EMT conduits. Install in accordance with NEC.

END OF SECTION

SECTION 26 05 34
BOXES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Floor boxes.
   2. Expansion joint fittings.
   3. Sealing fittings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Galvanized boxes:
      a. Base:
         1) Appleton Electric.
         2) Thomas & Betts / Steel City.
         3) Raco Manufacturing & Engineering.
   2. Corrosion resistant boxes and fittings:
      a. Base:
         1) Crouse-Hinds Lighting.
         2) Appleton Electric.
   3. Conduit fittings:
      a. Base:
         1) Appleton Electric.
         2) Thomas & Betts / Steel City.
         3) Raco Manufacturing & Engineering.
         4) O-Z/Gedney.
   4. PVC coated conduit fittings and boxes:
      a. Base:
         1) Robroy Industries.
         2) Occidental Coating.
   5. Box supporting brackets:
      a. Base:
         1) Caddy.

B. Galvanized boxes shall be galvanized steel minimum 14 gauge. Finish shall be "Hot Dip" whenever available.

C. Lighting outlet boxes:
   1. Galvanized, 4 IN octagon or square, minimum 2 1/8 IN deep.
   2. Verify proper depth with partition type and thickness.
   3. Provide with proper fittings to support and attach lighting fixtures.
   4. Support outlet boxes for fixtures 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.
   5. Provide box extensions as required and square cut tile rings in all types of wall construction and suspended ceilings. Rings shall be installed such that device plates fit snug against finished surfaces.

D. Surface mounted boxes in dry locations:
   1. Galvanized 4 IN octagon or square, minimum 1 1/2 IN deep with 1/2 IN raised steel cover.

E. Surface mounted boxes in damp or wet locations:
   1. Corrosion resistant cast ferrous metal type, with threaded hubs and neoprene gasket: Crouse-Hinds Type FS.

F. Outlet boxes for flush wall devices:
   1. Single conduit (dead end) or device – 3 IN x 2 IN x 2 1/2 IN deep switch box.
   2. Two or more conduits or two devices – 4 IN square x 2 1/8 IN deep.
   3. Three or more devices – multigang 3 IN x 2 IN x 2 1/2 IN deep switch boxes.
   4. Provide 3 3/4 IN high masonry box in masonry walls. Locate at top or bottom of masonry course.
   5. Provide welded square cut tile ring or square drawn ring equal to RACO #768, 769, 773-796 for all flush mounted locations. Depth of ring shall be such that the ring is flush with the finished surface. Rings shall be installed such that device plates fit snug against finished surfaces.
   6. Provide barriers between switches in boxes with 277 volt switches on opposite phases.

G. Pull and junction boxes:
   1. Galvanized steel with screwed or bolted cover.
   2. Size per NEC, minimum 4 IN square.
   3. Boxes up to 12 IN x 12 IN – 14 gauge.
   4. Boxes 12 IN x 12 IN and larger – 12 gauge.
   5. Boxes 100 cubic inch and larger shall comply with UL50 electrical cabinets and boxes.

H. Multi-service floorbox.
   1. Floorbox shall be four compartment, fully adjustable, cast iron suitable for flush mounting in slabs-on-grade and above grade slabs.
   2. Floorbox size shall be 14 1/2 x 11 7/8 x 3 7/16 IN.
   3. Four independent wiring compartments for duplex receptacles or communication devices.
      a. Two power compartments shall have a minimum wiring capacity of 27 cubic inches with one 1 IN knockout. Provide device mounting plate to accept duplex receptacle.
      b. Two communication compartments shall have a minimum wiring capacity of 36 cubic inches with one 1 IN and two 1 1/4 IN knockouts. Coordinate device mounting plate with Section 27 05 32.
   4. Provide maximum 1 7/8 IN per pour adjustment and maximum 3/4 IN after pour adjustment.
   5. Cover shall be die-cast aluminum, textured finish, flanged, 8 x 6 3/4 IN with blank hinged access doors with sliding panels for cable egress.
   6. Wiremold RFB4-CI-1 floorbox with S36BBTCAL cover.
   7. Provide other types as indicated on drawings. See floor box schedule.

I. Poke-thru device:
   1. Flush mounted in tile or carpeted floor with brushed aluminum trim flange and black slide covers. Comply with requirements for scrub water exclusion.
   2. Provide one 20 amp, 125 volt, 2 pole, 3 wire NEMA 5-20R duplex receptacle.
   3. Provide accommodations for up to four Cat 5e and/or fiber optic connectors. Coordinate connector type with 16745.
   4. Maintain fire rating of floor assembly.
   5. Suitable for use in plenum ceilings.
   6. Wiremold RC3ATCAL.
   7. Provide other types as indicated on drawings. See floor box schedule.

J. Box supporting brackets: Caddy SGB Series.

K. Conduit bodies:
   1. Cast ferrous metal type, with gasketed cover in wet and damp locations.
   2. 99.4 percent copper free aluminum in indoor dry locations.

L. Fittings and boxes with PVC coated steel conduit: Specified boxes and fittings with 40 mils minimum coating of PVC.

M. Pull and junction boxes in PVC conduit: Minimum 4 IN square plastic boxes.

N. Where RGS or IMC enters a box or other fitting through a knockout, an approved double locknut and bushing shall be provided.
   1. Conduit bushings shall be threaded type, having insulated inserts equal to O.Z., steel, type "B". Bushings for feeder conduits shall be grounding type, having lay-in type lug.

O. Provide EMT conduit with steel set screw, insulated throat, concrete tight type couplings and connectors as manufactured by Appleton #4000ST/5000S Series, OZ/Gedney #4000ST/5000S Series, UL/CSA listed, meeting Federal Spec #WF408D. Other type fittings will not be acceptable.

P. Flexible conduit connectors shall be UL listed for grounding, squeeze type, malleable iron with insulated throat, one or two screw type as O-Z/Gedney, T&B, Raco or approved equal (set screw type, die-cast or screw-in type are not acceptable).

Q. Liquidtight fittings shall be UL listed for grounding, ferrule and sleeve type with insulated throat as O-Z/Gedney "4Q" series, T&B, Appleton "ST" or approved equal.

R. Expansion joint fitting: Watertight deflection type, O-Z , type "DX" or approved equal.

S. Conduit seals: Watertight and vaportight, O-Z, Type "FSK" or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mounting of outlet boxes for concealed wiring.
   1. Boxes mounted adjacent to studs shall be attached directly to stud with a minimum of 4 metal screws.
   2. Boxes that are not attached directly to studs shall be attached to bracket spanning studs. Bracket shall be attached to studs with 2 screws at each end. Attach box to bracket with 2 screws minimum.

B. When a metallic junction box for electrical receptacles or switches is contained within a 1 or 2-hour rated fire or smoke wall of gypsum drywall construction and an opening is provided for the box in the surface of that wall, the area of the opening may not exceed 16 square inches, unless the junction box is protected by an approved method such as a UL listed "putty pad".
   1. The aggregate area of all such junction boxes in a rated wall not protected by an approved method shall not exceed 100 square inches in 100 square feet 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 inches 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. Thread fittings for rigid conduit and IMC.

D. Install rigid conduits squarely into boxes. Rigidly clamp to box with locknut on outside and inside and provide bushing on inside.

E. Fill unused punched-out openings in boxes with proper closures.

F. Use outlet boxes sized to accommodate quantity of conductors enclosed.

G. Provide pull boxes or junction boxes in conduit runs where indicated or as required to facilitate pulling of wires or making of connections. Make covers of all boxes accessible.

H. Spray paint inside of boxes and exposed conduits for 3 IN beyond the outlets with non-flammable paint per Section 26 00 10.

I. Stagger outlet boxes where located back to back a minimum of 12 IN to minimize sound transmission between rooms.

END OF SECTION

SECTION 26 05 35
SURFACE METAL RACEWAYS AND WIREWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Surface metal raceways shall be provided for branch circuit wiring and voice, telecommunications, video and other low-voltage wiring as indicated.

1.2 SUBMITTALS

A. Shop drawings:
   1. Surface metal raceway.

B. Product data:
   1. Surface metal raceway.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Surface metal raceway:
      a. Base:
         1) Wiremold/Isoduct.
         2) Post Glover/Versa-duct.
   2. Wireway:
      a. Base:
         1) Hoffman Engineering.
         2) Square D.
   3. Floor trench duct:
      a. Base:
         1) Square D.
         2) Walker.
         3) Thomas & Betts/Steel City.

B. Surface metal raceway: One or two piece steel raceway with base and snap-on cover for mounting power and/or communication devices:
   1. Refer to drawings for types.
   2. Provide fittings and accessories for a complete installation. Provide base with fittings where applicable.
   3. Provide wire clips to hold conductors/cables in places.
   4. Provide 2 IN radius inserts at elbows within the communication compartment.
   5. Raceway shall be electrically continuous and listed as an equipment grounding conductor.
   6. Base, cover, fitting and accessory finish shall be gray and suitable for field repainting.
   7. Device mounting plate shall be high impact resistant plastic mounting bracket and trim plate which overlaps the raceway cover to provide a seamless transition between the plate and the cover:
      a. Provide single, duplex, GFCI, twistlock and/or blank faceplate as required by layout indicated on the drawings.
      b. Provide communication faceplates which accept voice/data jacks/connectors as specified and/or full or half blank inserts as required by layout indicated on the drawings.

c. Coordinate communication outlet requirements with supplier of voice/data communication system.

C. Wireway: NEMA I lay-in wire-way:
1. Arrange wireway cover for removal, hinging and locking closed by captive type fasteners.
2. Finish: Gray baked-enamel, over phosphatized surfaces.
3. With necessary fittings, with or without knockouts, with solid cover where passing through partitions, with manufacturer's name or trademark visible after installation.
4. Designed for continuous grounding.

D. Floor trench ducts: 6 IN wide, 2 IN deep waterproof with dividers, removable covers and suitable fittings:
1. Cover shall be maximum 3 FT long with gasket seals.
2. Coordinate trim type with finish floor material.
3. Provide two equal sized compartments separated by an adjustable partition.
4. Provide end closures at each end.
5. Provide vertical riser at wall feed points.
6. Wiremold – VA Trench duct.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

3.2 SURFACE RACEWAY INSTALLATION

A. Mount surface raceway on walls or support channels as indicated on drawings and as indicated in manufacturer's instruction sheets.

B. Use one section for runs up to ten feet. Do not use random scraps to assemble a run less than ten feet.

C. Install wiring devices of the type, quantity and location indicated on drawings.

D. 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.

E. Do not install more than 30 current carrying conductors in any compartment of any surface raceway.

F. Maintain equipment grounding continuity of surface raceway systems.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop drawings:
   1. Manholes, signed and sealed by professional engineer.
   2. Duct bank layouts, sections and elevations indicating existing and final grade elevation, ductbank elevation and elevation of crossing utilities.

1.2 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Building Industry Consulting Services International (BICSI) Telecommunications Distribution Methods Manual (TDMM).

B. Store conduit to avoid warping or deterioration.

C. Store plastic conduit on flat surface protected from direct rays of sun.

D. Equipment shall be delivered in original packages with labels intact and identification clearly marked.

E. Equipment shall not be damaged in any way and shall comply with manufacturer's operating specifications.

F. Equipment and components shall be protected from the weather, humidity, temperature variations, dirt, dust, or other contaminants. Equipment damaged prior to system acceptance shall be replaced at no cost to the Owner.

1.3 JOB CONDITIONS

A. Protect existing utilities and structures as indicated in Section 26 00 10.

B. Provide full access to public and private premises, to fire hydrants, street crossings, sidewalks and other points as designated by Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Manholes:
      a. Base:
         1) Smith-Midland.
         2) Rotondo Precast.
         3) Strongwell.

2.2 DUCT SYSTEM

A. Duct system: Single or multiple, round-bore rigid steel conduit or Schedule 40 PVC conduits completely encased in concrete as indicated:
   1. Conduit:
      a. Rigid PVC conduit: As specified in Section26 05 33.
      b. Rigid steel conduit: As specified in Section 26 05 33.
   2. Separators: PVC. Conduit, wood or other materials are unacceptable.
   3. Concrete: 3000 PSI. Conform to Division 3 requirements.

4. Reinforcing steel: ASTM-A615 Grade 60. Conform to Division 3 requirements.

B. Pull wire: 3/16 IN kevlar cord with marked footage, free of kinks and splices.

C. Marker tape: 3 IN wide, .005 IN thick red colored plastic tape with continuous metallic backing and a .001 IN corrosion resistant metallic foil core. Tape shall be labeled "electric" or "communication" at intervals not exceeding 10 FT.

D. Where all-dielectric cables are used below ground, an additional insulated conductor shall be placed along with the cable to provide means of tone locating. The trace conductor shall be 10 AWG or larger.

2.3 MANHOLES

A. Electric and communication manholes:
1. Precast reinforced concrete: Two piece construction with inside dimensions as indicated on the drawings.
2. Concrete: Minimum 4000 PSI at 28 days. Conform to Division 3 requirements.
3. Reinforcing:
   a. Bars: ASTM A615 Grade 60.
   b. Welded wire fabric: ASTM A185.
4. Design Criteria:
   a. Dead loads:
      1) Concrete: 150 pounds per cubic foot.
      2) Earth: 120 pounds per cubic foot.
   b. Lateral loads:
      1) Equivalent fluid pressure: 60 pounds per square foot per foot of depth.
      2) ASSHTO Traffic Surcharge: 2 feet of earth.
   c. Live Loads:
      1) Rear wheel truck load: 20,800 pound, H20 ASSHTO.
5. Joint sealant: Preformed butyl rubber between precast sections.
6. Knockouts: Provide knockouts in wall conforming to the arrangement and configuration of duct banks indicated on the drawings.
7. Cover and frame: Cast iron with 36 inch diameter clear. Label covers “ELECTRIC” or “COMMUNICATION” as applicable with 2 inch high letters. Manhole covers are required to be either over 100 lbs or lockable.
8. Collars: Precast reinforced concrete.
9. Sump with grate: 12 inch x 12 inch x 6 inch with cast iron grate.
10. Cable racks and arms: Galvanized with porcelain insulators or heavy duty fiberglass reinforced plastic:
    a. Vertical stanchion shall be minimum 36 inch with equally spaced arm mounting holes. Provide two stanchions on each manhole wall.
    b. Arms length shall be appropriate for cable installation. Provide holes in the arms for cable ties. Provide one spare arm on each stanchion.
11. Pulling irons: Provide one pulling iron opposite each knockout panel.
12. Ladder rungs: 3/4 inch diameter, 16 inch wide, 7 inch off the wall and spaced 12 inch on centers.
13. Ground rod sleeves: Provide two sleeves in opposite corners for ground installation.

2.4 BACKFILL MATERIAL

A. Backfill Material: See Section 31 23 33.

2.5 INNERDUCTS

A. Outside plant innerduct shall be installed in UG conduits and duct banks.
1. Outside Plant Inner Ducts shall be 1.25-inch selected to optimize current and future cable routing through underground conduits. Outside plant innerduct shall include the following features.

2. Innerducts shall be constructed of high-density polyethylene with internal and external longitudinally ribs.
3. Innerducts shall be furnished with factory installed nylon pull ropes. Pull ropes shall be rated with a tensile strength of 1250 pounds.
4. Innerduct reel lengths shall be provided as necessary to insure that ducts are continuous; one piece runs from handhole to maintenance hole/handhole. No innerduct connectors will be allowed between maintenance holes/handholes.
5. Pulling accessories used for innerduct shall be compatible with materials being pulled. Accessories shall be furnished as required to complete the installation, including but not limited to, inner duct lubricants, spreaders, applicators, grips, swivels, harnesses, and line missiles.

B. Each segment of innerduct shall extend at least twelve inches beyond the end of the service conduit.

2.6 HANDHOLES

A. Handholes shall comply with the following requirements.
1. Handholes shall be sized in accordance with BICSI CO OSP Manual but no larger than four feet by four feet and shall be constructed of 2-inch thick cement covered with 3/8 inch steel plate.
2. The Handhole Loading Requirements per ANSI/SCTE 77-2002 Specifications for Underground Enclosures Integrity, shall be TIER 15, vertical loads of 15000 lbs and lateral loads of 800 lbs/sgft. TIER 15 is defined as Driveway, parking lot, and off-roadway applications subject to occasional non-deliberate heavy vehicular traffic.
3. Handholes shall be constructed of polymer concrete with fiberglass cloth reinforcement.
4. The handholes shall be design with a straight wall design.
5. Install watertight penetrations through foundation, handhole and maintenance hole walls.
6. Shall have drainage provisions (e.g., drain holes, open bottom, sumphole).

B. The cover shall be a two piece heavy duty flat slab and shall have a service load of 15,000 lbs over 10 inches square and shall have a communication logo attached to the top.
1. The cover shall be securable with security bolts (five sided bolts).

C. Assemble duct banks with non-magnetic saddles, spacers and separators. Position separators for 2-inch minimum concrete separation between outer surfaces of adjacent ducts.
1. Make uniform required bends with a minimum of a 48 inch radius for conduits 3 inches and larger.
2. Maintain vertical or horizontal separations of 12 inches of well-packed topsoil from any electrical service conduit run parallel to communications conduits.

D. Install reinforcing. Install concrete encasement fully surrounding reinforcing steel and ducts.
1. Unless otherwise noted on the drawings, reinforce with No. 5 longitudinal steel bars placed at each corner and along each face at maximum parallel spacing of 12 inches o.c., and No. 5 tie-bars transversely placed at 12 inches o.c. maximum longitudinal. Maintain maximum clearance of 2 inches from bars to edge of forms and ducts.
2. Place concrete with minimum 3-inch cover surrounding ducts and reinforcement.
3. Maintain ducts in proper place during concrete placement.

E. Transition from Schedule 40 rigid PVC non-metallic to metallic conduit where duct banks enter structures.

F. Where ducts enter structures such as handholes, maintenance holes, pullboxes, or buildings, terminate ducts in proper end bells, insulated L-bushings, hubs or couplings on steel conduits.

G. Tag conduits entering pull boxes with stamped stainless steel tags following cable and conduit schedule. Install one bare stranded copper duct bank ground cable in each duct bank envelope. Make ground electrically continuous throughout duct bank system. Connect to each handhole and maintenance hole ground rod.

H. Pull a 12-inch long mandrel (1/4 inch smaller than duct diameter) through ducts. Pull a rag swab or sponge through to remove debris, until it shows clean.

I. Provide a measured pull tape in all underground conduits.

PART 3 - EXECUTION

3.1 EXCAVATING AND TRENCHING - GENERAL

A. Excavating and Trenching: See Section 31 23 33.

3.2 INSTALLATION OF DUCT SYSTEM

A. 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.

B. Install duct lines so that top of concrete is not less than 30 IN below finished grade or finished paving at any point.

C. Provide minimum 12 IN separation between electric and communication ducts.

D. Where underground conduits run parallel with pipelines, a one (1) foot minimum clearance shall be maintained, and at crossings, a one (1') minimum clearance shall be maintained below the bottom of the pipes. Conduits should cross under existing pipes when practical and reasonable.

E. Accomplish changes in direction of runs exceeding total of 10 degrees, either vertical or horizontal, by long sweep bends with minimum radius of 25 FT:
   1. Provide rigid steel elbows at turn-ups to electrical equipment.
   2. Manufactured bends: Minimum radius of 48 IN for ducts of 3 IN in diameter and larger.
   3. Long sweep bends may be made up of one or more curved or straight sections and/or combinations thereof.

F. The number, size and arrangement of conduits in the cast-in-place underground duct bank sections shall be as indicated on the drawings. Outer encasement of concrete shall be 3" minimum with 7-1/2 IN between conduit centers.

G. Stagger conduit joints a minimum of 12 IN in concrete encased duct banks.

H. Conduit spacers shall be sized to allow for the full separation of conduits as indicated on the drawings and spaced a maximum of eight (8) feet on centers.

I. Provide steel reinforcement throughout the duct bank as indicated on the drawings.

J. Duct lines shall be doweled to the manhole with rebar.

K. Terminate conduits in end bells where duct lines enter manholes.

L. Thoroughly clean conduit before using or laying.

M. Lay no conduit in water or in unsuitable weather or trench conditions.

N. During construction and after duct line is completed, plug ends of conduits to prevent water washing into conduit or manholes:
   1. Take particular care to keep conduits clear of concrete, dirt, and any other substance during course of construction.

O. 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.

P. Encase each conduit completely in concrete not less that 3 IN beyond any surface of conduit:
   1. Do not place concrete until conduits have been inspected by Architect/Engineer.
   2. Mix, place and cure concrete in accordance with Division 3 requirements.

Q. Pneumatic rodding may be used.

R. Color top layer of concrete encasement red by heavily sprinkling with red oxide cement coloring while still wet.

S. After completion of duct bank section, same shall be thoroughly cleaned by passing a mandrel, no smaller in diameter than ¼ inch less than conduit size, through each conduit. After this initial cleaning with the mandrel, each conduit shall be thoroughly cleaned and dried by pulling an approved swab and spiral wire brush back and forth until a satisfactorily clean condition has been obtained. Contractor shall then pull three 10 feet long pieces of 500kcmil cable through each conduit 3" and larger and examine for any damage after each pass. Broken or obstructed conduits shall be repaired and rechecked with the mandrel.

T. After cleaning of conduits, install a 3/16" Kevlar pull string with marked footage in each spare conduit.

U. Place detectable marker tape centered above duct bank 12 IN below finish grade. Tape shall have appropriate labeling for type of duct.

3.3 INSTALLATION OF MANHOLES

A. Determine exact location of each manhole after careful consideration has been given to location of other utilities, grading, and paving:
   1. Do not begin construction until location of each manhole has been approved by Owner.

B. Set manhole depth to maintain minimum 8 IN earth cover and as required to maintain duct bank drainage.

C. Set manhole level on minimum 6 IN gravel bed.

D. Set manhole frame and cover:
   1. In paved areas, set top of frame and cover flush with finish surface of pavement.
   2. In unpaved areas, set top of frame and cover approximately 1/2 IN above finish grade.
   3. Provide precast collar(s) with mortared joints as required to elevate frame and cover to finish grade.
   4. Grout frame to manhole top of to collar.
   5. Paint exterior of the frame with two coats of asphaltic paint.

E. Drive two 3/4 IN diameter 10 FT long copper-clad ground rods. Leave 4 IN of rod exposed.

F. Provide #4/0 ground around perimeter of manhole 1 FT below top. Support at minimum 3 FT spacings. Provide #4/0 connection to each manhole ground rod and to each #4/0 duct bank ground conductor.

G. Bond all metallic surfaces with #6 bare copper conductor to the ground rods or #4/0 perimeter ground.

3.4 INSTALLATION OF HANDHOLES

A. Conduits entering a handhole should be aligned on walls at the same elevation.

B. The conduits shall be run in as straight a manner as possible.

C. Handholes shall be installed as shown on the drawings or as directed by the Owner.

D. The handhole excavation shall have bedding material of 6 inches covering the entire bottom of the excavation and the handhole shall be placed so the top of the handhole is level with the existing grade.

E. The location of each handhole will be indicated by a stake and reviewed by the Owner prior to installation.

F. The locate wire shall be bonded to a 1/2 inch x 5 feet copper bonded pointed ground rod driven 4 feet into undisturbed earth at each new handhole. The locate wire shall be wire bonded to the ground rod (inside of the handhole) with a bronze ground rod clamp suitable for direct burial.

3.5 BACKFILLING

A. Backfilling: See Section 31 23 33.

3.6 COMPACTION

A. Compaction: See Section 31 23 33.

END OF SECTION

SECTION 26 05 48

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide vibration control devices, materials, and related items. Perform all work as indicated on drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.2 QUALITY ASSURANCE

A. Coordinate the size, location and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes and proper loading to meet the specified requirements.

C. Provide any incidental materials needed to meet the requirements stated herein, even if not expressly specified or indicated on drawings, without claim for additional payment.

D. Verify correctness of equipment model numbers and conformance of each components with manufacturer's specifications.

E. Should any electrical equipment cause excessive noise or vibration, provide remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

F. Upon completion of the work, Owner shall inspect the installation and shall inform the installing contractor of any further work that must be completed. Make all adjustments as directed by Owner that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

1.3 SUBMITTALS

A. Shop drawings:
   1. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
   2. Detailed selection data for vibration isolator supporting the generator, including:
      a. The isolator type.
      b. The actual load.
      c. The static deflection expected under the actual load.
      d. Specified minimum static deflection.
      e. The additional deflection-to-solid under load.
      f. The ratio of spring height under load to spring diameter.

B. Product data:
   1. Specifications and installation instructions.
   2. Detailed selection data for each vibration isolator supporting equipment, including:
      a. The equipment identification mark.
      b. The isolator type.
      c. The actual load.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Double neoprene pads and hanger neoprene:
      a. Base:
         1) Mason Industries.
         2) Kinetics Noise Control.
         3) Vibration Mountings & Controls.
   2. Flexible electrical connections:
      a. Base:
         1) Crouse-Hinds.
         2) Spring City Electrical Mfg. Co.

2.2 VIBRATION ISOLATION MOUNT TYPES

A. Type DNP (Double Neoprene Pad):
   1. Neoprene pad isolators shall be formed by two layers of 1/4 IN to 5/16 IN thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate. These layers shall be permanently adhered together. Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.
   2. Type DNP isolators shall be formed from one of the following products or approved equal:
      a. Type WSW: Mason Industries.
      b. Type NPS: Kinetics Noise Control.
      c. Multi Layers of Series Shear-Flex or Maxi-Flex: Vibration Mountings & Control.

2.3 FLEXIBLE ELECTRICAL CONNECTIONS

A. Type A:
   1. Flexible Electrical Connection Type A shall be a prefabricated unit incorporating a flexible and watertight outer jacket, grounding strap, plastic inner sleeve to maintain smooth wire way, and end hubs with tapered electrical threads to fit standard threaded rigid metal conduit.
   2. Flexible Electrical Connection Type A shall be Crouse-Hinds (Syracuse, NY) "XD Expansion/Deflection Coupling", Spring City Electrical Mfg. Co., (Spring City, PA) "Type DF Expansion and Deflection Fitting".

B. Type B:
   1. Flexible Electrical Connection Type B shall be field fabricated using a minimum 24 IN length of flexible conduit.

C. Type C:
   1. Flexible Electrical Connection Type C shall be field fabricated using a minimum 48 IN length of flexible conduit with a minimum 90 degree bend.

2.4 GENERATOR ISOLATION

A. The engine generator set shall be rigidly mounted on a steel rail skid base.

B. The skid base shall be resiliently mounted on the concrete foundation.
   1. Skid base shall be supported on spring isolators that achieve at least 1-1/2 IN deflection under load.
   2. Provide side-mounted height saving brackets for attachment of the isolators positioned on the sides of the skid base that are parallel to the axis of rotation.
   3. There shall be at least 1 IN clearance between the underside of the skid base and the slab.
   4. Spring isolators shall be "Floor Spring and Neoprene Travel Limited" Type FSNTL as indicated in Section 20 05 50.

C. The generator enclosure shall be rigidly mounted to the concrete foundation.

D. The muffler exhaust pipe shall be rigidly connected to the roof of the generator enclosure.

E. The muffler shall be resiliently supported from the roof of the generator enclosure on spring and neoprene isolators that achieve at least 1-1/2 IN deflection under load.
   1. Spring and neoprene isolators shall be "Hanger Spring and Neoprene" Type HSN as indicated in Section 20 05 50.

F. Electrical connections from the ductbank to the generator shall be provided with a off-set bend in the liquid-tight flexible conduit to allow three dimensional freedom of movement of the generator.

PART 3 - EXECUTION

3.1 APPLICATION

A. Dry type transformers (480-208/120V):
   1. Transformers shall be mounted on type DNP isolators.
   2. Electrical connections to transformers shall be made using flexible connections Type C.

B. Mechanical equipment:
   1. Electrical connections to vibration isolated mechanical equipment shall be made using flexible electrical connections Type C.

C. Across vibration isolation joints in the structural system:
   1. Electrical connections across vibration isolation joints in the structural system shall be made using flexible connections Type A or Type B.

3.2 INSTALLATION

A. General:
   1. In all cases, isolated electrical equipment shall be positioned so that it is free-standing and does not come in rigid contact with the building structure or other systems.

B. Isolation mounts:
   1. All mounts shall be aligned squarely above or below mounting points for the supported equipment.
   2. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plate shall rest entirely on the pad.
   3. Hanger rods for vibration isolated support shall be connected to structural beams or joists, not to the floor slab between beams and joists. Provide suitable intermediate support members as necessary.
   4. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360 degrees about the rod axis without contacting any object.

C. Flexible electrical connections:
   1. Type C connections shall be installed with a minimum 90 degree bend.
   2. Rigid conduit on the isolated-equipment side of the flexible connections, and the flexible connection itself, shall not be tied to the building construction or other rigid structures.

END OF SECTION

SECTION 26 05 73

SHORT-CIRCUIT/COORDINATION/ARC FLASH STUDY

PART 1 - GENERAL

1.1 REFERENCE

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 1 General Requirements.

1.2 DESCRIPTION

A. Short circuit, protective device coordination, and arc flash studies have been performed for equipment utilizing SKM System Analysis Power Tools for Windows software. In general, equipment and protective devices have been selected and analyzed to minimize arc flash incident energies. Protective device setting tables ARC flash results are included as part of electrical system analysis report. Additional report information and electronic files are available for Contractor's use.

B. The study has been performed using acceptable manufacturers from individual specification sections. Equipment and protective device settings have been selected to reduce arc flash energies below 8 cal./cm2 whenever possible.

C. Alternate approved manufacturers are acceptable. Equipment will be evaluated during shop drawing submission and review. Equipment which would cause arc flash energies to increase above 8 cal./cm2 will be cause for rejection.

D. Equipment suppliers may perform independent studies to verify performance of proposed devices. Studies must be performed using "ETAP" Electrical Engineering Software.

E. Contractor must submit as-built system data for inclusion in a final study report prior to equipment startup.

F. Contractor shall install arc flash PPE labels prior to startup. Owner standard labels will be provided for Contractor's use.

1.3 REFERENCE STANDARDS

A. IEEE 141 - Recommended Practice for Electric Power Distribution and coordination of Industrial and Commercial Power Systems.

B. IEEE 241 - Recommended Practice for Electric Power Systems in Commercial Buildings.

C. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

D. IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis.

E. IEEE 1015 - Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.

F. ANSI C37.13 - Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.

G. ANSI C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.

H. NFPA-70E – Standard for Electrical Safety in the Workplace.

I. IEEE 1584 – Guide for Performing Arc Flash Hazard Calculations.

1.4 SUBMITTALS

A. Submit equipment data in accordance with referenced specification sections. Owner will evaluate proposed submissions utilizing the ETAP computer model.

B. If elected, submit independent ETAP model of proposed equipment for Owner's approval.

C. Preliminary short-circuit and protective device coordination studies are required to evaluate the submission of distribution equipment shop drawings:
   1. The drawings and specifications indicate the general requirements for the electrical equipment being provided. Upgrade and modification to equipment characteristics and ratings will be finalized by the results of the short circuit and protective device coordination studies at no additional cost to the owner. Field settings of devices and adjustments to the new equipment to accomplish conformance with the accepted short circuit and protective device coordination studies shall be carried out by the contractor at no additional cost to the owner. Any proposed deviations from the system indicated on drawings and in specifications shall include demonstration of short circuit and breaker coordination.
   2. Short circuit study shall be approved prior to manufacture of equipment.
   3. Coordination and arc flash studies shall be approved prior to energizing equipment.
   4. Arc flash labeling shall be installed prior to energizing equipment.

D. Submit as built one line diagrams to reflect approved shop drawings, actual cable lengths, breaker settings, and any other approved field changes.

E. Final short-circuit, protective device coordination studies, and arc flash analysis shall be issued after equipment is installed but before it is energized.

F. Final report shall include:
   1. One-line diagram.
   2. Descriptions and scope of the study.
   3. Tabulations of circuit breaker fuse and other protective device ratings versus calculated short circuit duties.
   4. Time versus current coordination curves, tabulations of circuit breaker trip unit settings and fuse selection.
   5. Fault current calculations.
   6. Recommendations.
   7. Three phase arcing current ratings for each piece of electrical equipment indicated on one-line diagram.
   8. Required PPE (Personal Protective Equipment) level labels for each piece of electrical equipment (medium voltage switches, substations, switchboards, switchgear, motor control centers, distribution panels, panelboards, UPS and downstream panels, Inverters and down stream panels, remote motor controllers, enclosed switches, etc.).

G. If Contractor has prepared all studies, submit all electronic files associated with short circuit, coordination and arc flash studies to allow review and future use of the files. Provide (4) copies on CD and (4) hard copies in binders. Files shall be complete to allow exact regeneration of all studies.

H. If Owner completes studies, Contractor will be provided with (1) hard copy of the one line drawing containing all final arc flash results.

1.5 QUALIFICATIONS

A. Electrical analysis has been performed by Owner or his designated representative.

B. If elected, short circuit, coordination studies, and arc flash analysis may be conducted by the Contractor under the supervision and approval of a Registered Professional Electrical Engineer.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 SHORT CIRCUIT STUDY

A. Entire electrical system including lighting and appliance panelboards and all upstream equipment (automatic transfer switches, remote motor controllers, enclosed switches, etc.) shall be modeled to facilitate the arc flash study as required below.

B. Use typical conductor impedances.

C. Transformer design impedances shall be used when test impedances are not available.

D. Provide:
1. Calculation methods and assumptions.
2. Selected base per unit quantities.
3. One-line diagram.
4. Source impedance data, including utility system and motor fault contribution characteristics.
5. Typical calculations.
6. Tabulations of calculated quantities.
7. Results, conclusions, and recommendations.

E. Calculate short circuit momentary and interrupting duties for a three phase bolted fault at:
1. Utility's supply termination point.
2. Branch circuit panelboards, if above 10,000 AIC.
3. Enclosed Switches.

F. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short circuit ratings.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Entire electrical system including lighting and appliance panelboards and all upstream equipment (automatic transfer switches, remote motor controllers, enclosed switches, etc.) shall be modeled to facilitate the arc flash study as required below.

B. Time-current curves shall be displayed on log-log scale paper.

C. Include on each curve sheet a title and legend, identifying portion of the system covered.

D. Identify device by manufacturer type, function and tap, time delay, and instantaneous settings recommended.

E. Selective Coordination:
1. All circuit breakers associated with the fire pump, elevator, and emergency lighting shall be selectively coordinated per the current National Electric Code.

F. Plot characteristics where applicable:
1. Electric utility's protective device.
2. Low voltage fuses including minimum melt, total clearing and damage bands.
3. Low voltage circuit breaker trip devices.
4. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters.
5. Conductor damage curves.
6. Ground fault protective devices.
7. Motor starting characteristics and motor damage points.
8. Generator short circuit decrement curve and generator damage point.

9. All CT ratios.

3.3 ARC FLASH POTENTIAL STUDY

A. Arc flash potential study shall be performed after short circuit and protective device coordination studies have been completed.

B. Three phase arcing currents for each piece of electrical equipment shall be indicated on a one line diagram of the entire electrical system including 208Y/120V panelboards and all upstream equipment.

C. Calculations shall be performed using an iterative process:
   1. Study shall include calculations for minimum flash protection boundary (measured in meters and feet), incident energy at working distance of 18" (measured in cal/cm^2), required PPE level, limited approach, restricted approach and prohibited approach boundaries (measured in meters and feet).
   2. Calculations shall be performed using both NFPA 70E and IEEE 1584 methods for each piece of equipment. Worst case calculation for each piece of equipment shall be used for report:
      a. Minimum Flash Protection Boundary shall be 4'-0" even if calculated to be less.
      b. Assume maximum arc duration to be 2 seconds.
      c. Do not exclude equipment below 240V fed from transformers rated 125kVA or below. Owner requirements exceed those outlined in NFPA 70E and IEEE 1584.
   3. Pieces of equipment that will require PPE greater than level 1 shall be investigated:
      a. Investigation shall include adjustment of upstream breaker settings to determine if required PPE level can be reduced with minimal compromise to breaker coordination with other upstream breakers.
      b. Investigation shall continue until lowest PPE level for each piece of electrical equipment can be reached with minimal impact to breaker coordination.
      c. Compromises to breaker coordination as a result of lowering the required PPE level shall be listed and documented for review by Architect/Engineer.

3.4 FINAL REPORTS

A. One Line Diagram

B. Input Data:
   1. Cable and conduit materials.
   2. Transformers.
   3. Circuit resistance and reactive values.

C. Short Circuit Data:
   1. Source fault impedance.
   2. Generator contributions.
   3. X to R ratios.
   4. Asymmetry factors.
   5. Motor contributions.
   6. Short circuit kVA.
   7. Symmetrical and asymmetrical fault currents.

D. Recommended Protective Device Settings:
   1. Circuit Breakers:
      a. Adjustable pickups and time delays (long time, short time, ground).
      b. Adjustable time-current characteristic.
      c. Adjustable instantaneous pickup.
   2. Phase and Ground Relays:
      a. Current setting.
      b. Time setting.
      c. Instantaneous setting.
      d. Specialty non-overcurrent device settings (ex. Relay 27/47, 81 O/U, 25, etc.).

3. Fuses:
   a. Types.
   b. Rating.

E. Arc Flash Potential Study Data:
   1. Calculated three phase arcing currents for all electrical equipment.
   2. PPE rating for all electrical equipment.
   3. Owner standard PPE labels will be provided by Owner and installed by Contractor.
   4. Compromises to breaker coordination resulting from lowering of PPE value at a particular piece of electrical equipment.

3.5 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

3.6 INSTALLATION

A. Install Owner standard PPE labels on each piece of equipment prior to energizing equipment.

B. PPE label shall be clearly visible upon approach to equipment.

C. For large pieces of equipment, label shall be placed near main overcurrent device or incoming feeder to equipment.

D. Label shall be mounted at a minimum of 42” to bottom and maximum of 66” to top above finished floor.

E. Laminate final one line diagram and mount within the facility where directed by Owner.

END OF SECTION

SECTION 26 09 13
POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 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. Operating and maintenance data.
   2. Owner instruction reports.

1.2 SYSTEM DESCRIPTION

A. The 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. The power monitoring system shall utilize local system display units to display circuit monitor data.

1.3 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 POWER MONITORING SYSTEM

A. Acceptable manufacturers:
   1. Power monitoring system:
      a. Base:
         1) Schneider Electric/Square D. (Powerlogic PM800 series)
      b. Optional:
         1) Eaton Electrical. (Eaton Power Expert 2000 series)
         2) Siemens Energy & Automation.
   2. Manufacturer must have local service organization.

B. All equipment: UL listed.

2.2 POWER MONITORING SYSTEM OPERATION

A. The power monitoring system shall monitor points in power distribution system and provide local and remote readings as indicated.

B. The power monitoring system shall, through software / web-interface on a personal computer workstation, provide for:

1. Monitoring multiple devices at one time.

2.3 CIRCUIT MONITORS

A. Description:
   1. Design shall be based on Square D Powerlogic PM800 series.
   2. The electronic circuit monitors shall provide metering values such as frequency, current, voltage, power factor, power, demand current and real power, and accumulated real and reactive energy.
   3. 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.

B. Installation:
   1. Electronic circuit monitors shall be installed by the switchgear manufacturer for all circuits as indicated by the project drawings.
   2. All control power, CT, PT, and communications wiring shall be factory installed and harnessed.
   3. 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.

C. Circuit monitor characteristics:
   1. The electronic circuit monitors shall accept inputs from industry standard instrument transformers (120VAC secondary PTs and 5A secondary CTs).
   2. Current and voltage signals shall be digitally sampled at a rate high enough to provide accurate RMS sensing.
   3. 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.
   4. 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.
   5. The following minimum instantaneous readings shall be reported by the circuit monitor:
      a. Frequency.
      b. Temperature.
      c. Current, per phase rms.
      d. Neutral current, rms.
      e. Current, 3-phase average rms.
      f. Current, apparent rms.
      g. Voltage, phase-to-phase & phase-to-neutral.
      h. Power factor, per phase.
      i. Power factor, 3-phase total.
      j. Real power, 3-phase total.
      k. Reactive power, 3-phase total.
      l. Apparent power, 3-phase total.
   6. The following minimum demand readings shall be reported by the circuit monitor:
      a. Average demand, real power.
      b. Peak demand, real power.
   7. The following energy readings shall be reported by the circuit monitor:
      a. Accumulated energy.
      b. Accumulated reactive energy.

D. The circuit monitor shall have the ability to monitor separate inputs from various devices and report the status of each input to a system display unit or personal computer workstation.

E. Outputs shall be password-protected to prevent unauthorized reconfiguration of the system and may be disabled by a keyswitch located in front of the monitor.

F. Each circuit monitor shall display, on an integral display, the following electrical parameters (as a minimum):
   1. Current, per phase RMS.
   2. Voltage, phase-to-phase RMS.
   3. Voltage, phase-to-neutral RMS (per phase).
   4. Real power, 3-phase total.
   5. Reactive power, 3-phase total.
   6. Apparent power, 3-phase total.
   7. Power factor.
   8. Frequency.
   9. Peak demand, real power.
   10. Accumulated energy (MWH and MVARH).

G. Reset of the following parameters shall be allowed from the circuit monitor:
   1. Peak demand power.
   2. Energy (MWH).
   3. Reactive energy (MVARH).

H. Circuit monitor setup shall be allowed from the circuit monitor display. Setup parameters shall include:
   1. CT rating (XXXX:5).
   2. PT rating (XXXXX:120).
   3. System type (3-wire or 4-wire).
   4. Demand interval (5 to 60 minutes).

I. All reset and setup functions shall be keyswitch-protected to prevent unauthorized/accidental changes.

J. Provide CT's and PT's where not provided under other sections.

2.4 SYSTEM DISPLAY UNITS (SDU)

A. Description:
   1. Each SDU shall provide real-time access to all metering and device data available for each monitored device.

B. Installation:
   1. Each SDU shall be installed by the manufacturer as indicated in the project drawings.
   2. Each SDU shall be flush mounted in switchgear or large power panelboard door panels as indicated.

C. Characteristics:
   1. 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.
   2. Each SDU shall utilize a high contrast, backlit liquid crystal display (LCD) to provide high reliability and readability in all lighting conditions.
   3. Backlighting and contrast levels shall be adjustable.

D. Keypad:
   1. Each SDU shall allow for easy operation by providing a keypad with large keys for operator selections.
   2. Each key shall have a raised perimeter and tactile feedback to ensure a positive response even with gloved hand operation.
   3. The keys shall be clearly marked to indicate function and shall be separated into meaningful groups with display prompts to aid operator selections.

E. Configuration:
   1. 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.

2. It shall be possible to modify the SDU configuration using the integral keypad. This capability shall be password-protected to prevent unauthorized modifications.

F. Data Viewing:
1. All data shall be accessible from the SDU.
2. Data shall be displayed in a logically organized form, complete with proper scalings and units.
3. 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.
4. 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.

G. Display Reset:
1. 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all 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 all wiring required to externally connect equipment lineups.

D. Interconnection wiring requirements shall be clearly identified on the power monitoring system drawings.

E. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

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 hours 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.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 09 43

SWITCHING AND DIMMING SYSTEM (Reissued AD-4)

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Provide an intelligent switching system capable of time based, manual based, vacancy based, and daylight based control. System shall consist of parts and pieces not limited to intelligent devices, relay panels, sensing devices, and touchscreens connected together by a dataline, as well as associated wiring.
   1. Extent of lighting control system work is indicated by drawings and by the requirements of this section. It is the intent of this section to provide an integrated, energy saving lighting control system including, but not limited to, Lighting Control Panels, Vacancy Sensors, and Daylighting Controls from a single supplier.
   2. Contractor shall be responsible for confirming that the panels and sensors interoperate as a single system.

B. Requirements are indicated elsewhere in the specifications for work including, but not limited to, raceways and electrical boxes and fitting required for installation of control equipment and wiring.

1.2 QUALITY ASSURANCE

A. Manufacturers:
   1. Firms regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years. Manufacturer shall be ISO 9001 certified.

B. Component Pre-testing:
   1. Components and assemblies shall be factory pre-tested prior to installation.

C. System Support:
   1. Factory applications engineers shall be available for telephone support.

D. NEC Compliance:
   1. Comply with NEC as applicable to electrical wiring work.

E. NEMA Compliance:
   1. Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

F. UL Approvals:
   1. Relay panels and accessory devices shall be UL listed under UL 916 Energy Management Equipment. Configured to order or custom relay panels shall be UL Listed under UL 508, Industrial Control Panels.

G. FCC Emissions:
   1. Assemblies shall be in compliance with FCC emissions Standards specified in Part 15 Subpart J for Class A application.

1.3 SUBMITTALS

A. Shop Drawings:
   1. Submit dimensional drawings of lighting control system components and accessories.
   2. Submit detailed point to point wiring diagrams and floor plans showing vacancy and daylighting sensor locations.
   3. Submit typical mounting details for vacancy and daylighting sensors for this application.

4. Submit a list of labels for each digital dataline switch.

B. Product Data:
   1. Submit typical wiring diagrams for components including, but not limited to, relay panels, relays, switches, vacancy sensors and daylighting controls.
   2. Specification comparison.

C. Contract Closeout Information:
   1. Operating and maintenance data.

D. For each type of product or material specified in this section, supplied for the Project, submit written certification, on company stationary, executed by an authorized agent of the particular product or material company, certifying that the particular product or material provided for the project qualifies as a domestic material or product under FAR 52.225-23.

PART 2 - MATERIALS AND COMPONENTS

2.1 SWITCHING AND DIMMING SYSTEM - GENERAL

A. Acceptable manufacturers:
   1. Switching and Dimming System:
      a. Base:
         1) Acuity Brand Controls.
      b. Optional:
         1) Crestron.
         2) Lutron.
         3) Leviton.
         4) Wattstopper.
   2. Other manufacturers desiring approval comply with Section 00 26 00.

2.2 SYSTEM REQUIREMENTS

A. The system shall be a networked system that communicates via RS485 and shall be capable of issuing time based, vacancy based, daylight based, and manual based commands to devices connected to control backbone. System shall be fully integratable and shall be capable of interfacing with switches, vacancy sensors, photocells, relay panels, dimming outputs, touch screens, BMS systems, and contact closures.

B. Lighting control system shall have the capability to be remotely controlled via the internet and by a building wide Ethernet LAN.

C. Each device shall have (2) RJ-45 connectors or (2) low voltage connectors, shall be capable of having a digital address assigned to it, and shall be able to communicate with one another.

D. Devices shall be connected with low voltage cabling, in a daisy-chain fashion, and in any order.

E. System shall be capable of maintaining intelligence and shall be capable of providing default level of control in the event of a system communication failure with the main control processor.

F. Devices shall fail to on.

G. System shall be capable of accessing and controlling other system devices from a centralized point and shall be capable of linking into an Ethernet Local Area Network (LAN).

H. System shall have a web-based software management program that shall enable remote system control, status monitoring, and creation of lighting control profiles.

I. Programs, schedules, and profiles shall be held in non-volatile memory for an indefinite time exceeding 10 years in the event of power failure. At restoration of power, lighting control system shall implement programs required by current time and date. Time of date shall be battery backed for at least 10 years.

J. The system shall be capable of implementing On commands, Off commands, Raise commands, and Lower commands for any relay, group or zone by means of wall switches, contact closures, time clocks, and sensors.

K. Control system shall enable a basic level of integration with a Building Automation System (BAS).

2.3 SYSTEM PROCESSOR

A. Module shall be capable of communicating and controlling downstream system control devices and linking into an Ethernet LAN.

B. The controller shall accept local control using built in button prompts. Controller shall run from non-volatile memory so that system programming is retained indefinitely and time of day is battery backed up for 10 years.

C. Device shall have a standard and astronomical time clock.

D. Device shall automatically detect devices on control network.

E. Control shall be capable of controlling a minimum of 127 addresses on a single bus, and shall be capable of networking with multiple controllers to expand the system.

F. System Processor Manufacturer: Acuity Brand Controls
   1. Lighting Control and Design Cat. No. GR2400 DTCMOD DV.
   2. Sensor Switch NLight Cat. No. nGWY KIT.

2.4 LIGHTING CONTROL PANELS

A. Provide lighting control panels in the locations and capacities as indicated on the drawings and schedules. Each panel shall be of modular construction and shall consist of the following components:
   1. Enclosure/Tub shall be NEMA 1, NEMA 3R, or NEMA 4 as indicated on the drawings, sized to accept an interior with 4 relays and be expandable to 8 relays. Standard relay system shall be sized to accept an interior of up to 8 relays, 16 relays, 32 relays or 48 relays.
   2. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the drawings. The panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.
   3. 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, but shall not be limited to, intelligence boards, power supply, and individually replaceable latching type relays. The panel interiors shall include, but shall not be limited to, the following features:
      a. Single pole mechanically latching relays with modular 5-pin plug-in connector design. Relays shall provide the following ratings and features:
         1) Electrical:
            a) 30 A at 277V Ballast and HID.
            b) 20 A tungsten at 120V.
            c) 20 A Latching Relay with 18,000A SCCR at 277V.
            d) Relays shall be individually replaceable. Relay terminal blocks shall be capable of accepting (2) #8 AWG wires on both the line and the load side. Systems that do not allow for individual relay replacement or additions are not acceptable.
            e) Relays to be rated for 250,000 operations minimum at a full 30A lighting load.
            f) Relay shall be closed at normal power loss, Normally Closed Latching.
            g) Optional Relay Types:
               (1) Normally Open Latching.
               (2) 600V 2-pole.
               (3) Single Pole, Double Throw relay.

b. Power supply shall be a multi-voltage transformer assembly with rated power to supply electronics, vacancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply shall have internal over-current protection with automatic reset and metal oxide varistor protection.

4. The Dataline wire shall be supplied by the equipment manufacturer and shall include, but shall not be limited to, the manufacturers name printed on the wire jacket. The Contractor, at his or her own expense, shall replace an improper dataline wire.
5. Panels shall be digitally addressed and support bi-directional communication between each other and other intelligent field devices specified elsewhere.
6. A barrier shall separate the high voltage and low voltage compartments of the panel and separate 120V and 277 V.
7. Panel shall connect to vacancy sensors and photocells on low voltage network. Devices shall take commands and control digital relays through network commands.
8. Lighting Control Panel Manufacturer: Acuity Brand Controls
   a. Lighting Control and Design Cat. No. GR2448 INT XNCL DV.

B. Provide plenum rated distributed relay panel enclosure in the locations and capacities as indicated on the drawings and schedules. Each panel shall be of modular construction. Panels shall have the same properties as the lighting control panels unless listed below.
1. Panels shall have 4 relays and be capable of expanding to or networked together to make 8 relays.
2. Panel shall connect to vacancy sensors and photocells on low voltage network. Devices shall take commands and control digital relays through network commands.
3. Panel shall be capable of controlling receptacles.
4. Panel shall be capable of dimming (4) separate sources of Fluorescent and LED lights through four separate 0-10V dimming signals, one independent dimming signal for each relay. Panel shall be expandable to 8 relays and 8 dimming inputs. Panel shall provide a minimum of 1 programmable photocell per relay. In order to maximize daylight harvesting and minimize disruption to occupants, each dimming output shall provide adjustment for:
   a. Baseline.
   b. Start point.
   c. Mid point.
   d. End point.
   e. Trim.
   f. Fade up rate.
   g. Fade down rate.
   h. Time delay.
   i. Enable/disable masking.
5. Panel shall be capable of integrating with line voltage dimming module to dim line voltage incandescent and line voltage LED sources. Relay panel shall connect to module through low voltage Cat5 network.
6. Plenum Rated Distribution Panel Manufacturer: Acuity Brand Controls
   a. Lighting Control and Design (Switch) Cat. No. GR1408 LT INT 4/8NCL DV.
   b. Lighting Control and Design (Dim) Cat. No. GR2408 LT INT 4/8NCL IDIM4/8 DV.
   c. Sensor Switch NLight Cat. No. nPANEL 4 120/277 4.
   d. Sensor Switch NLight (Line Voltage Integration) Cat. No. nSP5 PCD 2W.

2.5 NETWORK SYSTEM VACANCY SENSORS

A. Vacancy sensors system shall sense the presence of human activity within the desired space and fully control the OFF function of the lights when the desired space is not occupied. Space Occupant shall provide Manual ON of lights providing the following control sequence:
1. Occupant Manual ON.
2. Vacancy Sensor OFF.

B. The following sensing technologies shall be acceptable:
1. Passive Infrared (PIR).
2. Dual Technology:

a. Either PIR/Ultrasonic or PIR/Microphonic.

C. Sensors shall utilize passive infrared technology, which shall detect occupant motion, to maintain lights on from Occupant Manual ON state. Ultrasonic or Microphonic based sensing technologies shall be accepted in conditions where passive infrared sensors will not adequately detect motion.

D. Dual technology sensors shall have two technologies for motion detection. Acceptable dual technology combinations include PIR/Microphonic and PIR/Ultrasonic.

E. Sensing technologies shall not transmit waves that interfere with electronic devices within the space. Devices shall be tested prior to installation to ensure compatibility.

F. Sensing technology or communication shall not interfere with laboratory research spaces, such as vivariums with living animals.

G. Sensors shall be available as line voltage devices and low voltage devices.
   1. Sensors shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output.
   2. Line voltage devices shall switch lighting zones on and off through integral relay.
      a. Shall be capable of switching 120/277 V. Load ratings shall be a minimum of:
         1) 800W at 120 V.
         2) 1200 W at 277 V.
         3) 1/4 HP motors.
   3. Low voltage sensors shall switch zones on and off through a line voltage power pack.
      a. Shall control lighting zones through connection to 120 V / 277 V power pack capable of switching up to 20A.

H. Single Sensor shall be capable of controlling multiple zones, including receptacle zones.

I. Sensors shall be capable of providing 0-10VDC dimming single to associated dimming ballasts.

J. Sensors shall be available with one or two Vacancy “poles”, each of which shall provide a programmable time delay.

K. Sensor shall be connected to control system via low voltage cabling.

L. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature shall be available at any time for lamp replacements.

M. Sensors shall be available for the following mounting:
   1. Ceiling.
   2. Fixture.
   3. Recessed.
   4. Corner.
   5. Wall switch.

N. Sensors shall have option for photocell/daylight override, dimming control, and low temperature/high humidity operation.

O. Network System Vacancy Sensor Manufacturer Devices:
   1. Provide the following devices as indicated on drawings.
      a. Line Voltage Devices.
         1) Ceiling Mounted.
            a) Standard range 12 foot radius.
               (1) Passive Infrared.
                  (a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CMR 9.
               (2) Dual Technology.
                  (a) Manuf. Acuity Brands Controls Sensor Switch Cat. No.CMR 9 PDT.
            b) Extended range 28 foot radius.
               (1) Passive Infrared.
                  (a) Manuf. Acuity Brands Controls Sensor Switch Cat. No.CMR 10.

(2) Dual Technology.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No.CMR 10 PDT.

2) Wall mounted vacancy sensor and on/off switch combination.
a) Standard range 20 foot radius.
(1) Passive Infrared.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No.WSDR.
(2) Dual Technology.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No.WSDR PDT.

3) Lighting Fixture Integral Vacancy Sensor.
a) As indicated on Fixture Schedule.

b. Low Voltage Devices.
1) Ceiling Mounted.
a) Standard Range 12 foot radius.
(1) Passive Infrared.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CM 9.
(2) Dual Technology.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CM 9 PDT.
b) Extended range 28 foot radius.
(1) Passive Infrared.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CM 10.
(2) Dual Technology.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CM 10 PDT.

2) Wall mounted vacancy sensor and on/off switch combination.
a) Standard range 20 foot radius.
(1) Passive Infrared.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. WSD.
(2) Dual Technology.
(a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. WSD PDT.

2.6 NETWORK SYSTEM DAYLIGHT SENSOR

A. Photocell shall provide for an on/off set-point and a deadband to prevent the artificial light form cycling. Delay shall be incorporated into the photocell to prevent rapid response from passing clouds.

B. Photocell and dimming sensor's set-point and deadband shall be automatically calibrated through the sensor's microprocessor by initiating an "automatic set-point programming" procedure. Min and max dim settings as well as set-point shall also be manually entered.

C. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space.

D. Sensors shall be available as line voltage devices and low voltage devices.
1. Line voltage devices shall switch lighting zones on and off through integral relay.
a. Shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output.
b. Shall be capable of switching 120/277 V. Load ratings shall be a minimum of:
1) 800W at 120 V.
2) 1200 W at 277 V.
3) 1/4 HP motors.
2. Low voltage sensors shall switch zones on and off through a line voltage power pack.
a. Shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output.
b. Shall control lighting zones through connection to 120 V / 277 V power pack capable of switching up to 20A.

E. Dimming sensors shall control 0-10 VDC dimmable ballasts by sinking up to 20 mA of class 2 current.

F. Photocell and dimming sensors shall be equipped with an automatic override for 100 hour burn-in lamps. This feature shall be available at any time for lamp replacements.

G. A dual zone option shall be available for on/off photocell, automatic dimming control photocell, or combination units. The second zone shall be capable of being controlled as an "offset" from the primary zone.

H. Network System Daylight Sensor Devices:
   1. Provide the following devices as indicated on drawings.
      a. Line Voltage Devices:
         1) Line Voltage dimming/on/off ceiling mounted photocell for 0% to 100% output.
            a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CMR PC ADC.
         2) Line voltage on/off ceiling mounted photocell for on/off output.
            a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CMR PC.
         3) Lighting Fixture Integral Photocell:
            a) Refer to Lighting Fixture Schedule on drawings.
      b. Low Voltage:
         1) Dimming/on/off ceiling mounted photocell for 0% to 100% output.
            a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CMR PC ADC.
         2) Dimming on/off ceiling mounted photocell for on/off output.
            a) Manuf. Acuity Brands Controls Sensor Switch Cat. No. CMR PC.

2.7 WALL SWITCHES AND DIMMERS

A. Intelligent digital switching shall be provided operating on the dual twisted pair communication wire. Switches shall be available in up to 4 zone combinations.
   1. Each button shall be individually programmable.
   2. Programming of buttons shall not require the use of a computer or other programming device.
   3. It shall be possible to assign relays or channels to buttons using a simple button press interface. Each button can control any one of the following options:
      a. Any individual lighting zone.
      b. Any group of lighting zones.
      c. Any group of zones in the system via network clock, Automation Appliance, or Software package.
   4. Scene control switches shall be available for applications that require preset scenes. Scene selector switches shall be available for up to 4-zone selection.
   5. Switches shall be capable of having custom engraving for button/scene labeling.
   6. Multiple dataline switches programmed to control the same relay or relay group shall indicate the same status automatically.
   7. Switches shall have two RJ-45 ports.

B. On/Off and Dimming Switches:
   1. Switch shall utilize traditional tactile button and LED user feedback.
   2. On/Off Switch shall be configurable in one to six zone keypads capable of controlling the same number of zones on/off in single gang box.
   3. On/Off dimming switch shall be configurable in one to two zone keypads capable of turning the same number of zones on/off and dim up/down in single gang box.
   4. Wall Switches and Dimmer Devices.
      a. Switching for On/Off Control.
         1) 1 Button Switch, 1 Zone On/Off Control.
            a) Manuf. Acuity Brands Controls Lighting Control and Design Cat. No. CH1 1B.
         2) 2 Button Switch, 2 Zone On/Off Control.

a) Manuf. Acuity Brands Controls Lighting Control and Design Cat. No. CH2 2B.

3) 3 Button Switch, 3 Zone On/Off Control.
   a) Manuf. Acuity Brands Controls Lighting Control and Design Cat. No. CH3 3B.

4) 4 Button Switch, 4 Zone On/Off Control.
   a) Manuf. Acuity Brands Controls Lighting Control and Design Cat. No. CH4 4B.

5) 5 Button Switch, 5 Zone On/Off Control.
   a) Manuf. Acuity Brands Controls Lighting Control and Design Cat. No. CH5 5B.

6) 6 Button Switch, 6 Zone On/Off Control.
   a) Manuf. Acuity Brands Controls Lighting Control and Design Cat. No. CH6 6B.

b. Dimming Control.

1) 3 Button Switch.
   a) Top Button shall be engraved with “On/Off”, Middle button shall be engraved with arrow point up, and Bottom button shall be engraved with arrow Pointing Down.
   b) Manuf. Acuity Brands Controls Lighting Control and Design Cat. No. CH3 3B.

2) 6 Button Switch.
   a) Top Buttons shall be engraved with “On/Off”, Middle button shall be engraved with arrows point up, and Bottom button shall be engraved with arrows Pointing Down.
   b) Manuf. Acuity Brands Controls Lighting Control and Design Cat. No. CH6 6B.

2.8 LIGHTING CONTROL PROFILES

A. Provide an advanced communications network that supports optional features like PC connectivity, TCP/IP connections, advanced programming system documentation, enhanced diagnostics, historical and runtime accumulation, and graphic programming and control.

1. The system shall at a minimum support the following operating scenarios:
   a. Lighting control profiles shall be capable of being scheduled to track or ignore information regarding vacancy, daylight, and local user switches via lighting control profiles.
   b. Lighting control profiles shall be stored on the network control processor and on the software’s host server.
   c. Shall be capable of schedules to run according to the following calendar options:
      1) Start date/hour/minute.
      2) End date/hour/minute.
      3) Sunrise/sunset +/- timed offsets.
   d. Adjustable override periods shall be capable of daily, weekend, weekday, monthly, and yearly commands.
   e. Allow common areas to remain ON when specific zones are ON. Egress timer may start a countdown when the last watched relay turns OFF.
   f. Interior daylighting control to turn OFF lights when available daylight sufficiently meets occupants’ lighting needs. Lights shall only come on during occupied periods when sufficient daylight is not available.
   g. Vacancy Sensor Integration: Allows zones to automatically follow vacancy sensor status, or interlock the sensors with daily schedules.
2. Communications:
   a. Each panel shall support RS232 twisted pair and optional RS-485 connections. Either protocol may be used for programming, monitoring, and control.

b. The dataline shall allow simultaneous operation of multiple communications access points to support multiple operator terminals and communications with other building automation systems.
c. Each device shall be capable of stand-alone automatic operation and the network shall achieve full distributed processing.
d. Programming shall be accomplished with a Windows based PC running compatible software package.
e. Time Delay / Blink Warning:
    1) Used during unoccupied periods, assignable for each relay.
        a) Time delays from 2 to 1,440 minutes.
        b) Blink Warning: 1-second OFF blink followed by a 5 minute grace period before OFF.
        c) An optional second blink warning one minute before OFF.
    2) Operates automatically for scheduled OFF periods and time delay overrides.
    3) Occupant overrides may be entered before the blink warning to prevent a scheduled blink and shutdown.
f. Analog Photocell Configuration:
    1) Enable any group switch card input, eight per group card, to act as an analog input into the panel for use with photocells or other analog devices
    2) Photocells shall include, but shall not be limited to, the following types:
        a) Skylight, 0 - 6000 foot candles:
            (1) UV stabilized plastic with dome lens.
            (2) 12V input voltage, 0.0 – 4.4V sensor output voltage, direct current.
        b) Outdoor, 0 - 200 foot candles:
            (1) Water tight, UV stabilized plastic with integral hood.
            (2) 12V input voltage, 0.0 – 4.4V sensor output voltage, direct current.

2.9 OPERATOR'S SOFTWARE

A. Every device parameter shall be available and configurable remotely from the software.

B. User programming and editing may conducted both online or offline in a Windows based software application.

C. Data shall be entered through a simple menu-driven user interface.

D. The software shall simplify integration with other software products by allowing the lighting control manufacturer's components to be embedded into other Windows applications.

E. Basic operating software shall provide the following:
    1. Site wiring documentation for connected relay panels and system components.
    2. English descriptions of each relay's circuit designation, circuit description, switch and calculated load.
    3. RS232 and TCP/IP Connection to Lighting Control Panel
    4. Monitor/Control relays. Software shall show actual relay states, with an optional menu showing how and when the relay state occurred, and when next scheduled to change.
    5. Simulate functions.

F. System Parameters:
    1. Passwords Matrix Features allowed per site.
    2. User defines functions accessible for each password:
        a. Document.
        b. Program.
        c. Initialize.
        d. Transfer from PC.
        e. Transfer to PC.
        f. Control.
        g. Simulate/Test.
    3. Configure software to automatically contact remote sites using a modem or I/P address.

2.10 CENTRAL PROGRAMMING, MONITORING, AND CONTROL WORK STATION

A. Desktop Computer workstation shall provide monitoring, programming and control of the system.

B. The computer shall be a personal computer with monitor for enhanced color graphics display. The system shall be shipped complete with memory, cables, and peripheral devices. The complete system shall be factory tested prior to shipment. The system shall include, but shall not be limited to, at a minimum the following:
   1. 3 GHz, Intel Pentium 4 based personal computer.
   2. 17” SVGA flat panel color monitor.
   3. 60 GB hard disk.
   4. 256 MB RAM.
   5. CD +R/+W drive.
   6. Lighting control software compatible operating system.

2.11 REALTIME COLOR GRAPHICS SOFTWARE

A. System Description:
   1. Color graphics software, shall allow a user to monitor and control the relays through a graphical color interface. The system shall allow the user to create drawings through a graphics generator provided with the system. The system shall control the relays in a real-time environment; i.e. system changes be communicated immediately through the color graphic screens.
   2. The application shall provide a visual representation of the floor plan, drawn to scale, with each fixture displayed on screen. Fixtures shall automatically indicate the relay controlling them on screen. The software shall include “fly overs” which shall display fixture information when the mouse pointer is over a defined object on the screen.
   3. The software shall fully integrate with the base software; system databases including, but not limited to, wiring documentation and system runtime information shall be available to the graphic software.
   4. The software shall be based upon Microsoft’s Component Object Model (COM) and shall support Active-X technology for integration.
   5. The software shall include, but shall not be limited to, 3 color graphic screens created by a factory authorized representative.

B. Graphic Screen Features:
   1. The graphic software shall allow full programming of the system from the animated graphic floor plans.
   2. The operator shall be able to zoom in and pan the floor plan for more detail.
   3. The system shall be provided with a matrix password table to allow any user access to individual, selectable features.
   4. Manual control of the relays, or simulation of system wide functions, shall be possible by a single click of the mouse.
   5. Programmable "action spots" shall allow an operator to pre-define commonly used manual control functions, or allow the operator to jump to other color graphic screens.
   6. System animation shall support multi-ballast control of a fixture representing multi-level lighting, as well as animation for monitoring of fans or other "animated devices."
      a. Animation shall also include a "Failure" definition to occur in event of relay failure.
   7. Relay definitions and circuit numbers from the base software shall be displayed on screen when requested by the user.
      a. Relay circuit numbers shall be automatically displayed inside the fixture to provide useful information to the operator.

C. Graphic Screen Generation:
   1. Contractor shall provide CAD floor plans to the manufacturer for generation of graphic screens.

2. As-Built relay panel and reflected ceiling documentation shall be provided to the manufacturer before graphic screen development can begin.

PART 3 - EXECUTION AND SUPPORT SERVICES

3.1 INSTALLATION

A. Dataline switches and photocells shall be installed and mounted in the spaces as indicated on the drawings. Each low voltage wire shall be labeled clearly indicating which relay panel it connects to. Use only properly color-coded, stranded #18 AWG (or larger) wire as indicated on the drawings. Relays and switches shall be tested after installation to confirm proper operation, and connected loads shall be recorded on the relay schedule for each panel.

B. The relay panels shall be mounted in electrical closets or in the plenum as indicated on the drawings. The numbered relays in the panel shall be wired to control the power to each load as indicated on the Panel Wiring Schedules included in the drawings. Power wiring shall be identified with the circuit breaker number controlling the load. If multiple circuit breaker panels are feeding into a relay panel, wires shall clearly indicate the originating panel's designation.

3.2 SYSTEM STARTUP

A. Manufacturer shall provide a factory authorized technician to confirm proper installation and operation of system components. The startup requirement is intended to verify:
   1. That vacancy sensors, daylighting sensors, switches and dimmers are located, installed,
   2. and adjusted as intended by the factory and the contract documents.
   3. That vacancy sensors, daylighting sensors, switches and dimmers are operating within the manufacturers specifications.
   4. That vacancy sensors, daylighting sensors, switches, dimmers and relay panels interact as a complete and operational system to meet the design intent.

B. Manufacturer to provide a written statement verifying that the system meets the above requirements.

3.3 TRAINING

A. Manufacturer shall provide factory authorized application engineer to train building occupant personnel in the operation and programming of the lighting control system.
   1. The training shall be coordinated with the building occupant facilities personnel and shall consist of no less than two (2) four hour sessions.

3.4 SYSTEM PROGRAMMING

A. Manufacturer shall provide system programming including but not limited to:
   1. Wiring documentation.
   2. Switching and Dimming operation.
   3. Telephone overrides.
   4. Operating schedules.

END OF SECTION

SECTION 26 11 16
SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Unit substation design, testing and assembly: Conform to ANSI, IEEE and NEMA standards.

B. Each unit substation shall consist of a single High Voltage (HV) incoming line section close coupled to a cast coil dry type transformer close coupled to with a Low Voltage (LV) outgoing line section.

C. Factory inspection and witness testing: The Owner reserves the right for factory inspection and witness testing of high voltage switches and/or transformers:
   1. Notify Owner three (3) weeks in advance of factory testing.

1.2 SUBMITTALS

A. Shop drawings:
   1. Include all dimensions, ratings, high and low voltage terminal connections, arrestors, switches, etc., for the complete substation assembly.

B. Product data:
   1. Technical data on each component.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Test reports.
   3. Spare fuses.

1.3 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 UNIT SUBSTATION

A. Acceptable manufacturers:
   1. Unit substation:
      a. Base:
         1) ABB.
      b. Optional:
         1) Square D.
         2) Siemens.
         3) Eaton Cutler-Hammer.

B. Unit substations: Consisting of high voltage (HV) incoming line section, transformer section and (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. Suitable for outdoor installation.
   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 500 MVA available on the incoming side of the unit substation.
5. Connect sections by bolted flanges.

2.2 HV INCOMING LINE SECTION

A. HV incoming line section: 15kV metal-clad switchgear, outdoor non-walk-in type:
   1. Cable entry: From bottom.
   2. Construct for entrance and termination of three (3) single conductor, 15 KV cables.
   3. Provide ground bus in HV terminal compartment to connect to area ground.
   4. Provide three 12 KV, intermediate class, metal oxide gapless type lightning arrestors for grounded system. Select arrestors to limit sparkover voltage to less than 80 percent of transformer BIL HV rating. Connect arrestors to line side of breaker.
   5. Insulation barriers shall be provided between live parts and between live parts and grounded parts.
   6. The switchgear assembly shall consist of individual vertical sections housing various combinations of circuit breakers and auxiliaries, bolted together to form a rigid metal-clad switchgear assembly:
      a. BIL rating (of enclosure and circuit breaker, either individually or as a unit): 95 kV
      b. Provide access doors with provision for padlocking.
      c. Provide protected ventilation openings, as required.
      d. Provide thermostatically controlled 250 watt, 120 volt rated space heater in each bay. Heater shall be factory wired and fused protected. On-Off control shall be accessible without opening high voltage compartment.
      e. Completely enclose all major parts of primary circuit (such as circuit breaker, buses and potential transformers) with grounded metal barriers.
      f. Finish: Chemically cleaned and treated for good bond; primed; finish painted with acrylic lacquer, light gray (ANSI Color 61) or medium light gray (ANSI Color 49).
   7. Buses and Connections:
      a. Buses shall be silver-plated copper and shall be fully insulated along their entire length.
      b. Main bus shall be rated at 1200 amperes.
      c. All bus joints and connections shall be plated, bolted and insulated with easily installed boots.
      d. Brace buses to withstand fault currents equal to the close-and-latch rating of installed breakers.
      e. Temperature rise of all buses and connections shall be in accordance with ANSI standards and shall be documented by design tests.
      f. Provide a non-insulated copper ground bus extending the entire length of the switchgear.

2.3 TRANSFORMER SECTION

A. Transformer: Cast coil dry type outdoor substation type, self cooled with option for forced air cooling (FA):
   1. Capacity rating: KVA as indicated on drawings, 3 phase, 60 Hz.
   2. HV voltage rating: 13.8 KV, connected delta:
      a. Provide two 2-1/2 percent FCAN taps and two 2-1/2 percent FCBN taps.
      b. Provide tap changing mechanism, externally operable in de-energized condition only. Mechanism shall be padlockable.
   3. Basic impulse level: 95 KV BIL, HV rating and 30 KV BIL, LV rating.
   4. LV rating: 480/277 V, connected wye.
   5. 55 degC rise above a 40 degC ambient. Transformer shall be capable of carrying a 12 percent continuous overload without exceeding 65 degC rise above a 40 degC ambient.
   6. Impedance: 5.75 percent on its base KVA rating plus or minus 7.5 percent.

7. Rated sound level: Not greater than ANSI/NEMA standards.
8. Core and coil assembly: Wound core (five-legged) type with copper windings.
9. No fastening devices externally removable.

B. RC snubber: Series connected resistor and capacitor shall be connected between the transformer primary terminal and ground:
   1. RC snubber shall absorb and dampen high frequency transients.
   2. Size resistor and capacitor to match system surge impedance.

2.4 LOW VOLTAGE OUTGOING SECTION

A. General:
   1. Low voltage outgoing section: Air terminal cabinet arranged for bottom entry cables.
   2. NEMA two hole copper spade terminals.
   3. Terminals shall be arranged and braced to support the number of conductors indicated on drawings.

B. High Resistance Grounding System:
   1. General:
      a. High resistance grounding system shall be pulsing type with fault detection via current relay suitable for use on a 480Y volt, 3 phase, 3 wire, 60 hertz distribution system.
      b. The resistors and instruments shall be mounted within the low voltage outgoing section. The metering and controls shall be mounted within the indoor switchgear.
      c. The resistor assembly shall be a self-contained housing having an instrument compartment and a resistor compartment. The instrument compartment shall be segregated from the resistor compartment by means of steel barriers.
      d. Tapped resistors with taps wired out to a convenient front accessible terminal block. Taps shall provide 1 to 5 amperes of ground current in 1 amp increments. Resistors shall be heavy-duty industrial type, edgewound or wirewound design. Each resistor tube shall have a stamped steel rating nameplate. The resistor assembly shall be interconnected with 200 degree C rated #8 AWG wire. All connections to the resistor assembly shall be #8 AWG SIS wire.
      e. All wiring in the grounding circuit from the neutral point to the system ground terminal shall be #8 AWG type SIS minimum. All control wiring shall be #14 AWG type SIS minimum.
      f. Provide ventilators with removable air filters located on the roof and/or sides of the section to ensure adequate ventilation within the enclosure.
      g. High resistance grounded neutral system shall be installed so only qualified persons can service the installation.
   2. Metering and Controls:
      a. A switchboard type ground current ammeter, 1% accuracy, 250-degree scale, 0 to 10 A ac.
      b. System control selector switch with PULSE/NORMAL/TEST positions. Switch shall spring-return from the test position.
      c. Reset control selector switch with AUTO/MANUAL/RESET positions. Switch shall spring-return from RESET position. The AUTO position shall cause the ground fault relay to automatically reset when a ground is no longer detected. The MANUAL position shall cause the ground alarm relay to latch and remain latched until the selector is moved to the RESET position by the operator.
      d. A green lamp to indicate that the system is in normal condition, a red lamp to indicate that a ground fault has been detected, and a white lamp that flashes at the same rate and at the same time as the pulsing contactor.
      e. An instruction nameplate that provides the operator with a step-by-step procedure for operating the controls.
      f. A rating nameplate that states the maximum ground current, maximum pulse current and duty rating of the equipment at maximum current levels.

g. An alarm horn with an alarm silence pushbutton and re-alarm timer. The horn shall be a high-decibel type. Alarm silence control shall reset when ground relay is reset. Alarm shall automatically re-sound at the end of a 2- to 48-hour field-settable time interval if alarm has been silenced but ground fault still exists. Re-alarm timer shall not be defeatable via any control device.
h. Ground fault relay with harmonics filter to prevent nuisance tripping. Ground fault relay shall have a UL 1053 label.
i. One normally open and one normally closed ground fault alarm contact.
j. Test loops (for convenient attachment of a snap-on hand-held ammeter) in the ground current and test current circuits.
k. A test circuit protected by a current-limiting fuse rated 200,000 amperes and operated by the system control switch via a panel-mounted test circuit relay. The test circuit shall connect phase B to ground through a current-limiting resistor. The test circuit shall not be direct-wired to the door-mounted test switch. The test circuit relay shall be constrained from operating if a ground fault is presently being detected.
l. A pulsing contactor, controlled by an adjustable timer. The timer shall allow an adjustment range of 0-10 seconds.
m. 120 Vac control power transformer for self-contained operation. The control power transformer shall have current limiting primary fuses rated 200,000 AIC at the system voltage.
n. Primary disconnect switch mounted ahead of test and control power fuses.

2.5 CONCRETE PAD

A. Provide concrete pad below substation sized and located as indicated on drawings.

B. Coordinate opens in pad with approved submittals.

C. Slope pad to prevent ponding of rain water.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Each transformer shall receive all standard routine tests as required by ANSI C57.12.00 and performed as specified by ANSI C57.12.90.

B. Short Circuit withstand capability shall be verified by full short circuit tests on a similar unit in accordance with the latest revision of ANSI C57.12.00 and ANSI C57.12.90.

C. Additional tests, as indicated below will also be required, if not already included in the standard battery of test:
1. Schedule of testing.
a. Resistance Measurements.
b. Ratio Tests.
c. Polarity and Phase-Relation Tests.
d. No-Load Losses.
e. Exciting Current.
f. Impedance and Load Test.
g. Applied Potential Test.
h. Induced Potential Test.
i. Temperature Test.

3.2 INSTALLATION

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

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.3 LABELING

A. Provide labeling as specified in Section 26 00 10.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 13 17

MEDIUM VOLTAGE FUSIBLE INTERUPTER SWITCHGEAR (LOW PROFILE) (Revised AD-1)

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

AD-1: Section 26 13 17: Add paragraph 1.1.A and renumber subsequent paragraph.

A. Equipment specified in this section shall be furnished by the owner and will be placed and installed by the electrical contractor.

B. Design and construction standards:
   1. NEMA, SG-5.
   2. IEEE, Standard 27.
   3. Switches: ANSI/IEEE-C37.30, ANSI/IEEE-C37.32 and ANSI/IEEE-C37.34.
   4. Fuses: ANSI/IEEE-C37.40, ANSI/IEEE-C37.41, ANSI/ IEEE-C37.42 and ANSI/IEEE-C37.46.
   5. Enclosures: ANSI/IEEE-C57.12.28.
   6. NEC, Article 710.

1.2 SUBMITTALS

A. Shop drawings:
   1. Switches:
      a. Outline drawings of assembly.
      b. One line diagrams and wiring diagrams for assembly and components.
      c. Interconnection wiring diagrams.

B. Product data:
   1. Technical data on each component.
   2. Switches:
      a. Certified test reports on interrupter switches, in enclosures, with and without power fuses, indicating fault closing rating, if requested by Architect/Engineer.
      b. Fuse time-current characteristic curves and other characteristics and current ratings, for coordination with source and load protective devices.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.
   3. Letter stating maintenance materials and tools have been delivered.

1.3 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 LOAD INTERRUPTER SWITCHES

A. Acceptable manufacturers:
   1. 15 KV class load interrupter switches:

a. Base:

AD-1: Section 26 13 17: Revise paragraph 2.1.A.1.a.1)

1) S & C Electric. Remote Supervisory Vista Type

b. Optional:

1) General Electric.
2) Eaton Electrical.

2. Other manufacturers desiring approval comply with Section 00 26 00.
3. All components and assembly by same manufacturer.

B. Load interrupter switches: Outdoor style, low profile, pad-mounted, metal-enclosed, free-standing, self-supporting, manual type, completely factory assembled.

1. Ratings and arrangements as indicated, for operating a system rated 13.8 KV, three-phase, four-wire, 60 Hz, grounded wye.
2. Assembly and parts conform to all applicable NEMA, IEEE, and ANSI standards.
3. S & C Electric Vista.
4. Load interrupter switches, quantity: As indicated on drawings.
5. Dual purpose front barriers for each fuse and switch compartment.
6. Provide 12 IN base spacer.

C. Switchgear ratings:

1. Individual ratings apply to each component.
2. Base switchgear nameplate rating on overall maximum capacity but do not restrict ratings of individual components.
3. Voltage: 13.8 KV nominal, 95 KV BIL.
4. Continuous current:
   a. Load interrupter: 600 A.
   b. Power fuse: 200 A.
   c. Main bus: 600 A.
5. Load interrupting: 600 A.
6. Short circuit interrupting: 22,400 A.
7. Fault closing capability: 22,400 A.
8. Momentary rating: 22,400 A.

2.2 COMPONENTS

A. Load interrupter switches: Externally-operated, no-external-arc type, three-pole, heavy duty, with quick-make, quick-break operation.

1. Interrupting action which liberates appreciable quantities of ionized gas into the enclosure not permitted.
2. Mechanically operated, with quick-make, quick-break device in padlockable compartment.
3. Interlocked so as not to open until the blades have cleared main contacts by a distance greater than the external flashover distance.
4. Proof against defeat by incomplete switch opening or closing operation.
5. Linkages between blades and operating mechanism: Leakage and flashover properties equivalent to those of the mounting insulators.
6. Provide with interphase and end barriers.
7. Provide folding switch operating handle secured inside of switch operating hub pocket.

B. Power fuses: High-interrupting capacity, readily refusible with low cost refill units.

1. Fusible units: Non-aging, non-damageable; no unblown fuses need replacing.
2. Current limiting fuses acceptable ONLY for potential transformer protection.
3. Interrupting ratings not reduced by close lightning arrestor application.
4. Positive means and demonstrated ability to clear all levels of fault current up to maximum rating, including lowest level of fault which can melt element.
5. Rating: 14.4 KV, _____ MVA, three phase symmetrical at operating voltage of 13.8 KV.
6. Mountings: Disconnect style, with silencers. Provide _____ with equal number of fuses and fuse end fittings.

C. Terminal pads: With NEMA drilling; provide for each incoming connection to interrupters and each power fuse mounting to outgoing connection.

D. Tie bus, ground bus and interconnections: Aluminum bus of 56 percent IACS conductivity, braced to withstand the stresses associated with the short circuit rating of the switchgear, including proper allowance for transient condition.
   1. Bus supports: NEMA BIL rated porcelain insulators or solid dielectric material or cycloaliphatic epoxy resin insulators.
   2. Complete coordinated assembly of non-hygroscopic, inorganic material.

2.3 ENCLOSURES

A. Enclosures: 11 GA sheet steel completely welded, unitized assembly. Suitable for incoming and outgoing cables entering from the bottom.
   1. No access to high voltage parts by means of any external removable panel.
   2. Conform to minimum construction specifications of fuse manufacturer.
   3. Provide adequate space for fuse handling, as recommended by fuse manufacturer.
   4. Provide sufficient space, venting, enclosure strength and rigidity for fuse exhaust.
   5. Provide doors, louvers and identification.
   6. Grind all welds, sand to remove scale, degrease, clean and etch.
   7. Finish: Apply conductive zinc coating to all surfaces, prime with rust resistant iron oxide primer and finish coat.
   8. Finish coat: 4 mil dry thickness epoxy; green.
   9. Coat underside of roof with anti-condensation coating (Insulmatic).

B. Doors: 11 GA sheet steel, with reinforcing if required, and with concealed hinges and sturdy door stops.
   1. Use 2-point latching for tamper resistance.
   2. Locks on fuse compartment doors: Key interlock to all switches.
   3. Provide built in container for spare fuses and fuse handling tool on all doors giving access to fuses.
   4. Provide all doors with recessed latching assembly permitting padlocking.

C. Louvers:
   1. Provide louvers as required to provide free air movement throughout enclosure.

D. Identification: Conform to local power company requirements and Section 26 00 10.
   1. Provide nameplates, labeling , instructions and warning signs.

2.4 MAINTENANCE MATERIALS AND TOOLS

A. Spare fuses: Provide _____ spare power fuses.

B. Fuse handling tool: Provide one tool and one grappler per assembly.

C. Paint touch-up kit: Provide with each assembly.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install complete assembly.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 22 13
LOW VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 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.

B. Contract closeout information:
   1. Operating and maintenance data.

1.2 QUALITY ASSURANCE

A. Provide transformers conforming to following standards:
   1. NEMA-ST20.
   2. UL-1561.
   3. NEMA-TP1.
   4. NEMA-TP2.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Dry-type transformers:
      a. Base:
         1) Schneider Electric/Square D.
      b. Optional:
         1) Eaton Electrical.
         2) General Electric.
         3) Siemens.
   2. Other manufacturers desiring approval comply with Section 00 26 00.

B. Ratings information:
   1. All insulating materials are to exceed NEMA ST20 standards and be rated for 220°C UL component recognized insulation system.
   2. Three phase transformers 15kVA and larger shall be 150 degC temperature rise above 40 degC ambient.
   3. Three phase transformers 15kVA and larger shall have a minimum of 4 - 2.5 percent FCBN primary taps and 2 – 2.5 percent FCAN primary taps.
   4. Three phase transformers smaller than 15 kVA shall have a minimum of 2 – 5 percent FCBN primary taps.
   5. Maximum temperature of top of enclosure shall not exceed 50 degC rise above a 40 degC ambient.
   6. Transformers shall be low loss type with minimum efficiences per NEMA TP1 when operated at 35% of full load capacity. Efficiency shall be tested in accord with NEMA TP2.

Single Phase		Three Phase	
kVA	Efficiency	kVA	Efficiency
15	97.7%	15	97.0%
25	98.0%	30	97.5%
37.5	98.2%	45	97.7%
50	98.3%	75	98.0%
75	98.5%	112.5	98.2%
100	98.6%	150	98.3%
167	98.7%	225	98.5%
250	98.8%	300	98.6%
333	98.9%	500	98.7%

C. Construction:
1. Transformer coils (except buck/boost type) shall be dual winding of continuous wound construction and shall be impregnated with nonhygroscopic, thermosetting varnish.
2. All 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.
3. Completed core and coil shall be bolted to base of enclosure but isolated by means of rubber vibration-absorbing mounts.
4. Provide copper windings only.
5. There shall be no metal-to-metal contact between core and coil and enclosure except for a flexible safety ground strap.
6. Sound isolation systems requiring complete removal of all fastening devices will not be acceptable.
7. 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.
8. Transformer enclosures shall be ventilated (30 kva and above) and fabricated of heavy gauge, sheet steel construction.
9. Provide finish suitable for outdoor applications as applicable.
10. Provide weather shields for outdoor units.

D. 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 6 IN clearance on both sides and rear of all ventilated transformers or greater when required by manufacturer.

C. External wiring connections: Use flexible steel conduit. 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 00 10.

END OF SECTION

SECTION 26 24 13
SWITCHBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide switchboard(s) as specified herein and shown on the associated electrical drawings.

1.2 QUALITY ASSURANCE

A. System standards:
   1. ANSI/IEEE C12.16 – Solid State Electricity Metering.
   2. ANSI C39.1 - Electrical Analog Indicating Instruments.
   3. ANSI C57.13 - Instrument Transformers.
   4. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
   5. NEMA PB 2 - Deadfront Distribution Switchboards, File E8681
   6. NEMA PB 2.1 - Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or Less.
   7. NEMA PB 2.2 - Application Guide for Ground Fault Protective Devices for Equipment.
   8. UL 489 - Molded Case Circuit Breakers.
   9. UL 891 - Dead-Front Switchboards.
   10. UL 943 - Ground Fault Circuit Interrupters.
   11. UL 1053 - Ground-Fault Sensing and Relaying Equipment.
   12. CSA 22.2 No. 5 - M1986 Molded Case Circuit Breakers.
   13. Federal Specification W-C-375B/Gen - Circuit Breakers, Molded Case, Branch Circuit And Service.

1.3 SUBMITTALS

A. Shop drawings:
   1. One line diagrams and wiring diagrams for assembly and components.
   2. Interconnection wiring diagrams.
   3. Front and side enclosure elevations with overall dimensions shown.
   4. Conduit entrance locations and requirements.
   5. Nameplate legends.
   6. Switchboard instrument details.

B. Product data:
   1. Technical data on each component.
   2. Overcurrent protective device time-current characteristic curves, specifications and ratings, for coordination with source and load protective devices.

C. Project Information:
   1. Certified test reports on protective devices, in enclosures if requested by Architect/Engineer.

D. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.
   3. Ground fault system test report.

1.4 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Switchboards:
      a. Base:
         1) Schneider Electric/Square D.
      b. Optional:
         1) Eaton Cutler Hammer.
         2) Siemens.

B. Switchboard(s): As described herein and as indicated in diagrams and schedules:
   1. Arrange switchboard(s) as indicated and coordinate space requirements with space allotment.

2.2 SWITCHBOARDS-GENERAL

A. Service voltage: 480 V, 3 phase, 3 wire.

B. Accessibility: Front only.

C. Construction: NEMA Standard PB-2 1995, Deadfront Distribution Switchboards:
   1. Completely-enclosed, self-supporting metal structure:
      a. Provide required number of formed and welded vertical panel sections, incorporating circuit protective devices and other associated equipment as indicated.
   2. Bolt all fastenings between vertical sections.
   3. Completely enclose switchboard(s) on front, sides, top and rear with removable sheet steel plates minimum 12 GA.
   4. Provide bolted frame rear to support and house cables and other items.
   5. Switchboard bussing and protective devices shall be rated for short circuit stresses as indicated.
   6. Neatly lace all control wiring and leave flexibility at hinge locations.

D. Buses:
   1. Buses shall be tin-plated copper.
   2. Provide main horizontal bus of rating indicated, full-size continuous with provision for future extension.
   3. Tin plate each main bus and tap connection over full surface of joints.
   4. Heat rise of all buses shall not exceed ANSI/UL-891 listings.
   5. Tightly fasten main bus connections to insure maximum conductivity.
   6. Properly brace feeder circuit bussing.
   7. Provide continuous copper ground bus rated 50 percent of main bus rating for switchboard(s):
      a. Solidly bond to each structure near bottom.
   8. Do not use cabling inside switchboards as substitute for bus bar conductors, unless otherwise indicated.

E. Finish: Two coats of light gray enamel on all surfaces. Rustproof all sheet steel parts after fabrication, prior to painting.

F. Provide means for padlocking all main and feeder devices in open position.

G. Feeder Devices:
   1. Individually mounted feeder devices.
   2. Molded case circuit breaker(s):
      a. Provide adjustable long time, short time, instantaneous and ground fault electronic trip unit.
      b. See specification Section 26 28 00.

2.3 CUSTOMER METERING EQUIPMENT

A. Current transformers (CT): Dry, indoor, 600V type with short-circuiting device, and with accuracies to meet latest ANSI and NEMA requirements for burden connected to its secondaries:
   1. Mount and brace to withstand mechanical stresses resulting from rated short circuit currents.
   2. Provide CT's for each phase, and ground of the associated incoming feeder.

B. Potential source: Provide fused potential tap.

C. Multi-function digital meter:
   1. Provide meter as described in Section 26 09 13. Refer to single line diagram drawings for quantity and locations of meters.

2.4 MISCELLANEOUS DEVICES

A. Control power transformer:
   1. Fused control power transformers shall be provided as required for proper operation of equipment. Provide manual disconnect ahead of primary fuses.

B. Surge Protective Device:
   1. Install Transient Voltage Surge Suppression (TVSS) as indicated on drawings and as specified in Section 26 43 13. Mount TVSS within switchgear. Provide fused disconnect ahead of TVSS and connect to main bus. Locate to minimize length of conductors between main bus and TVSS. Provide remote indicating devices on the door to mimic indication on TVSS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate switchboard(s) as indicated.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 TESTING

A. Ground fault: Test installed ground fault system in main normal switchboard. 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.

3.3 LABELING

A. Provide switchboard labeling as specified in Section 26 00 10.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide power panelboard(s) and lighting and appliance panelboard(s) as specified herein and as indicated on associated schedules and drawings.

B. Provide all breakers with provisions to pad lock each breaker in the off position.

C. Provide panelboards with SPD where indicated.

D. Provide voltage alert pilot light on cover of all panelboards.

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-M1989 – Panelboards and Enclosed Panelboards.
   7. Federal Specification W-P-115C – Type I Class 1.
   8. Federal Specification W-P-115C – Type II Class 1.

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.

B. Product data:
   1. Technical data on each type of panelboard.

C. Contract closeout information:
   1. Operating and maintenance data.

PART 2 - PRODUCTS

2.1 PANELBOARDS

A. Acceptable manufacturers:
   1. Panelboards:
      a. Base: Same manufacturer for all panels on project:
         1) Square D.
      b. Optional:
         1) EATON Cutler Hammer.
         2) Siemens.

B. All panelboards: Dead front type:
   1. Provide dead front metal barrier over circuit breakers and bus which allows access to gutters without exposure to live parts.

2. Provide with non-insulated equipment grounding terminal strip located in top or bottom gutter including main grounding lug and individual terminals for 100 percent 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 or sub-feed lugs for 2 and 3 section panels.
5. Equip bus bars for panelboard with main lugs or main circuit breaker, capacity as required or indicated.
6. Bus bars in lighting and appliance panelboards shall be covered and phase isolated.
7. Panelboard bussing to be silver plated copper.
8. Provide panelboard buses fully rated for specified interrupting rating. Series rating of panelboards and overcurrent protective devices is not acceptable.
9. All space provisions shall be totally bussed.
10. Provide hinged door in door construction for all panelboards.
11. Panelboards served by a K-rated transformer shall be provided with a single 200 percent neutral bus.
12. Provide integral Transient Voltage Surge Suppression (TVSS) per specification 26 43 13 where indicated on plans or schedules.
13. Voltage alert pilot light.

C. Circuit breaker panelboards:
1. Bolted-on or Square D I-Line circuit breaker type. Plug-in circuit breakers not acceptable.
2. Lighting and appliance panelboards shall accept branch circuit breakers up to 125A. Above 125A, sub-feed circuit breakers may be used.
3. A branch circuit breaker shall not be allowed to be used as a main breaker unless specifically indicated.
4. In larger power and distribution panelboards, provide main buses and back panels which permit changing of circuit breakers without additional machining, drilling or tapping.
5. All multi-pole breakers of single handle and common trip.
6. All multi-pole breakers, 100A rated and larger shall include means for padlocking in off position.
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. Multi-section panels shall have equal height boxes.

D. Electronic grade panelboards:
1. Electronic grade panelboards are circuit breaker panelboards with an integrally mounted transient voltage surge suppression device.
2. The electronic grade panelboards shall meet all the specifications of this section as well as those in Section 26 43 13, Transient Voltage Surge Suppression.
3. Neutral bus shall be rated 200 percent.
4. Provide isolate equipment grounding bus in addition to equipment grounding bus.
5. Electronic grade panelboards are designated on the Panelboard Schedules.

E. Circuit breakers: Thermal-magnetic type unit construction, employing quick-make and quick-break toggle mechanisms for manual operation as well as automatic operation:
1. 1, 2 and 3 pole circuit breaker ratings:
   a. In 120/208 V panelboards: Minimum 10,000 AIC symmetrical, or greater as indicated.
   b. In 277/480 V panelboards: Minimum 14,000 AIC symmetrical, or greater as indicated.
2. Handles with three positions: "OFF", "ON", and "TRIPPED".
3. When circuit breaker opens on overload or short circuit, operating handle shall automatically assume "TRIPPED" position and clearly indicate abnormal condition of circuit.

4. Units operable in any position and removable from front of panelboard without disturbing adjacent units.
5. Tandem or half-size circuit breakers not allowed.

F. Ground fault circuit interrupter circuit breakers:
1. Operate on differential transformer principle; rated 20A, 120V or 240V, Class A fault-trip sensitivity of 5 milliamperes, UL approved, with built-in testing switch and ON-OFF switch.
2. Provide in panelboards in lieu of standard circuit breakers to serve circuits in wet locations.
3. Provide separate neutral for each interrupter circuit where neutral is required.

G. Cabinets: Trim, door and box, of galvanized sheet steel, code thickness:
1. 5-3/4 IN deep with gutter space meeting NEC requirements for wire termination space in panelboards.
2. Distribution panelboards: Cabinet depth not to exceed 12 IN, with gutter space meeting NEC requirements for wire termination space in panelboards.
3. Fasten trim to cabinet by means of approved adjustable clamps.
4. Equip door with chrome-plated combination lock and catch; supply two milled keys with each lock; key locks alike.
5. Provide directory frame on inside of door.
6. Finish: Primed, one coat gray lacquer.
7. Identify all circuit locations in each respective panel with load and location served:
   a. Directory shall be typed.
   b. Mechanical equipment identified in directory shall be identified by Owner-furnished designation and not designation indicated on plans.
   c. 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.

H. Voltage alert pilot light: Indicate presents of voltage via LED's and redundant circuitry:
1. Voltage alert pilot light shall be 40 – 750 VAC LED type with 8 LED's, 2 per Line 1, Line 2, Line 3 and Ground (or Neutral where available).
2. LED'S shall flash when a minimum of 30 VAC is voltage present.
3. Pilot light shall be mounted on the front cover of the equipment enclosure.
4. Pilot light shall be 40 mm in diameter and mount in a standard 30 mm knockout.
5. Provide four 6 FT #18AWG 1000V leads. Connect to line side of main lugs or main circuit breaker.
6. Voltage alert pilot light shall be equal to Diversified Electronics #UPA-130.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Support panelboard cabinets from wall structure via steel support cross members bolted to wall structure or from steel support framework.

C. Wall mounted panelboards shall be installed 6 IN above floor minimum. Large panels that rest on floor shall be mounted on house-keeping pads per specification 26 00 10.

3.2 LABELING

A. Provide panelboard labeling as specified in Section 26 00 10.

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 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.

B. Product data:
   1. Technical data on each type of controller and/or feeder device.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.

1.2 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Motor control centers:
      a. Base:
         1) Square D.
      b. Optional:
         1) EATON Cutler-Hammer.
         2) Siemens.
         3) Allen-Bradley.

B. Motors:
   1. Verify all motor sizes and types of control from approved mechanical shop drawings.
   2. Motors 1/2 HP and above: 460V, three phase, 60 cycle; provide 3 phase combination magnetic starters.
   3. Do not provide starters if indicated as part of Division 25 work.
   4. Motors below 1/2 HP: 115V, single phase, 60 cycle; provide manual thermal element units.

2.2 ENCLOSURES

A. General:
   1. Service voltage: 480 V, 3 phase, 60 cycle.
   2. Branch circuit short circuit protection: Motor circuit protector (MCP):
      a. Operating handle shall clearly indicate whether MCP is on, off or tripped.
      b. Provide means to lock each operating handle in off position with cover closed by means of one to three padlocks.
      c. Interlock so that operating handle must be in off position before door can be opened.

3. 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.

B. Motor control centers: NEMA Standard Construction, Class I, Type B:
   1. Incoming line: Main lugs, main circuit breaker or main fused switch as indicated.
   2. Configuration: Front mounted units accessible from the front only and front and rear mounted units as indicated.
   3. Structure units: Totally enclosed, free-standing type with structures joined together to form one assembly:
      a. Fabricate of not less than 14 GA steel, with 16 GA steel doors, in standardized units.
      b. Design so that units may be readily removed or future structures added as required.
      c. Provide each structure with two horizontal wiring spaces, one at top and one at bottom, which will line up with adjacent units to form convenient wiring raceway entire length of control center.
      d. Provide each structure with vertical wiring space between starter cell and side sheet for unit wiring, equipped with cable tie supports to hold cables and wiring in place.
      e. Bottom shall have ample unrestricted space for conduit and feeder entry.
      f. Doors: Formed round corners, rolled edges, neoprene gaskets, and at least two heavy duty hinges, held closed by means of quick-captive fasteners.
      g. Fabricate doors as part of structure and not part of starter, to cover openings after starters have been removed.
      h. Provide main horizontal bus, rated as indicated, across top of each structure; full capacity, full-length with provisions for extension.
      i. Bus bars: High-strength copper, of rectangular cross section; support in each structure by means of bus supports.
      j. Provide each structure with vertical 1/4 x 2 IN, minimum, copper bus to distribute incoming power to each unit in structure.
      k. Brace bussing for 42,000 RMS symmetrical amperes minimum, or greater as indicated.
      l. Provide continuous copper ground bus rated 50 percent of main bus rating for motor control center.
   4. Circuit breaker (MCP) and linestarter units: Built-in interchangeable modular height combinations:
      a. Line plug-in, pull-out, lock-out type.
      b. Provide guides in structure for supporting and aligning unit starter during removal or replacement.
      c. Plug-in units: With tin-plated, pressure type line disconnecting stabs of high-strength copper alloy.
      d. Lock-out latch to enable electrician to padlock unit in "pull-out" position and at same time isolate stubs and entire unit from bus. Hold each unit in place by means of quick-captive fasteners.
      e. Totally-enclosed and effectively baffled to isolate any ionized gases which may occur within unit starter.
      f. Ventilated so that it can be located anywhere within structure using same overload heaters for same load.
   5. Feeder tap unit: Circuit breaker type.

C. Combination controller/disconnect: NEMA standard construction, Type A wiring in NEMA 1 general purpose enclosure:
   1. Combination motor controller with motor circuit protector.

D. Separately mounted controller: NEMA standard construction, Type A wiring in NEMA 1 general purpose enclosure.

2.3 AUTOMATIC CONTROLLERS

A. General:
   1. Provide with three overload relays for complete single-phasing and overload protection.

2. Provide H.O.A. selector switch and red and green pilot lights for each motor starter on cover of each unit where indicated on drawings or schedules.
3. Provide with two extra NO and NC interlocking contacts in addition to seal-in contacts.
4. Provide 480/120 volt control transformer with 2 primary and one secondary fuse.
5. Overload relays: Solid state.

B. Combination full voltage non-reversing starters:
   1. External manual reset thermal overload relays.

2.4 MANUAL CONTROLLER

A. Manual thermal element units: 120/240 volt, single phase, maximum 1 HP, with overload protection and toggle switch:
   1. Provide means for padlocking in off position.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Floor mount on concrete pad per Specification 26 00 10.

C. Set adjustable trip settings of motor circuit protectors to match characteristics of motor installed.

D. Set adjustable solid state overload settings to match characteristics of motor installed.

E. Provide heater elements which match characteristics of motor installed.

F. Mount adjustable frequency drives furnished by Division 25. Refer to Sections 25 23 00 and 26 00 11.

G. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES (Revised AD-1)

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Technical data on each type of device.
   2. Product Data: Describe configurations, finishes, colors, and dimensions for floor boxes, receptacles, switches, device plates, dimming switches, dimming systems, occupancy sensors, receptacle strips, multi-outlet assemblies.
   3.

B. Project information:
   1. Occupancy sensor test report.

C. Contract closeout information:
   1. Manufacturer's installation instructions.
   2. Special Warranty: Warrant occupancy sensor switches for 5 years from date of Substantial Completion.

1.2 QUALITY ASSURANCE

A. Provide wiring devices conforming to the following standards:
   1. Underwriter's Laboratories (UL):
      a. Switches (UL 20).
      b. Receptacles, plugs and connectors (UL 498).
      c. Device plates (UL 514 and 514A).
      d. Ground fault circuit interrupters (UL 943).
   2. National Electric Manufacturers Association (NEMA):
      a. General purpose wiring devices (NEMA WD-1).
      b. Wiring devices dimensional requirements (NEMA WD-6).
   3. US Federal Specifications:
      a. Fed Spec switches (WS-896E).
      b. Fed Spec receptacles (WC-596F).
      c. Fed Spec device plates (W-P-455).

1.3 WARRANTIES

A. Provide 5 year warranty on following devices:
   1. Occupancy sensors.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Acceptable manufacturers:
   1. Wiring devices:
      a. Base:
         1) Hubbell.
      b. Optional:
         1) Leviton Manufacturing.
         2) Pass & Seymour.
         3) Cooper Wiring Devices.

c. All wiring devices shall be provided by the same manufacturer.

2.2 SWITCHES

A. Lighting switches:
1. Heavy duty, Specification grade, quiet-operating toggle-type 120-277 volts, AC only, 2 hp at 240V, 1 hp at 120V, 20 amp rated unless otherwise indicated:
   a. Standards: NEC Article No. 404; NEMA; UL.
   b. 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".
   c. All switches shall be equipped with a green grounding terminal.
   d. Wiring Type: Back and side, for #10 AWG if required.
   e. Type: Flush, quiet, AC, totally enclosed brush tumbler, toggle handle, single pole, 3-way and 4-way as shown.
   f. Modifications: Pilot light, key operation, interchangeable type as shown.

AD-1: Section 26 27 26: Revise paragraph 2.2.A.2.

2. Use white devices.
3. Refer to symbol legend.
4. Design Standard Manufacturer: HUBBELL. Substitutions subject to Section 01 25 13 are:
   a. Cooper Wiring Devices.
   b. Leviton.
   c. Lutron.
   d. Pass and Seymour.
   e. Other substitutions are not permitted.
5. Toggle-type switch:
   a. Single-pole: Hubbell HBL1221.
   b. Double-pole: Hubbell HBL1222.
   c. Three-way: Hubbell HBL1223.
   d. Four-way: Hubbell HBL1224.
   e. Single-pole key switch: Hubbell 1221-L.
   f. Red pilot light switch with illuminated toggle in the ON position: Hubbell HBL1221-PL.
   g. Momentary contact double-throw, three position, center-off switch: Hubbell HBL1557.

AD-1: Section 26 27 26: Delete paragraphs 2.2.B through 2.2.B.5.

B. Deleted

AD-1: Delete paragraphs 2.2.C through 2.2.C.15 and replace with paragraphs 2.2.C through 2.2.C.13.

C. Wall-box lighting:
1. Standards: UL, ANSI/IEEE, California Title 24 listed.
2. Circuitry: Solid-state with air gap switch; power failure memory restoring lights to preset level; radio frequency suppression filter.
3. Cover Plates: Decorative style with stainless steel finish as selected from manufacturer's standards. At locations with multiple devices, mount gangable wall boxes and provide continuous faceplate appearance.
4. Ballasts: Dimming type, compatible with intensity selector; refer to Section 26 51 00.
5. Multiple Location Switching: Provide one single pole, 3-way pre-set dimmer and 3-way or 4-way switches, as required, at other locations.
6. All devices shall be UL listed specifically for the required loads (i.e., incandescent, fluorescent, low voltage, electronic low voltage). Universal dimmers are not acceptable.
7. Electronic solid state type, rated for load, 120 and 277 volts AC.
8. All dimmers shall incorporate an air gap which shall be accessible without removing the faceplate. The air gap switch shall be capable of meeting all applicable requirements of UL 20 for air gap switches in dimmers.

9. All dimmers shall provide power failure memory. Should power be interrupted and subsequently returned, the light intensity will return to the same levels set prior to the power interruption.
10. Dimmers shall be tested to withstand voltage surges of up to 600 V and current surges of up to 200 A without damage per ANSI/IEEE Standard C62.41-1980.
11. Dimmer control shall be linear slide. Dimmer shall provide a smooth and continuous Square Law dimming curve.
12. Control Device Finish: White.
13. Faceplate shall snap on to the device with no visible means of attachment. Metal heat sink/mounting plate shall not be visible on front, top, bottom, or sides of device. At locations with multiple devices, one seamless, multi-gang faceplate shall be provided. Contractor is responsible for coordination of proper faceplate size and type.

D. Occupancy Sensors:
1. Passive Infrared Wall Mounted Switch:
a. Design Standard Manufacturer: Watt Stopper "WS-200". Substitution subject to Section 01 25 13 is:
1) Sensor Switch.

AD-1: Section 26 27 26: Delete paragraph 2.2.D.1.a.2)

2) Deleted
b. Standards: UL, California Title 24 listed.
c. Performance: Wall mounted motion sensor using infrared to detect moving personnel (minimum 300 square foot coverage for desktop activity with a field of view of 180 degrees). When motion is detected lights switch ON; if no motion is detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Selectable automatic or manual control mode, integrated light level sensor, adjustable intensity (2 to 200 footcandles), light level and time delay switches, and compatible with electronic ballasts.
d. Rating: 60HZ, 0 to 500 watts incandescent, 0-800 watts at 120V; 0-1200 watts at 277V.
e. Finish: White.
f. Provide five year product warranty.
g. Sensor shall combine analog and digital processing to provide immunity to RFI and EMI.
h. Sensor shall have a DIP switch to control the following functions:
1) Built-in light level feature adjustable from 8 to 180 foot candles.
2) Automatic-ON or manual-ON operation.
3) Time delay adjustable from 30 seconds to 30 minutes.
4) High/low sensitivity adjustments.
i. Sensor shall not protrude more than 3/8" from the wall.
j. For normal operation, sensor shall have two positions only: OFF and AUTO.
2. Dual-Level Occupancy Sensor Switches – Wall Mounted:
a. Design Standard Manufacturer: Watt Stopper "WA-300". Substitution subject to Section 01 25 13 is:
1) Sensor Switch.

AD-1: Section 26 27 26: Delete paragraph 2.2.D.2.a.2)

2) Deleted
b. Standards: UL, California Title 24 listed.
c. Perofmance: Wall mounted infrared motion sensor capable of controlling two independent lighting loads or circuits with isolated second relay; selectable time delay before shutting off lights (5, 10, 15, 20, or 30 minutes); dual on/off buttons for independent control of loads; integrated adjustable light level sensor for controlling secondary relay (8 to 180 footcandles); compatible with electronic ballasts.
d. Rating: 60HZ, 0 to 500 watts incandescent, 0-800 watts at 120V; 0-1200 watts at 277V.

e. Finish: White.
f. Provide five year product warranty.
g. Sensor shall combine analog and digital processing to provide immunity to RFI and EMI.
h. Sensor shall have a DIP switch to control the following functions:
   1) Built-in light level feature adjustable from 8 to 180 foot candles.
   2) Automatic-ON or manual-ON operation.
   3) Time delay adjustable from 30 seconds to 30 minutes.
   4) High/low sensitivity adjustments.
i. Sensor shall not protrude more than 3/8" from the wall.
j. For normal operation, sensor shall have two positions only: OFF and AUTO.

3. Dimmable Occupancy Sensor Switches – Wall Mounted:
   a. Design Standard Manufacturer: Watt Stopper "WD-180" for 277V; "WD-170" for 120V. Substitution subject to Section 01 25 13 is:

AD-1: Delete paragraphs 2.2.D.3.a.a) through 2.2.D.3.a.b) and replace with paragraph 2.2.D.3.a.1)

   1) Sensor Switch.
   2) Standards: UL, California Title 24 listed.
   3) Compatible for use with the following:
      a) Philips Lighting Ecotron with line voltage phase control.
      b) Advance Mark X electronic dimmable ballasts.
      c) Incandescent fixtures.
   4) Description: Wall mounted infrared motion sensor (150 square foot coverage for desktop activity); adjustable time delay before shutting off lights (30 seconds to 30 minutes); integral slide dimmer; compatible with electronic ballasts.
   5) Rating: 10-500 watts at 277V; 10-500 watts at 120V.
   6) Finish: White.
   7) Provide five year product warranty.
   8) Sensor shall combine analog and digital processing to provide immunity to RFI and EMI.
   9) Sensor shall have a DIP switch to control the following functions:
      a) Built-in light level feature adjustable from 8 to 180 foot candles.
      b) Automatic-ON or manual-ON operation.
      c) Time delay adjustable from 30 seconds to 30 minutes.
      d) High/low sensitivity adjustments.
   10) Sensor shall not protrude more than 3/8" from the wall.
   11) For normal operation, sensor shall have two positions only: OFF and AUTO.

4. Dual Technology Ceiling Mounted Directional Occupancy Sensor (180deg):
   a. Design Standard Manufacturer: WATT STOPPER "DT-200". Substitution subject to Section 01 25 13 is:
      1) Sensor Switch.

AD-1: Section 26 27 26: Delete paragraph 2.2.D.4.a.2)

      2) Deleted
   b. Standards: UL, California Title 24 listed.
   c. Performance: Ceiling mounted dual technology (infrared and ultrasonic) directional motion sensor; detection range up to 50 feet from sensor. When motion is detected lights switch ON; if no motion is detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Provide with integrated light level sensor, adjustable intensity (from 3 to 200 footcandles); time delay (15 seconds to 30 minutes) switches, and compatible with electronic ballasts.
   d. Rating: 24VDC; 19mA.
   e. Finish: White.
   f. Provide five year product warranty.
   g. Accessories: Provide quantity required to adequately switch loads controlled via occupancy sensor:

1) Power Pack: Provides 24VDC operating power to sensors, and switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.
2) Slave Pack: Switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.

h. Walking motion coverage up to 1500 sq. ft. when ceiling mounted at 12 feet with 180 deg field view.
i. Each technology shall have independent sensitivity adjustments.
j. Two outputs: one based on occupancy. The second based on occupancy with hold OFF for light level sensing DIP switch adjustable from 2.5 to 430 foot candles.
k. Provide 24 VDC power supply, ceiling mounting bracket and swivel mounting bracket.

5. Occupancy Sensor Switches - 360 Degree Ceiling Mounted:
   a. Design Standard Manufacturer: Watt Stopper "DT-355". Substitution subject to Section 01 25 13 is:
      1) Sensor Switch.

AD-1: Section 26 27 26: Delete paragraph 2.2.D.5.a.2)

      2) Deleted

   b. Standards: UL, California Title 24 listed.
   c. Performance: Ceiling mounted 360 degree dual-technology (infrared and ultrasonic) occupancy sensor with 1400 sq ft coverage. When occupancy is detected lights switch ON; if occupancy is not detected after a pre-selected (adjustable) duration, lights automatically switch OFF. Provide integrated light level sensor, adjustable intensity (10 to 300 footcandles); and adjustable time delay (5 to 30 minutes). Unit shall be compatible with electronic ballasts.
   d. Rating: 120/277V.
   e. Finish: White.
   f. Provide five year product warranty.
   g. Accessories: Provide quantity required to adequately switch loads controlled via occupancy sensor:
      1) Power Pack: Provides 24VDC operating power to sensors, and switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.
      2) Slave Pack: Switches up to 20 amps of ballasted load. Provide 120 or 277V, as required.
   h. Walking motion coverage up to 1400 sq. ft. when ceiling mounted at 360 deg field view
   i. Each technology shall have independent sensitivity adjustments.
   j. Two outputs: one based on occupancy. The second based on occupancy with hold OFF for light level sensing DIP switch adjustable from 2.5 to 430 foot candles.
   k. Provide 24 VDC power supply, ceiling mounting bracket and swivel mounting bracket.
6. Low Temperature, Gasketted Motion Sensor Switches – Wall Mounted:
   a. Design Standard Manufacturer: Watt Stopper "CB". Substitution subject to Section 01 25 13 is:
      1) Sensor Switch.

AD-1: Section 26 27 26: Delete paragraph 2.2.D.6.a.2)

      2) Deleted

   b. Standards: UL, California Title 24 listed.
   c. Description: Wall mounted infrared motion sensor with swivel mounting bracket; CB-100-1 coverage pattern of 8 feet by up to 90 feet, CB-100-2 bi-directional coverage pattern of 5 feet by up to 50 feet in each direction, or CB-100 fanning coverage pattern of up to 50 feet; selectable time delay before shutting off lights (15 seconds, 5 minutes or 10 minutes); gasketted water-tight enclosure; operating temperature range of -40 to 95 degrees F; UL 773A rated raintight; compatible with electronic ballasts.
   d. Rating: 24VDC, 20mA; provide with associated power pack for 120/277V operation.
   e. Provide 5 year product warranty.
7. Exterior Motion Sensor/Photocell Switches – Surface Mounted:
   a. Design Standard Manufacturer: Watt Stopper "EN". Substitution subject to Section 01 25 13 is:

1) Sensor Switch.

AD-1: Section 26 27 26: Delete paragraph 2.2.D.7.a.2)

2) Deleted

b. Standards: UL, California Title 24 listed.

c. Description: Wall or ceiling mounted infrared motion sensor uses 3/4 inch threaded nipple to attach to standard NEMA weatherproof junction box; EN-200 coverage pattern of 10 feet by up to 100 feet or EN-100 fanning coverage pattern of up to 50 feet; adjustable delay before shutting off lights; integrated adjustable light level sensor (0.4 to 42 footcandles) to select level below which lights will turn on; operating temperature range of -40 to 130 degrees F; UL 773A rated raintight; compatible with electronic ballasts.

d. Rating: 0-1000 watts at 120V or 277V.

e. Provide 5 year product warranty.

E. Switching Power Pack:

AD-1: Section 26 27 26: Delete paragraphs 2.2.E.1 through 2.2.E.8 and replace with paragraphs 2.2.E.1 through 2.2.E.8.

1. Design Standard Manufacturer: Watt Stopper "B120E-P and B277E-P". Substitution subject to Section 01 25 13 is:
   a. Sensor Switch.
2. Power pack shall be a shelf contained transformer and relay module measuring 1.75 IN x 2.75 IN x 1.5 IN.
3. Power and slave packs shall have dry contacts capable of switching 20 amp ballast load, 13 amp incandescent, 1 hp @ 120 VAC, 60 Hz; 20 amp ballast @ 277 VAC, 60 Hz.
4. Power pack shall provide a 24 VDC, 100 mA output.
5. Power packs shall be capable of parallel wiring without regard to AC phases on primary.
6. Power pack can be used as a stand alone, low voltage switch, or can be wired to sensor for auto control.
7. Power pack shall have low voltage teflon coated leads, rated for 300 volts, suitable for use in plenum applications.
8. Provide control wire as recommended by manufacturer in conduit.

2.3 DUPLEX AND SINGLE RECEPTACLES

A. Receptacle outlets:
1. Specification grade.
   a. Specification grade receptacles shall be 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:
      1) Constructed with impact resistant nylon or polyester face and body.
      2) 0.050 IN brass nickel-plated backstrap with one piece ground design.
      3) 0.040 IN brass nickel-plated contacts.
2. Flush, grounding convenience outlets for side wiring, or side and back wiring.

AD-1: Section 26 27 26: Revise paragraph 2.3.A.3.

3. Use white devices.
4. Use gray devices on equipment branch circuits.
5. Refer to symbol legend.

B. 20A, 125V, 2 pole, 3 wire grounding, duplex: NEMA 5-20R; Hubbell HBL5362.

C. 20A, 125V, 2 pole, 3 wire grounding, single; NEMA 5-20R; Hubbell HBL5361.

D. Weatherproof receptacles: Type as indicated on drawings:
1. Mount on "FS" cast metal box.
2. Suitable for wet location when receptacle is not in use:
   a. Gasketed and self-closing lift cover.
      1) Single outlets: Hubbell HBL7423 WO.

2) Duplex outlets: Hubbell HBL5206 WO.
3) Duplex GFI receptacles: Hubbell WPFS26.

3. Suitable for wet location when receptacle is in use:
   a. High impact polycarbonate with single gasketed lift cover; NEMA 3R rating while in use; tinted lid.
      1) Hubbell/Raco Rayn Tite II weatherproof cover with receptacle type as indicated.

E. GFI type duplex receptacles: With built-in ground fault interruption, 5-mA sensitivity, indicator and reset. UL listed:
   1. 20A, 125V, 3 wire duplex: NEMA 5-20R; Hubbell GF5362.

F. Isolated ground receptacles: Device type as indicated with receptacle ground isolated from conduit grounding system:

AD-1: Section 26 27 26: Revise paragraph 2.3.F.1.

1. White device with orange triangle.
2. Specification grade, Hubbell and IG-5362.

2.4 SPECIAL PURPOSE RECEPTACLES

A. NEMA 6-20R receptacle: 20A, 250V, 2 pole, 3 wire grounding, side and back wired, single; black; Hubbell HBL5461I.

B. NEMA 14-20R receptacle: 20A, 125/250V, 3 pole, 4 wire, 1 phase grounding, single; NEMA 14-20R; 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 14-30R receptacle: 30A, 125/250V, 3 pole, 4 wire, 1 phase grounding, single; black; Hubbell HBL9430A.

G. NEMA 15-30R receptacle: 30A, 250V, 3 pole, 4 wire, 3 phase, grounding, single; black; Hubbell HBL8430A.

H. NEMA 6-50R receptacle: 50A, 250V, 2 pole, 3 wire, 1 phase, grounding, single; black; Hubbell HBL9367.

I. NEMA 14-50R receptacle: 50A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single; black; Hubbell HBL9450A.

J. NEMA 15-50R receptacle: 50A, 250V, 3 pole, 4 wire, 3 phase, grounding, single; black, Hubbell HBL8450A.

K. NEMA L5-20R receptacle: 20A, 125V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2310.

L. NEMA L6-20R receptacle: 20A, 250V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2320.

M. NEMA L14-20R receptacle: 20A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2410.

N. NEMA L15-20R receptacle: 20A, 250V, 3 pole, 4 wire, 3 phase, grounding, single, twist-lock; black; Hubbell HBL2420.

O. NEMA L5-30R receptacle: 30A, 125V, 2 pole, 3 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2610.

P. NEMA L6-30R receptacle: 30A, 250V, 2 pole, 3 wire, 1 phase grounding, single, twist-lock; black; Hubbell 2620.

Q. NEMA L14-30R receptacle: 30A, 125/250V, 3 pole, 4 wire, 1 phase, grounding, single, twist-lock; black; Hubbell HBL2710.

R. NEMA L15-30R receptacle: 30A, 250V, 3 pole, 4 wire, 3 phase, grounding, single, twist-lock; black; Hubbell HBL2720.

S. Refer to contract documents for other types.

2.5 DEVICE PLATES

A. Manufacturer: Same as wiring device manufacturer.

B. Standards: NEC Articles No. 404 and No. 406; UL.

C. Device plates for concealed wiring: single or ganged in one piece with beveled edges that match faces of plates:

AD-1: Section 26 27 26: Revise paragraph 2.5.C.1.

1. For Recessed Boxes: Stainless steel, brushed finish:
   a. Clean room: Stainless steel, brushed finish

AD-1: Section 26 27 26: Revise paragraph 2.5.D.

D. Device plates for surface type cast-metal boxes: Stainless steel Corrosion resistant cast ferrous metal designed for application.

E. Ganging: As required by number of devices.

F. Weatherproof: Gasketted, cast aluminum, spring-loaded lift cover plates.

G. Labeling: Provide circuit label on each receptacle device plate indicating panelboard and circuit number supplying the device. Provide NEMA type label on each special receptacle device plate:
   1. The label shall be indoor/outdoor, high gloss, durable, scratch proof, flexible, dimensionally stable, pressure sensitive adhesive backed vinyl film type.
   2. Label shall be suitable for use in ambient temperatures from –40 degF to 176 degF.
   3. Label shall be suitable for continuous exposure to alcohols, detergents, grease and oils.
   4. Circuit label shall have one line of text centered on label indicating panelboard name and circuit number separated by a hyphen.
   5. NEMA type label shall have two lines of text with NEMA type centered on the top line and voltage, phase, wire and amperes centered on the bottom line.
   6. Text shall be 1/8 IN high.
   7. Background and text color as follows:
      a. Normal distribution system: Clear with black text.
      b. Emergency branch (devices served by EATS): Yellow with black text.
      c. Optional Standby branch (devices served by QATS): Green with black text.
   8. Other Types: As shown or specified.
   9. Explosion-proof surface mounted switch:
      a. Single-pole: Crouse-Hinds EFS-1129 and/or EFS-2129.
      b. See Section 26 00 10 for hazardous areas.

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, etc.

C. Any outlet which is improperly located must be corrected at Contractor's expense.

D. Set outlets plumb or horizontal and extending to finished surface of wall, ceiling or floor as case may be without projecting beyond same.

E. Install receptacles, switches, etc., indicated on wood trim, cases or other fixtures symmetrically. Where necessary, set with long dimension of plate horizontal, or gang in tandem.

F. Install vertically mounted receptacles with the ground pin down. Install horizontally mounted receptacles with the ground pin to the left.

G. Where fluorescent dimming is indicated, extend Class 1 or Class 2 wiring with 600 V insulation in conduit with power conductors from dimmer to dimming ballast.

H. GFCI receptacles shall be connected so that downstream devices are not protected by GFCI receptacle.

I. Occupancy Sensors:
   1. The locations and quantity of sensors shown on the drawings are diagrammatic and indicate only the rooms and spaces to be provided with sensors.
   2. Verify sensor type, quantity, location, aiming and sensitivity with manufacturer's recommendations.
   3. All controlled spaces shall be tested to insure 90 to 100 percent coverage of the controlled space. If test fails, adjust sensitivity, re-aim, relocate, and/or add sensor(s) as required at no cost to Owner.
   4. Power supplies and slave units if required shall be located above accessible ceilings.
   5. Verify and adjust all adjustable settings of each sensor with Owner preferences.

AD-1: Section 26 27 26: Delete Article 3.2 in its entirety.

3.2 DELETED

END OF SECTION

SECTION 26 28 00
OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Technical data on each type of device.
   2. Time-current curves for all devices on project.
   3. Submit with associated switchgear, panelboard or other assembly.

B. Project information:
   1. All data necessary, and as requested by the government, to allow the government to prepare a complete coordination study.

1.2 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Overcurrent protective devices.
      a. Base:
         1) Square D.
      b. Optional:
         1) EATON Cutler Hammer.
         2) Siemens.
   2. Fuses:
      a. Base:
         1) Bussmann.
      b. Optional:
         1) Shawmut.
         2) Brush.
         3) Littelfuse.

B. Equipment and devices by same manufacturer.

C. Square D and Bussmann types listed for quality, performance short circuit coordination study reference. Refer to short circuit coordination study for system breaker types.

2.2 CIRCUIT BREAKERS

A. Molded case type: Unit construction, quick make, quick break, manual and automatic operation, 3 position "on" "off" and "tripped". "Tripped" condition clearly indicated. All poles open and close simultaneously:
   1. Thermal magnetic type providing inverse time overload and instantaneous short circuit protection by means of a thermal magnetic element. Interchangeable trip as indicated:
      a. 120/240V, 15A through 100A:
         1) 10,000 AIC - Type QO.

2) 25,000 AIC - Type HD.
3) 65,000 AIC - Type HG.

b. 277/480V, 15A through 100A:
1) 18,000 AIC - Type ED.
2) 35,000 AIC - Type FG.

c. 277/480V, 15A through 150A:
1) 65,000 AIC - Type HJ.

B. Solid State trip type providing inverse time overload, adjustable instantaneous short circuit, and short time delay protection by means of a solid state trip element with associated current monitors and flux transfer shunt trip. Provide interchangeable rating plug and push-to-trip button. Built-in adjustable ground fault protection as indicated:
a. 240V, 100A through 600A:
1) 65,000 AIC - Type DG.

b. 480V, 75A through 600A:
1) 35,000 AIC - Type DG.
2) 65,000 AIC - Type DJ.

C. Draw-out power air type solid state trip element with two-step stored energy mechanism. Provide interchangeable sensor element. Rate for application at 100 percent of frame size:
1. Manually operated or Electricaly operated. (refer to single line diagram drawings).
2. Draw-out construction. Roll out type operated by removable crank handle. Interlock with door.
3. 100A - 250A, Type Masterpact NT:
a. 480V - 100,000 AIC.
4. 100A - 1200A, Type Masterpact NT LF:
a. 480V - 100,000 AIC.
5. 400A through 6000A, Type Masterpact NW:
a. 480V - 100,000 AIC.
6. Trip unit, Type 5.0 & 6.0 A/P/H:
a. Each drawout low-voltage power circuit breaker shall be equipped with a solid-state tripping system consisting of three (3) current sensors, microprocessor-based trip device and flux-transfer shunt trip to provide adjustable time-current protection functions with true RMS current sensing.
b. Interchangeable rating plugs shall establish the maximum continuous trip ratings of each circuit breaker. Rating plugs shall be fixed type. Rating plugs shall be interlocked so they are not interchangeable between frames, and interlocked such that a breaker cannot be closed and latched with the rating plug removed.
c. Main, tie and feeder trip units shall be provided with the following individually adjustable time/current curve shaping solid-state elements:
1) Long delay pickup and time.
2) Short delay pickup and time with selective flat or l^2t curve shaping.
3) Instantaneous pickup.
4) Ground fault current pickup and time with selective flat or l^2t curve shaping.
d. Provide a ground fault protection scheme on the main and tie circuit breakers suitable for use with a multi-grounded neutral system.
e. A four-digit, 3/4-inch high, high output LED alphanumeric display shall be provided to indicate the following data:
1) Cause of trip.
2) Instantaneous value of maximum phase and ground current.
3) Level of fault current that initiated an automatic trip operation.
f. The trip unit shall include a potential transformer module, suitable for operation up to 600V, 50/60 Hz. The primary of the potential transformer module shall be connected internally to the load side of the circuit breaker through a dielectric disconnect plug. The unit shall calculate and display the following power and energy parameters:
1) Peak demand (Megawatts).
2) Present demand (Megawatts).

3) Energy consumption (Megawatt-hours).

D. Motor circuit protector (MCP) providing adjustable instantaneous short circuit protection only by means of a magnetic or solid state trip element:
   1. Molded case construction.
   2. Current-limiting as indicated or required providing 200,000 AIC by means of a current-limiter attachment.
   3. See motor control center schedules for required sizes and interrupting ratings.

E. 15 KV, vacuum interrupter, draw-out circuit breaker:
   1. Operation: By electrically charged, mechanically and electrically trip-free, spring type stored with energy mechanism, with provision for manual charging and slow closing of contacts for inspection and adjustment.
   2. Provide secondary disconnecting contacts which automatically engage in the operating positions.
   3. Provide mechanism which moves breaker between operating and disconnect positions, with interlock to prevent movement to or from operating position unless breaker contacts are open.
   4. Breaker control voltage: 120 V AC, 60 Hz.
   5. Each breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit which can be easily removed.
   6. Provide each interrupter with a contact wear gap indicator requiring no tools to indicate available contact life, easily visible when breaker is removed from cell.
   7. Secondary contacts shall be silver-plated:
      a. Automatically engaged in the breaker operating position.
      b. Manually engaged in the breaker test position.
   8. Provide interlocks for following functions:
      a. To prevent closing of breaker between operating and test positions.
      b. To trip breaker upon insertion or removal from housing.
      c. To discharge stored energy mechanism upon insertion or removal from housing.
   9. Each breaker shall have the following ratings:
      a. Maximum voltage: 15 kV.
      b. BIL rating: 95 kV.
      c. Continuous current: 1200 Amperes.
      d. Short circuit current at rated maximum voltage: 37 kA.
      e. Closing and latching capability: 130 kA.
      f. 3 second rating: 48 kA.
      g. Nominal 3 phase MVA Class: 1000 MVA.
      h. Rated interrupting time: 5 cycles.
   10. Multi-function overcurrent relays:
      a. The relay shall be a solid-state microprocessor-based multifunctional type that operates from the 5 ampere secondary output of current transformers. The relay shall provide ANSI 50/51N protective functions for each of the three (3) phases, and ANSI 50/51N or 50/51G ground fault protection functions as shown on the plans or as determined by the coordination study. The relay shall be true rms sensing of each phase and ground. Ground element shall be capable of being utilized in residual, zero sequence, ground source connection schemes, or deactivated
      b. The primary current transformer rating being used for phase and ground protection feeding the device shall be programmable for current transformers with primary current ratings from 5 through 5,000 amperes
      c. Both the phase and ground protection curves shall be independently field-selectable and programmable with or without load. Curves shall be selectable from the following:
         1) IEEE: Moderately inverse, very inverse, extremely inverse.
         2) IEC: A, B, C or D.
         3) Thermal: Flat, lt, I^2t, I^4t.
      d. The relay shall be field-configurable to have either of the following function combinations assigned to its two form A contacts:

1) One contact assigned ANSI 51 phase and ANSI 51 ground and the other contact assigned ANSI 50 phase and ANSI 50 ground.
2) One contact assigned ANSI 51/50 phase and the other contact assigned 51/50 ground.

e. The relay shall have a built-in alphanumeric display capable of displaying the following information with metering accuracy of +/- one (1) percent of full scale (l_n) from 0.04 x l_n to 1 x l_n and +/- two (2) percent of full scale (l_n) from 1 x l_n to 2 x l_n:
1) Individual phase currents.
2) Ground current.
3) Cause of trip.
4) Magnitude and phase of current causing trip.
5) Phase or ground indication.
6) Peak current demand for each phase and ground since last reset.
7) Current transformer primary rating.
8) Programmed phase and ground set points.

f. Relay shall have the following features:
1) Integral manual testing capability for both phase and ground protection function. Testing shall be selectable to either operate contact outputs or not operate output contacts.
2) Zone selective interlocking capability for short time and ground fault protection.
3) Continuous self-testing of internal circuitry.
4) Unit failure alarm contact for customer use.
5) Programmable lockout/self reset after trip function.
6) Programmable set points for device curve selection.
7) Programmable inputs, such as current transformer ratios.
8) Access to program and test modes shall be via sealable hinged cover for security.

g. Relay shall be suitable for operating temperatures from -30 degrees to 55 degrees C. Relay shall be suitable for operating with humidity from 0 to 95% relative humidity (non-condensing).

h. Relay shall have communication capability over a two-wire twisted pair area network to a central computer for storage and/or printout:
1) Ability to transmit all information contained in the relay such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
2) Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is DIP switch configured in remote close/open mode.

i. Relay alarm and/or trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip upon detection of an overcurrent or fault condition based upon programmed settings. A “protection OFF” alarm shall be provided which is normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. Upon loss of power or relay failure, this alarm relay shall be de-energized providing a failsafe protection OFF alarm.

j. Provide a dual-source power supply (DSPS) for each relay. During normal operation, relay control power shall be provided by the switchgear auxiliary 120 Vac, or 240 Vac, 50/60 Hz power source. If the normally connected auxiliary ac voltage is not available, the relay shall operate solely from the breaker main current transformers (CTs).

k. Provide the relay in a drawout case allowing for removal and replacement of the relay unit without disruption of the wiring. The drawout case shall have quick release operation with two-stage disconnect operation. The removal of the relay inner chassis shall disconnect the trip circuits and short the CT secondaries before the unit control power is disconnected. Provide protection against false tripping.

l. Schweitzer (SEL) – 751A Relay.

2.3 FUSES

A. 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:

1. Use for main and main feeder devices over 600A, where fuses are indicated.

B. 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:
   1. Use for main feeder devices 600A and smaller where fuses are indicated.

C. 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:
   1. Use for motor feeder and branch circuit devices where fuses are indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in switchgear, panelboards and motor control centers as indicated in those sections.

B. Install individually enclosed as specified in other sections or indicated. Use NEMA 1 enclosure unless indicated otherwise.

C. Set adjustable devices as indicated in coordination study.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 28 16
ENCLOSED SAFETY SWITCHES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Technical data on each type of disconnect switch.

B. Contract closeout information:
   1. Operating and maintenance data.
   2. Maintenance materials: Spare fuses, 10 percent or minimum of 3 of each type and rating of installed fuses.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Safety switches:
      a. Base:
         1) Square D.
      b. Optional:
         1) EATON Cutler-Hammer.
         2) Siemens.
   2. All fuses in fusible-type devices: Same manufacturer.

2.2 SAFETY SWITCHES

A. Safety switches: Fusible and non-fusible type, NEMA Type HD Heavy Duty construction, unless otherwise indicated:
   1. Enclosure: NEMA 1 unless otherwise indicated.
   2. Provide weatherproof disconnect switches as required by Section 26 00 10.
   3. Switch blades fully visible in OFF position with door open.
   4. Contact operation quick-make and quick-break.
   5. Provide solid neutral where neutral conductor is provided.
   6. Switches for motor circuits to be horsepower rated.
   7. Switches for motor circuits controlled by Adjustable Frequency Drives (AFD) shall include one N.O. and one N.C. contact which operates with the initial movements of the switch and prior to the opening of the main switch.
   8. Provide padlocking provisions in OFF position.
   9. Finish: Baked enamel over rust-inhibiting primer.
   10. Fuses for fusible switches: See Section 26 28 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install as indicated and in accordance with manufacturers instructions and recommendations.

B. Mount on wall or unistrut frame adjacent to motor served.

C. Switches for motor circuits controlled by AFD's shall be electrically interlocked to the controlling AFD via contacts provided in switch.

D. Provide labeling per Section 26 00 10.

END OF SECTION

SECTION 26 32 13
DIESEL ENGINE DRIVEN GENERATOR SETS

PART 1 - GENERAL

A. Provide a complete emergency system to automatically provide an alternate source of power in the event of a normal power outage.

B. The emergency system consists of a diesel engine generator set, automatic transfer switches, controls and all associated accessories.

C. The engine generator set shall consist of an engine, generator, sub-base fuel tank, silencer, vibration isolation, weather protective sound attenuated enclosure, controls and all associated accessories.

D. The automatic transfer switches specified in Section 26 36 23 shall be provided by the engine generator set manufacturer in order to establish and maintain a single source of responsibility and coordination for the complete emergency system.

E. The complete emergency system shall be factory tested before shipment and field tested after installation.

1.2 QUALITY ASSURANCE

A. The engine generator set shall be designed, built, assembled, factory tested, installed and field tested in accordance with all applicable ANSI, IEEE, NEMA, UL, UL 142, API 650, API 620 and NFPA standards including NFPA-30, NFPA-37, NFPA-70 and NFPA-110.

B. The manufacturer of the engine generator set shall manufacture the engine, the generator or the engine and generator.

C. The engine generator set manufacturer shall have been manufacturing the engine and/or the alternator for a minimum of ten years.

D. The engine generator set manufacturer shall assemble the engine and generator into one unit in the engine generator set manufacturer's factory.

E. The engine generator set manufacturer shall have been assembling and testing engine generator set for a minimum of ten years.

F. The engine generator set manufacturer shall have an authorized local distributor/supplier within 50 miles of the site that can provide installation, field testing, maintenance, parts and service through factory trained personnel on a 24 hour basis and able to respond within 4 hours of notification.

G. Engine-generator set must meet the latest EPA tier level for emission standards.

1.3 SUBMITTALS

A. Shop drawings:
   1. Submit all components together to permit checking of entire system, coordination between components and coordination of sensing devices required for local and remote derangement signal annunciator.

B. Product data:
   1. Technical data on all components.

C. Project information:
   1. Environmental permits.
   2. Test reports and certifications.

D. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction reports.
   3. Prorata warranty for batteries.

1.4 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 ENGINE GENERATOR UNIT

A. Engine generator unit: Diesel engine direct-connected to alternating current generator mounted on suitable rigid steel skid supports:
   1. Provide with vibration isolator assemblies consisting of both mechanical spring and rubber pad to control both high and low frequency vibrations between major components, subbase and structural foundation:
      a. Spring isolators shall be designed for seismic zone 1.
   2. Base rating on operation at rated RPM when equipped with all operating accessories.
   3. Mount unit with radiator on subbase suitable for installation on concrete foundation.

B. Acceptable manufacturers:
   1. Engine generator unit:
      a. Base:
         1) Caterpillar.
      b. Optional:
         1) Cummins/Onan.
         2) Kohler.
   2. Silencers:
      a. Base:
         1) Maxim.
         2) GT Exhaust Systems.
         3) Nelson.
   3. Battery charger:
      a. Base:
         1) Charles.
         2) LaMarche.
         3) Onan.
   4. Governor:
      a. Base:
         1) Woodward Governor.
         2) Barber Colman.
   5. Radiator:
      a. Base:
         1) Modine.
         2) IEA.
   6. Vibration isolators:
      a. Base:
         1) Mason Industries.
         2) Kinetics Noise Control.
         3) Vibration Mounting & Controls, Inc.

2.2 ENGINE

A. Engine: Four cycle, 1800 RPM, full compression ignition, single acting, solid-injection unit, either vertical or V-type with trunk-type pistons:
   1. Make engine perform satisfactorily on commercial grade No.2 dyed low sulfur-off road diesel fuel.
   2. Provide with removable full wet-type cylinder liners of close grained alloy iron, heat treated for proper hardness to obtain maximum life.
   3. Capable of operating at idle or light loads for extended periods of time.
   4. Provide for precombustion of fuel or similar means for prevention of carbonization.
   5. Provide components indicated.

B. Injection pumps and valves: Type not requiring adjustment in service, which may be individually removed and replaced from parts stock:
   1. Provide individual injection pumps and valves for each cylinder.
   2. Fuel injection pumps: Positive action, constant-stroke, actuated by cam driven by gears from engine crankshaft.
   3. Fuel lines between injection pumps and valves: Heavy seamless tubing, same length for each cylinder.
   4. Provide flexible fuel line connectors at engine.

C. Oil pump: Gear-type lubricating oil pump to supply oil under pressure to main bearings, crank pin bearings, pistons, timing gears, camshaft bearings and valve rocker mechanism:
   1. Spray cool and lubricate pistons.
   2. 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.
   3. Filter elements accessible and easily removable.
   4. Filter elements: Effective full flow, replaceable resin-impregnated cellulose type.
   5. Equip filter system with spring-loaded by-pass valve as insurance against stoppage of lubricating oil circulation in event filters become clogged.
   6. Oil cooler: Water-cooled, engine-mounted.

D. Fuel system:
   1. Fuel pump: Built-in gear-type, engine-driven fuel transfer pump, capable of supplying fuel at constant pressure against head of 12 FT.
   2. 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.
   3. Locate all fuel filters in one accessible housing, ahead of injection pumps to thoroughly filter fuel before it reaches pumps.
   4. Use no screens or filters requiring cleaning or replacement of injection pumps or valve assemblies.

E. Governor: Fully enclosed electronic type governor with actuator capable of providing accurate speed control within 1 percent of rated speed, complete with panel-mounted electronic assembly with ramp generator and speed-sensing modules.

F. Air cleaners: Engine-mounted, dry type air cleaners of sufficient capacity:
   1. Provide one or more.

G. Electric starting system:
   1. Sufficient capacity to crank at speed which will start engine under normal operating conditions.
   2. Automatic controls to provide automatic cranking of engine when normal power fails.
   3. Prevent excessive cranking which could damage cranking motor.
   4. Automatic stop controls.
   5. Starter motors with positive-engagement feature.

H. Cooling system: Sufficient capacity for cooling engine when delivering full output, in ambient temperature not over 125 degF at altitude of 1000 FT above sea level:

1. Unit mounted radiator:
    a. Provide core guard flexible duct adapter.
    b. Provide site glass at top of unit.
2. Provide heavy duty core and fan guards.
3. Fill system with solution of 50-50 water and ethylene glycol anti-freeze to prevent freezing at temperatures as low as minus 30 degF.

I. Jacket water heater: Provide two heaters to maintain coolant at 90 degF. Include thermostat:
1. 208V, single phase.

J. Silencer:
1. Critical type.
2. Seamless, stainless steel, flexible, exhaust adapter for exhaust outlet to silencer.
3. Locate silencer within enclosure and supported from enclosure structure.

K. Engine instruments and controls:
1. Engine-mounted instruments panel:
    a. Fuel pressure gauge.
    b. Oil pressure gauge.
    c. Oil temperature gauge.
    d. Water temperature gauge.
    e. Automatic cycle cranking and over-crank protection.

L. Safety controls: Equip engine with automatic safety controls to shut down engine in event of low lubricating oil pressure, high jacket water temperature, overspeed or overcrank.

M. Auxiliary control devices: 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.

N. Provide minimum three NO/NC auxiliary contacts for interface with louvers, fans or other miscellaneous equipment. Contacts shall operate when generator is started.

O. Subbase fuel tank: Provide sub-base day tank mounted underneath engine generator unit. The tank must be elevated a minimum of 2” to prevent corrosion associated with ground contact and to permit complete inspection of the structure:
1. Heavy gauge steel with top and bottom baffles.
2. Heavy gauge steel channel side supports.
3. 1/4 IN drain.
4. 1-1/2 IN fuel level gauge.
5. 2 IN fill-locking fill cap.
6. Primer and enamel exterior to match engine generator unit.
7. Vent sized to tank.
8. Double wall with alarm contact for rupture basin alarm. Provide contacts for remote alarm:
    a. The secondary containment tank must be capable of sustaining a minimum of five (5) pounds per square inch (gauge) pressure for testing the interstitial space for leaks.
9. The tank must have a positive means of preventing overfilling. A sight gauge and/or whistle vent is acceptable.
10. Low level alarm float switch to indicate when operating supply is under 3 hours. 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.
11. Minimum 24 hour full load capacity.
12. Provide vent on tank:
    a. Withstand pressure of day tank shall exceed total developed static head imposed by vent.

13. Tank must be externally coated. The coating must, as a minimum, consist of a primer coat, a bond coat, and two or more final coats of paint, or have an equivalent surface coating system designed to prevent corrosion and deterioration. As a minimum, coatings and application methods must meet the requirements of the Steel Structures Painting Council and National Association of Corrosion Engineers.
14. Pryco PYSB Series.

2.3 BATTERIES

A. Batteries: Dry-charged, lead-acid type:
   1. Furnish electrolyte separately for use when installation is complete and unit is ready for testing:
      a. Provide 3 year prorata warranty on engine-starting batteries.

B. Battery rack: Rack connected with suitable battery cables.

C. Battery charger: Output current rating of at least 1/20th of ampere hour capacity of battery and capable of automatically switching between low rate (float) mode and high rate (equalize) mode:
   1. Include solid state rectifiers, DC voltmeter and ammeter, fuse input and output, and 115 V AC input.
   2. Malfunction alarm contacts for loss of AC power voltage, low and high battery voltage, loss of charge and loss of high rate charge.

2.4 GENERATOR

A. Generator: 4-pole or 6-pole revolving field type with permanent magnet exciter and magnetic amplifier or SCR voltage regulator. No commutator or commutator brushes allowed:
   1. Minimum continuous standby ratings: As indicated, substantiated by manufacturer's standard published curves and conform to NEMA MG-1 specification. Special ratings or maximum ratings are not acceptable:
      a. Generator shall be rated to serve up to 50 percent non-linear load without exceeding standard NEMA temperature rise.
   2. Minimum efficiency: 92 percent at 50 to 110 percent of nominal standby rating, less than 30 percent instantaneous voltage dip at full load and rated power factor and suitable for simultaneous operation with other future units connected in parallel.
   3. Stator and rotor: Class F insulated with 100 percent epoxy impregnation and overcoat of resilient insulating material to reduce possible fungus and/or abrasive deterioration.
   4. Directly connect stator to engine flywheel housing. Gear driven generators are not acceptable.
   5. Drive rotor through semiflexible driving flange to ensure permanent alignment.
   6. Self ventilating with suitable blower, air inlet and outlet openings.
   7. Provide terminal box of adequate size for entrance of flexible conduit for generator leads out bottom from either side.
   8. Generator drive free from critical torsional vibration within operating range.
   9. Provide generator mounted main circuit breaker: Solid state molded case type, ratings as indicated.

B. Voltage regulator: SCR type, to maintain 2 percent voltage regulation from 0 to full load with steady state modulation not exceeding plus 1/2 percent including cross-current compensation to provide maximum of 5 percent unbalance in kva load sharing between this unit and possible future generators:
   1. Provide automatic protection against short circuits on system.
   2. Permit unit to operate at no load below rated frequency for engine start up and shut down procedures.
   3. Provide voltage level and gain controls for normal operating adjustments.
   4. Provide voltage level control with minimum range of plus or minus 5 percent from rated voltage.
   5. Mount regulator, volts per hertz type, in generator housing on suitable vibration isolators.

6. Provide "series boost" type short-circuit current sustaining attachment to allow downstream circuit breakers to trip sequentially.

C. Generator instruments and controls: Generator mounted NEMA 1 type, vibration isolated, code thickness steel instruments and control panel(s):
   1. AC voltmeter and phase selector switch.
   2. AC ammeter and phase selector switch.
   3. Hand-off-auto engine, start-stop control switch.
   4. Frequency meter.
   5. Running time meter.
   6. Indicating wattmeter with on-off switch.
   7. Governor control rheostat.
   8. Cool down time delay 0-15 MIN adjustable.
   9. Green light "ON" to indicate standby power generator system is supplying load.
   10. Red shut down indicating lights as follows:
      a. Overcrank.
      b. Overspeed.
      c. Low lubricating oil pressure.
      d. High engine water temperature.
   11. Amber alarm indicator lights as follows:
      a. Low engine water temperature (less than 70 degF).
      b. Low fuel.
      c. Control switch not in auto position.
      d. Battery charger malfunctioning.
      e. Low battery voltage.
   12. Amber prealarm indicator lights as follows:
      a. High engine water temperature.
      b. Low lubricating oil pressure.
   13. Dry contacts for remote alarms wired to terminal strips.
   14. Voltage level adjustment rheostat.
   15. Panel illumination lights and switch.
   16. Common audible alarm to indicate when one or more of alarm or prealarm conditions exist.

2.5 GENERATOR REMOTE DERANGEMENT SIGNAL ANNUNCIATOR

A. Generator remote derangement signal annunciator:
   1. Flush mounted, with flush plate of No.4 finish, stainless steel, 20 x 20 IN x 4-1/4 IN deep:
      a. Circuits: 24 volts DC powered from starting batteries. Verify circuit voltage to match battery voltage.
      b. Provide red and green signal lamps, buzzer, silencing switch, lamp test switch, relays, solid-state components, and engraved function identifications.

B. Annunciator functions:
   1. Green light "ON" to indicate generator is operating to supply power to load.
   2. Separate red light for each shutdown or alarm condition and amber light for each prealarm condition and common buzzer with silence/ acknowledge switch.
   3. Shut down indicating lights as follows:
      a. Overcrank.
      b. Overspeed.
      c. Low lubricating oil pressure.
      d. High engine water temperature.
   4. Alarm indicator lights as follows:
      a. Low engine water temperature (less than 70 degF).
      b. Low fuel.
      c. Control switch not in auto position.
      d. Battery charger malfunctioning.
      e. Low battery voltage.
      f. Fuel in tank rupture basin.

5. Prealarm indicator lights as follows:
    a. High engine water temperature.
    b. Low lubricating oil pressure.
    c. When generator "main breaker" is open.

C. Remote monitoring:
1. Provide two NO and two NC auxiliary contacts to be monitored by the BMCS system as follows:
    a. Generator running.
    b. Generator pre-alarm or alarm.
    c. Generator shutdown.
    d. Generator low fuel level

2.6 WIRING

A. Conduit: Galvanized steel, flexible heat resistant "Sealtite" conduit.

B. Terminal strip: Terminate wiring at identified terminals on terminal strip in NEMA 12 junction box.

C. Conductors: Stranded copper with THHN insulation.

2.7 ENGINE GENERATOR ENCLOSURE

A. Outdoor weather protective, sound attenuated, self-contained, freestanding, walk-in design enclosing engine-generator set, muffler, sub-base fuel tank and vibration isolators:
1. Twelve gauge steel post and supports with fourteen gauge steel removable panels.
2. Fourteen gauge steel lockable hinged doors with corrosion resistant stainless steel hardware and fasteners.
3. Each side of the engine-generator shall be easily accessible for routine inspection and service.
4. Louvers shall provide adequate ventilation.
5. Cambered roof to prevent water accumulation.
6. Enclosure shall be metal prepped, primed with two coats of self-etching primer, and finished with two coats of the factory standard acrylic enamel paint.
7. Provide anchor bolts for casting into the slab to attach enclosure to pad.

B. The sound pressure level produced by all sources of noise emission from the generator enclosure (including intake air openings, discharge air openings, casing radiated, and the exhaust system) at a distance of 50 feet in any direction from the enclosure shall not exceed 70 dBA:
1. Sound absorbing materials used in the interior walls, ceiling and doors shall have properties including 1200 degrees F continuous service, non-combustible, does not absorb moisture, will not mildew, does not promote or contribute to corrosion and shall include a galvanized, perforated interior liner.
2. Provide additional sound absorption and/or reduction materials to achieve the required sound pressure levels.

2.8 VIBRATION ISOLATION

A. Refer to Section 26 05 48.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install all wiring on engine in conduit except control wiring may be factory installed in high temperature loom.

C. Provide control wiring in conduit between generator control panel, remote derangement signal annunciator panel(s) and remote devices as described under generator instrument and controls paragraph and generator remote derangement signal annunciator paragraph of this specification.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FACTORY PERFORMANCE TEST

A. Each prime mover shall be individually tested. Derating factors for the proposed site shall be applied to test data. Test shall be for continuous period of no less than 2 hours. Test procedure shall be as follows:
   1. Start prime mover and upon reaching rated RPM, pick up 100 percent of nameplate KW rating at rated power factor in one step.
   2. Observe and record the cranking time(s) required to start and run for each prime mover.
   3. Observe and record the time required to come up to operating speed for each prime mover.
   4. Record voltage and frequency overshoot for each prime mover.
   5. Record voltage, frequency and amperes.
   6. Record oil pressure, water temperature where applicable and battery charge rate at first load acceptance and at 15 minute intervals thereafter for each prime mover.

3.3 FIELD PERFORMANCE TEST

A. Provide two load tests and one cycle crank tests. Tests one and two shall be for continuous period of no less than two hours each.

B. Test number one:
   1. With prime mover(s) in a "cold start" condition and emergency load at normal operating level, initiate a normal power failure by opening all switches or breakers supplying normal power to facility.
   2. Observe and record the time delay on engine start.
   3. Observe and record the cranking time(s) required to start and run for each prime mover.
   4. Observe and record the time required to come up to operating speed for each prime mover.
   5. Record voltage and frequency overshoot for each prime mover.
   6. Observe and record time required to achieve steady-state condition with all switches transferred to emergency position.
   7. Record voltage, frequency and amperes.
   8. Record oil pressure, water temperature where applicable and battery charge rate at 5-minute intervals for the first 15 minutes and at 15 minute intervals thereafter for each prime mover.
   9. Return normal power to facility, record time delay on retransfer to normal for each switch and cooldown time delay for each prime mover.

C. Test number two:
   1. Immediately after completion of test number one, start prime mover and upon reaching rated RPM, pick up 100 percent of nameplate KW rating in one step:
      a. Building load can serve as part or all of load, supplemented by a load bank of sufficient size to provide load required. Unity power factor is acceptable for on-site testing.
   2. Observe and record the cranking time(s) required to start and run for each prime mover.
   3. Observe and record the time required to come up to operating speed for each prime mover.
   4. Record voltage and frequency overshoot for each prime mover.
   5. Observe and record time required to achieve steady-state condition.
   6. Record voltage, frequency and amperes.
   7. Record oil pressure, water temperature where applicable and battery charge rate at first load acceptance and at 15 minute intervals thereafter for each prime mover.

D. Cycle crank test: Perform test for each prime mover. Utilize any method recommended by manufacturer to prevent prime mover(s) from running. Put control switch into "run" position to cause prime mover to crank. Observe complete crank/rest cycle as follows:

1. A complete cranking cycle shall consist of an automatic crank period of approximately 15 seconds duration followed by a rest period of approximately 15 seconds duration. Upon starting and running of the prime mover, further cranking shall cease. Two means of cranking termination shall be utilized so that one will act as a backup to the other to prevent inadvertent starter engagement. Cranking limiter time shall be 75 seconds for cycle crank.

E. Furnish load banks of required ratings necessary for tests.

F. Record engine fuel consumption by means of test equipment.

G. Test all safeties specified for generator instruments and controls and generator derangement signal annunciator as recommended by manufacturer and as required to verify proper operation.

H. Demonstrate proper operation of all equipment connected to and/or interfaces with the emergency system including:
   1. Egress lighting including battery operated equipment.
   2. Mechanical equipment including time delay on motor re-start.
   3. Elevator emergency mode operation.
   4. Remote dearrangement alarm panel.
   5. BMCS monitoring points.
   6. Generator exerciser.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide open transition combination bypass isolation automatic transfer switch(es) for following loads:
   1. Emergency branch.
   2. Optional Standby branch.

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. Open transition transfer switches shall have mechanical design of switch such that it will positively open all ungrounded conductors from normal source before connection is made to alternate source and will positively open alternate source before connection is made to normal source:
   1. Design mechanical interlock so it cannot be readily disabled, disconnected, improperly adjusted, removed or otherwise made inoperative.

E. Automatic transfer switch(es) shall be furnished in Type 1 enclosure unless otherwise shown on the plans.

F. All standard and optional door-mounted switches and pilot lights shall be 16-mm industrial grade type or equivalent for easy viewing and replacement.

G. Provide interface control wiring in conduit to other equipment as required for complete and operational system.

1.2 QUALITY ASSURANCE

A. Provide automatic transfer switches conforming to following standards:
   1. UL 1008 Standard for Transfer Switch Equipment.
   2. IEC 947-6-1 Low-voltage Switchgear and Controlgear; Multifunction equipment; Automatic Transfer Switching Equipment.
   3. IEEE Standard 446 Recommended Practice for Emergency and Standby Power. Systems for Commercial and Industrial Applications.
   4. NEMA Standard ICS10-1993 (formerly ICS2-447) AC Automatic Transfer Switches.
   5. UL 508 Industrial Control Equipment.
   6. Automatic transfer switch manufacturer shall be certified to ISO 9001 International Quality Standard and manufacturer shall have third party certification verifying quality assurance in design/development, production, installation and servicing in accordance with ISO 9001.

1.3 SUBMITTALS

A. Shop drawings:
   1. Switches:
      a. Outline drawings of assembly.
      b. One line diagrams and wiring diagrams for assembly and components.
      c. Interconnection wiring diagrams.

B. Product data:
   1. Technical data on each size and type of transfer switch.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Owner instruction report.
   3. Approved factory test reports.
   4. Approved letter of compliance.
   5. Field test reports.

1.4 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Combination bypass isolation/open transition automatic transfer switches:
      a. Base:
         1) Russelectric RTB or RTB-D.
         2) Automatic Switch, Series 7000.
      b. Optional:
         1) GE-Zenith ZBTS.
         2) Cummins BTPC
   2. Manufacturer of switches shall have a certified service representative within 50 miles of job site.

B. Automatic transfer switches: Electrically operated mechanically held 3 phase AC, air-break type, with supervisory relays on each phase of normal source and supervisory frequency/voltage relay for emergency source:
   1. ANSI/UL-1008 listed for paragraph 30.3 emergency service.
   2. Adjust normal source supervisory relays to transfer load if voltage on any phase drops below 70 percent of normal and to restore load to normal source when normal source voltage on all phases is 90 percent or more.
   3. Obtain voltage for main contact operating solenoid from source to which load is being transferred.
   4. 480 volt.
   5. Make mechanical design of switch such that it will positively open all ungrounded conductors from normal source before connection is made to alternate source and will positively open alternate source before connection is made to normal source.
   6. Design mechanical interlock so it cannot be readily disabled, disconnected, improperly adjusted, removed or otherwise made inoperative.
   7. Switch shall have provisions for visual inspection of switch blades and contacts.
   8. Silver-surface main contacts and protect by arcing contacts.
   9. Make all contacts and coils readily accessible for replacement from front of panel without major disassembly.
   10. Provide red and green indicating lights with fuses, identification nameplates, and test switch on front to simulate normal power failure at switch.
   11. Rate each individual switch as indicated.
   12. Provide engine starting contacts and all other auxiliary contacts and accessory devices for functions to be performed.

13. Provide time delay on engine start, field adjustable from 0 to 10 SEC, by SEC, and factory set at 4 SEC, to avoid unnecessary starting caused by short time outages.
14. Provide time delay on retransfer to normal, field adjustable from 2 to 30 minutes, by minute, and factory set at 5 minutes to avoid erratic operation caused by short time reestablishment of normal source.
15. Automatic transfer switches serving Emergency Branch (EATS):
    a. Transfer to be made to generator automatically within 10 SEC maximum.
16. Automatic transfer switches serving Optional Standby Branch (QATS):
    a. Provide time delay on transfer to generator, field adjustable from 0-120 SEC, by SEC, and factory set at 10 SEC.
17. Provide one of the following to prevent out-of-phase transfers in either direction:
    a. Dual operator with transition time delay field adjustable 1-300 seconds; set at 3 seconds.
    b. In-phase monitor: Manufacturer shall coordinate window width with transfer switch operating speed to limit inrush currents to normal starting currents or less.
    c. Neutral position integral to transfer switch with transition time delay field adjustable 1-300 seconds; set at 3 seconds.

C. Combination bypass isolation/automatic transfer switch(es):
1. Two-way bypass-isolation switch(es) 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.

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 percent of nominal voltage.

b. Frequency sensing shall be accurate to plus or minus 0.2 percent.
c. Panel shall be capable of operating over temperature range of minus 20 to plus 60 degrees C and storage from minus 55 to plus 85 degrees C.

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. All 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 requirements for Electromagnetic Compatibility (EMC) as follows:
   a. IEC/EN 55011: 1991Emission standard - Group 1, Class A.
   b. IEC/EN 50082-2: 1995 Generic immunity standard.
   c. IEC/EN 61000-4-2: 1995 Electrostatic discharge (ESD) immunity.
   d. IEC/EN 50140: 1993 Radiated Electro-Magnetic field immunity.
   e. IEC/EN 61000-4-4: 1995 Electrical fast transient (EFT) immunity.
   f. IEC/EN 61000-4-5: 1995 Surge transient immunity.
   g. IEC/EN 61000-4-6: 1996 Conducted Radio-Frequency field immunity.
   h. IEEE472 (ANSI C37.90A) Ring Wave Test.

2.2 OPERATION

A. Engine starting contacts shall be normally open contacts that close 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. Continuously monitor voltage and frequency on both normal and emergency sources and provide adjustable dropout and pickup setting ranges (nominal) as follows:
   1. Under-voltage dropout: 70 to 98 percent of nominal voltage. (3 phase).
   2. Under-voltage pickup: 85 to 100 percent of nominal voltage. (3 phase).
   3. Over-voltage dropout: 102 to 115 percent of nominal voltage. (3 phase).
   4. Over-voltage pickup: 2 percent below over-voltage dropout. (3 phase).
   5. Under-frequency dropout: 85 to 98 percent of nominal frequency.
   6. Under-frequency pickup: 90 to 100 percent of nominal frequency.
   7. Over-frequency dropout: 102 to 110 percent of nominal frequency.
   8. Over-frequency pickup: 2 percent below over-frequency dropout.
   9. Voltage unbalance dropout: 5 to 20 percent of nominal voltage.
   10. Voltage unbalance pickup: 1 percent below voltage unbalance dropout.

E. Repetitive accuracy of all settings shall be within plus or minus 0.5 percent over an operating temperature range of minus 20 degC to plus 60 degC.

F. Voltage and frequency settings shall be field adjustable in 1 percent increments either locally with display and keypad or remotely via serial communications port access.

G. 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).

H. 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.

I. 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.

J. 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.

K. 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.

L. 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.

M. 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 days controller is energized.
      4) Total number of hours both normal and emergency sources are available.

N. 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.

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.
2. Annunciator/control panels if provided.
3. Time delay signal prior to and after transfer from one source to another where indicated.
4. Building Control Systems where indicated. (Termination at BCS control panels by Mechanical Contractor).
5. Label both ends of all conductors noting points of opposite termination.

3.2 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.

C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 41 13
LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide system complying with UL and bearing the Master-C label.

1.2 QUALITY ASSURANCE

A. System standards: ANSI/UL-96A, and NFPA-780.

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.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM

A. Lightning protection system: Complete Master Label lightning protection system.

B. Acceptable manufacturers:
   1. Lightning protection system:
      a. Base: Listed in lightning protection section of current edition of UL electrical equipment test.
         1) Harger Lightning Protection.
         2) Thompson Lightning Protection.
         3) Robbins Lightning Protection.
         4) Heary Brothers Lightning Protection.
         5) Independent Protection.
         6) AC Erico Lightning Protection.
         7) National Lightning Protection.

2.2 MATERIALS

A. Materials - General: Labeled for lightning protection systems by UL.
   1. All components designed to blend in with appearance of building so that it appears as part of building.
   2. Maximum concealed system as required to meet Architect's requirements.

B. Conductors: Copper or aluminum, grade ordinarily used for commercial electric work and of weight required by height of building.
   1. Conductors above the roof shall be copper or aluminum and shall be compatable with roofing material to prevent galvanic corrosion.
      a. Attach conductors to building with proper cast bronze, copper, or aluminum base with adhesive or fasteners to adapt to building design.

2. Conductors below the roof and in contact with soil shall be copper.

C. Air terminals: Solid copper or aluminum rod with safety HP, non-impalement type, of height required.
   1. Attach rods to building with proper cast bronze, copper, or aluminum base with adhesive or fasteners to adapt to building design.
   2. On sloped roofs, provide swivel adapter to allow vertical mounting of rod.
   3. Mid roof terminals shall be safety tipped type.

D. Ground rods: 3/4 IN x 10 FT copper weld.

E. Main ground connection fittings: 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. Structural steel columns may be used as down conductors.

C. 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 for all 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.

D. Interconnect all metal bodies on roof (such as ventilators, stacks, pipes, gutters, downspouts, ducts, tracks, antennas, water pipes, ladders) to main conductor system.

E. Interconnect all metal bodies within bonding distance in accordance with NFPA 780.

F. Provide connection to incoming electric and telephone service ground per NEC for common bonding.

G. Provide connection to all underground metallic pipe services entering the building.

H. Provide roof flashings or other method approved by roof manufacturer for down conductor or fittings passing through roofs. Do not use pitch pockets.

I. Adhesives and fasteners shall be compatible with roofing material. Coordinate with roofing manufacturer.

J. Remove and replace any items found not in compliance with specification requirements.

END OF SECTION

SECTION 26 43 13

TRANSIENT VOLTAGE SUPPRESSION FOR LOW VOLTAGE EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This specification includes equipment that clamps transient voltage, diverts surge current and attenuates high-frequency electrical line noise.

B. TVSS's shall be provided in the following applications:
   1. Internally mounted within the switchgear and electronic grade panelboard enclosures.

1.2 QUALITY ASSURANCE

A. The specified system shall be designed, manufactured, tested, and installed in compliance with the following standards:
   1. American National Standards Institute and Institute of Electrical and Electronic Engineers (ANSI/IEEE-C62.41 and ANSI/IEEE-C62.45).
   2. Federal Information Processing Standards Publication 94 (FIPS PUB 94).
   3. Federal Specification (W-P-115b and W-C-375a, b).
   4. National Electrical Manufacturers Association (NEMA LS-1, AB-1, PB-1, PB-1.1 and PB-1.2.
   5. National Fire Protection Association (NFPA-70 [NEC], NFPA-75 and NFPA-78).
   6. Underwriters Laboratories (ANSI/UL-50, Enclosures for Electrical Equipment, ANSI/UL-67, Panelboards, ANSI/UL-489, Molded Case Circuit Breakers and Circuit Breaker Enclosures, ANSI/UL-943, Ground Fault Circuit Interrupters, ANSI/UL-1283, Electromagnetic Interference Filters and ANSVUL 1449 Second Edition, Transient Voltage Surge Suppressors).
   7. Military Standard 220A.

B. Internally mounted TVSS equipment shall be UL-1449 and UL-1283 component recognized as a transient voltage surge suppressor and electromagnetic interference filter and shall be UL-witnessed/tested within switchgear and panelboard enclosures as applicable.

1.3 DEFINITIONS

A. Clamping Voltage: The applied surge shall be induced at the 90 degree phase angle of the applied system frequency voltage. The voltage measured at the end of the 6 IN output leads of the TVSS and from the zero voltage reference to the peak of the surge.

B. Let-Through Voltage: The applied surge shall be induced at the 90 degree phase angle of the applied system frequency voltage. The voltage measured at the end of the 6 IN output leads of the TVSS and from the system peak voltage to the peak of the surge.

C. Maximum Continuous Operating Voltage (MCOV): The maximum steady state voltage at which the TVSS device can operate and meet its specification within its rated temperature.

D. Maximum Surge Current: The maximum 8x20 microsecond surge current pulse the TVSS device is capable of surviving on a single-impulse basis without suffering either performance degradation or more than 10 percent deviation of clamping voltage at a specified surge current. Listed by mode, since number and type of components in any TVSS may vary by mode.

E. Protection Modes: This parameter identifies the modes for which the TVSS has directly connected protection elements, i.e., line-to-neutral (L-N), line-to-line (L-L), line-to-ground (L-G), neutral-to-ground (N-G).

F. Surge Current per Phase: The per phase rating is the total surge current capacity connected to a given phase conductor. For example, a wye system surge current per phase would equal L-N plus L-G; a delta system surge current per phase would equal L-L plus L-G. The N-G mode is not included in the per phase calculation.

G. System Peak Voltage: The electrical equipment supply voltage sine wave peak (i.e., for 480/277 volt system the L-L peak voltage is 679V and the L-N peak voltage is 392V).

1.4 SUBMITTALS

A. Shop drawings:
   1. Submit all unit dimensions, weights, mounting provisions, connection details and layout diagram(s) of each unit.

B. Product data:
   1. Standard Catalog Data Sheet.
   2. UL 1449 product listing data.
   3. UL 1283 product listing data.
   4. Signed and Certified Clamping Voltage data from a third party testing laboratory, including oscilloscope waveform snap shots for IEEE C62.41 Category C3 and B3 waveforms. Testing shall be in accordance with IEEE C62.45.
   5. Signed and Certified spectrum analysis from a third part testing laboratory verifying the device meets the indicated noise attenuation. Testing shall be in accordance with MIL-STD-220A.
   6. Signed and Certified Surge Current data from a third party testing laboratory.
   7. Signed and Certified Repetitive Surge Current data from a third party testing laboratory.

C. Contract closeout information:
   1. Operating and maintenance data.
   2. Copy of five (5) year warranty on SPD equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufacturers:
   1. Transient Voltage Surge Suppression:
      a. Base:
         1) Square D/Advanced Protection Technologies.
      b. Optional:
         1) EATON Cutler-Hammer.
         2) Siemens Energey & Automation/Sentron.
         3) Current Technology.
         4) United Power.
         5) Liebert.
         6) Lea Dynatech.

B. Environmental requirements:
   1. Storage temperature range shall be minus 40 degF to plus 185 degF.
   2. Operating temperature range shall be minus 40 degF to plus 140 degF.
   3. Relative humidity range shall be 5 percent to 95 percent non-condensing.
   4. Capable of operation at altitudes up to 13,000 feet above sea level.
   5. No audible noise.
   6. No appreciable magnetic fields. System shall be capable of use directly in computer rooms or in any other location without danger to data storage systems or devices.

C. Electrical Requirements:
   1. The nominal unit operating voltage and configuration shall be as indicated on the drawings. The nominal unit operating frequency shall be 60 Hz.
   2. The maximum continuous operating voltage (MCOV) of all suppression components utilized in the unit shall be greater than 115 percent of the nominal system operating voltage.
   3. Tested and suitable for ANSI/IEEE C62.41 Category C3 environments.
   4. Protection modes:
      a. For a wye configured system, device must have directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G).
   5. Maximum surge current rating:
      a. Switchgear applications:
         1) Maximum surge current rating per phase shall be minimum 400kA.
         2) Maximum surge current rating per mode shall be minimum 200kA.
      b. Electronic grade panelboard applications:
         1) Maximum surge current rating per phase shall be minimum 120kA.
         2) Maximum surge current rating per mode shall be minimum 60kA.
   6. Maximum suppression voltage rating (SVR):
      a. 120/208V system: 400 volt (L-N, L-G, N-G).
      b. 277/480V system: 800 volt (L-N, L-G, N-G).
   7. Maximum ANSI/IEEE Category C3 let through voltage based on IEEE C62.41 and C62.45 recommended procedures for Category C3 surges (20 kV, 10 kA):
      a. 120/208V: 470 volt (L-N).
      b. 277/480V: 900 volt (L-N).
   8. All TVSS equipment shall be capable of surviving more than 2500 ANSI/IEE C62.41 category C3 transients without failure or more than 10 percent degradation of UL 1449 clamping voltage.
   9. EMI/RFI filter shall provide minimum 50 dB noise attenuation at 100 kHz using MIL-STD-220A insertion loss test method.
   10. Surge current shall be equally distributed to all components to ensure equal stressing and maximum performance.
   11. Suppression system shall not utilize gas tubes, spark gaps or other components which short or crowbar the line leading to interruption of power.
   12. Multiple TVSS units shall not be connected in series to achieve the specified performance.
   13. Provide 200 kAIC internal fusing at the component level.
   14. Safety and diagnostic monitoring:
      a. Solid state monitoring of each mode and power loss in any phase. Monitoring of fuse status only is unacceptable.
      b. Audible alarm and surge counter. Surge counter shall utilize self-contained batteries with a nominal life of ten (10) years.
      c. Form C dry contacts (NO/NC) for remote status monitoring. Alarm contact shall change state if any fault condition occurs.
      d. Externally visible green/red solid state indicator lights. Absence of a green light and presence of red light shall indicated which mode(s) or phase(s) have been damaged. Fault detection will activate a flashing trouble light.

D. Internally mounted TVSS equipment:
   1. Provide 200 kA input fuses integrally mounted to the TVSS unit. Provide integrally mounted fused disconnect if TVSS is not connected via branch circuit breaker.
   2. TVSS equipment shall be mounted in the factory of the enclosure manufacturer.
   3. TVSS equipment shall be connected directly to the protected equipment bus on the load side of the mains. If bus is not possible, provide minimum #1/0 conductors at a maximum length of 12 IN.
   4. Diagnostics shall be remotely mounted on the cover of the equipment enclosure and visible from outside the enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install TVSS equipment per manufacturer's recommendations.

3.2 TESTING

A. The unit(s) shall be thoroughly factory-tested before shipment. Testing of each unit shall include but shall not be limited to quality assurance checks, MCOV and clamping verification tests. The MCOV testing shall consist of the unit(s) being burned-in at the applicable MCOV for a minimum of one (1) hour.

B. When MEGGER testing the distribution system, temporarily disconnect all connections to TVSS equipment. Reconnect upon completion of test.

3.3 WARRANTY

A. The manufacturer shall provide a Limited Five-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.

END OF SECTION

SECTION 26 51 13

INTERIOR LIGHTING (Revised AD-4)

PART 1 - GENERAL

1.1 SUBMITTALS

A. Product data:
   1. Lighting:
      a. Names of manufacturers, cuts, catalog numbers and photometric performance curves with candlepower distribution and C.U. tables of all lighting fixtures to be used on project.
      b. Identify fixtures by Fixture Schedule number, including special notations for finishes, colors, and mountings.
      c. Product data on ballasts for 4 FT fluorescent lamps.
      d. Product data for 4 FT fluorescent lamps.

B. Contract closeout information:
   1. 5 year warranty for electronic fluorescent ballasts.
   2. 2 year warranty for HID ballasts.

1.2 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES - GENERAL

A. Acceptable manufacturers:
   1. Lighting fixtures:
      a. Base:
         1) As indicated on Fixture Schedule.
      b. Optional:
         1) As indicated on Fixture Schedule.
   2. Lamps:
      a. Base:
         1) Osram/Sylvania.
         2) General Electric.
         3) Philips Lighting.
         4) Venture.
   3. Lenses:
      a. Base:
         1) ICI Acrylics.
         2) As indicated.
   4. Ballasts:
      a. Base:
         1) Advance.
         2) Magnetek.
         3) Power Lighting Products.
         4) Motorola.

5) Osram/Sylvania.
6) Robertson.

5. Other manufacturers desiring approval comply with Section 00 26 00.

B. All lighting fixtures and electrical components: UL labeled, complete with lamps.

C. Provide all recessed fixtures with gaskets of rubber, fiberglass, or equivalent material to prevent light leaks around flush trim.
1. Provide recessed fixtures with trim gaskets cemented in proper position.

D. Provide standard plaster frame for all recessed lighting fixtures installed in plaster walls or ceilings.
1. Design, finish and fabricate material to preclude possibility of rust stain in plaster.

E. Coordinate fixture types with ceiling construction.

F. Provide pendant incandescent, compact fluorescent, and/or HID fixtures with swivel hangers which will allow fixture to swing in any direction but will not permit stem to rotate.
1. Provide hangers with enclosure rating (NEMA 1, 4, or 7) equal to enclosure requirements of area in which they are installed.
2. Swivel hangers for fixtures in mechanical equipment areas: Shock absorbing type.

G. Pendant mounted, open, industrial fluorescent fixtures, not in continuous rows, shall be supported by conduit or by approved chains with cord and plug connection to ceiling mounted twistlock receptacle as indicated on plans. Rigidly support continuous row pendant mounted fluorescent fixtures with conduit and fasten fixtures to each other or mount on continuous metal channel similar to Unistrut. Provide reflector alignment clips on all industrial fluorescent fixtures mounted in continuous rows.

2.2 LAMPS

A. Incandescent lamps: As indicated in fixture schedule.
1. Use only lamps that meet current Federal energy standards (EPACT 1992).

B. Fluorescent lamps:
1. T8 (265 mA) rapid-start medium bipin lamps.
a. Correlated color temperature of 3500 degrees Kelvin.
b. Minimum color rendering index (CRI) of 80.
c. Minimum initial lumen ratings for each lamp type shall be:
1) 1300 lumens for 24 inch, 17 watt F17T8 lamp.
2) 2025 lumens for 36 inch, 25 watt F25T8 lamp.
3) 2800 lumens for 48 inch, 32 watt F32T8 lamp.
2. T5 programmed-start miniature bipin lamps.
a. Correlated color temperature of 3500 degrees Kelvin.
b. Minimum color rendering index (CRI) of 82.
c. Minimum initial lumen ratings for each lamp type shall be:
1) 1350 lumens for 22 IN, 14 watt F14T5 lamp.
2) 2100 lumens for 34 IN, 21 watt F21T5 lamp.
3) 2900 lumens for 46 IN, 28 watt F28T5 lamp.
4) 3650 lumens for 58 IN, 35 watt F35T5 lamp.
5) 2000 lumens for 22 IN, 24 watt F24T5/HO lamp.
6) 3500 lumens for 34 IN, 39 watt F39T5/HO lamp.
7) 5000 lumens for 46 IN, 54 watt F54T5/HO lamp.
8) 7000 lumens for 58 IN, 80 watt F80T5/HO lamp.
3. T4 triple twin-tube compact fluorescent lamps.
a. Correlated color temperature of 3500 degrees Kelvin.
b. Minimum color rendering index (CRI) of 80.
c. Minimum initial lumen ratings for rapid-start 4-pin triple twin-tube lamps with a GX24q-2, GX24q-3, or GX24q-4 base shall be:
1) 1200 lumens for 4.3 IN, 18 watt CF18TTT lamp.

2) 1800 lumens for 4.9 IN, 26 watt CF26TTT lamp.
3) 2400 lumens for 5.5 IN, 32 watt CF32TTT lamp.
4) 3200 lumens for 6.3 IN, 42 watt CF42TTT lamp.

C. High intensity discharge (HID) lamps:
1. Metal halide lamps.
a. Metal halide lamps shall be pulse-start type. If used in an open luminaire, the lamp shall be rated for use in an open fixture and incorporate a protective arc tube shroud design.
b. Coated lamps shall have a correlated color temperature of 3200 degrees Kelvin. They are designated on the fixture schedule by "/C/3K".
c. Minimum color rendering index (CRI) for coated lamps is 70.
d. Minimum initial lumen ratings for metal halide lamps with a medium base in a vertical position shall be:
1) 3200 lumens for 50 watt, ED-17 (ANSI M110) clear lamp.
2) 5600 lumens for 70 watt, ED-17 (ANSI M98) clear lamp.
3) 8500 lumens for 100 watt, ED-17 (ANSI M90) clear lamp.
4) 14250 lumens for 150 watt, ED-17 (ANSI M102) clear lamp.
5) 17500 lumens for 175 watt, ED-17 (ANSI M137) clear lamp.
e. Minimum initial lumen ratings for metal halide lamps with a mogul base in a vertical position shall be:
1) 14250 lumens for 150 watt, ED-28 (ANSI M102) clear lamp.
f. Metal halide lamps are designated on the lighting fixture schedule by the following prefixes:
1) MH: Pulse start metal halide, enclosed fixture rated.
2) MP: Pulse start metal halide, open fixture rated.
2. High pressure sodium lamps.
a. Correlated color temperature of 2100 degrees Kelvin.
b. Minimum color rendering index (CRI) of 21.
c. High pressure sodium lamps are designated on the lighting fixture schedule by the prefix HPS.
3. Refer to lighting fixture schedule for proper specification of clear or coated lens, lamp operating position, and base type.
4. Ensure that lamps provided have the correct bulb shape for the fixture specified.

AD-4: Section 26 51 13: Add paragraphs 2.2.D through 2.2.D.2.

D. Light-emitting diode (LED) Lamps and Drivers:
1. Lamps and Driver System.
a. Shall comply with the following testing standards:
1) Illuminating Engineering Society of North America IESNA LM 79.
2) Illuminating Engineering Society of North America IESNA LM 80.
3) Department of Energy (DOE) Solid State Lighting (SSL) life cycle cost assessment.
b. Shall be Energy Star rated.
c. LED and Lamp Driver System shall be provided from the same manufacturer.
d. LED and Lamp Driver system shall carry a five-year warranty.
2. As indicated on Fixture Schedule.

2.3 BALLASTS

A. Fluorescent high frequency electronic ballasts:
1. "High Frequency" electronic ballast shall operate lamps at a frequency of 20 KHz or higher without visible flicker.
2. Electronic ballast shall have a Power Factor greater than 98 percent.
3. Electronic ballast's input current shall have Total Harmonic Distrotion (THD) of less than 10 percent for 120V ballasts and less than 15 percent for 277V ballasts.
4. Electronic ballast shall have Lamp Current Factor of less than 1.4, in accordance with lamp manufacturer's recommendations and ANSI C82.11.

5. Ballast shall be instant start with lamps wired in parallel.
6. Ballast shall be rapid start with lamps wired in series.
7. Electronic ballast shall support a sustained short to ground or open circuit of any output leads without damage to the ballast.
8. Ballast factor shall be greater than .85 per ANSI C82.11.
9. Audible noise rating of ballast shall be Class A or better.
10. Ballast shall tolerate operation in ambient temperatures up to 105 degF without damage.
11. Light output shall remain constant for a line voltage fluctuation of +/- 5 percent.
12. Ballast shall meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18, for non-consumer equipment for EMI and RFI.
13. Electronic ballast shall meet ANSI C82.11 standards regarding harmonic distortion.
14. Ballast shall meet ANSI C62.41 Cat. A for transient protection.
15. Electronic ballast shall comply with all applicable state and federal efficiency standards.
16. Electronic ballast shall be Underwriters' Laboratories (UL) listed (Class P) and CSA Certified where applicable.
17. Electronic ballast shall not contain Polychlorinated Biphenyls (PCB's).
18. Electronic ballast shall carry a five-year warranty.
19. Manufacturer shall have a 10-year history of producing electronic ballasts.
20. Electronic ballast shall be Advance Mark V, Magnetek Triad "RP", Valmont Ultra-Miser II, or Motorola High Performance.

B. HID ballasts: Constant wattage autotransformer (CWA) with ignitor, 277V controlled linear current reactor, or high reactance autotransformer (HX-HPF) type, energy efficient ballasts.
1. High power factor, ETL approved.
2. Starting current shall be no greater than operating current.
3. Ballasts for interior use:
   a. Encased and potted type.
   b. Audible noise rating of B or better.
   c. Built-in automatic resetting thermal protection switch.
4. Ballasts for exterior use shall be capable of operating at temperatures as low as -20 degF.

2.4 FLUORESCENT FIXTURES

A. Fluorescent fixtures: Troffer type.
1. Major structural parts: Minimum 22 GA electro-plated zinc-coated steel, bonderized for paint adhesion and rust prevention.
   a. Body of fixture and door frame shall be painted after fabrication.
2. Finish: Baked-on white enamel paint, 1.4 to 1.7 mil thick, with minimum reflection factor of 89 percent.
3. Sizes: As indicated on schedule.
4. Minimum efficiency: 65 percent.
5. Lenses: Low brightness, clear prismatic lens made of 100 percent virgin acrylic.
   a. Conical shaped, female .1875 IN square-based prisms aligned 45 degrees to the length and width of the panel for 2 x 4 FT fixtures and smaller.
      1) Nominal thickness: 0.125 IN.
      2) Maximum penetration: 0.080 IN.
      3) Average weight: 7.8 OZ per SQ FT.
   b. KSH-12.
6. Design door frames and lens assemblies to allow complete removal for cleaning, and to hold lens securely in position without light leaks.
7. Door latches: Finish for corrosion-resistance and fabricate of inconspicuous design, for operation without tools.
   a. Do not use slotted screws or thumb screws to latch door.
   b. Provide enclosed spring-loaded cam latches to provide positive latching of door.
8. Furnish hold-down clips for attachment to ceiling framing system as required.

2.5 HID FIXTURES

A. HID lighting fixtures: Provide with heavy-duty porcelain sockets.
   1. Fixtures: As indicated in fixture schedule.
   2. Fixtures with quartz restrike feature: Fixture shall be wired for single connection. Ballast shall provide power to quartz lamp as well as HID lamp.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten lighting fixtures supported by suspended ceiling systems to ceiling framing system with hold down clips.

B. Locate fixtures in accordance with reflected ceiling plans.

C. Locate in exact center of tile when indicated. Relocate misplaced fixtures and replace damaged ceiling materials.

D. Mount lighting fixtures at heights indicated in Section 26 00 10 and as detailed.

E. Provide access panels for recessed light fixtures that require access for maintenance when such access is not provided for in design of fixture. See Section 26 00 10.

F. Where indicated provide 2-level control of 3 and/or 4 lamp fluorescent fixtures. Provide 2 ballasts per fixture and control inside lamp(s) in each fixture by one switch or set of switches and the outside 2 lamps by a second switch or group of switches.

G. Orientate the fluorescent lamps of all 2 FT x 2 FT troffers and non-directional compact fluorescent downlights within a single room in the same direction.

H. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 ADJUST AND CLEAN

A. Wipe all lighting fixture reflectors, lenses, lamps and trims, clean, after installation. All fixtures shall be installed with caution so as to avoid any fingerprints or smudges on surfaces of parabolic louvers and downlight reflectors. Any fixtures with fingerprints or smudges shall be cleaned.

B. Replace all lamps operated during construction period with new lamps prior to final acceptance.

C. Adjust all incandescent fixture sockets to match the lamp specified.

D. Aim all adjustable fixtures as directed by Architect.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 56 00

EXTERIOR LIGHTING (Revised AD-1)

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop drawings:
   1. For special assemblies.

B. Product data:
   1. Lighting:
      a. Names of manufacturers, cuts, catalog numbers and photometric performance data and isofootcandle plots where applicable of all lighting fixtures to be used on project.
      b. Identify fixtures by Fixture Schedule number, including special notations for finishes, colors, and mountings.

1.2 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Luminaires:
      a. Base:
         1) As indicated on schedules.
   2. Contactors:
      a. Base:
         1) Schneider Electric/Square D.
         2) Eaton Electrical.
         3) General Electric.
         4) Allen-Bradley.
   3. Selector switches:
      a. Base:
         1) Allen-Bradley.
         2) Eaton Electrical.
         3) Schneider Electric/Square D.
         4) General Electric.
         5) Siemens Allis-ITE.
   4. Photo cells and time switch:
      a. Base:
         1) Tork.
         2) Intermatic.
         3) Sangamo.
         4) Paragon Electric.
   5. Rigid PVC conduit:
      a. Base:
         1) As specified in Section 26 05 33.

6. Other manufacturers desiring approval comply with Section 00 26 00.

B. Luminaire and pole assemblies: As scheduled.

AD-1: Section 26 56 00: Revise paragraph 2.1.C.

C. Poles: As indicated on schedules, designed for 100 MPH constant velocity wind load.
   1. Include base template, 4 anchor bolts, cadmium-plated hardware and pole grounding lug, handhole, cast steel anchor base and bolt covers.

D. Pole foundations: As indicated.

E. Underground wiring:
   1. Type XHHW or THW installed in rigid PVC conduit.
   2. Provide all wiring runs with separate green equipment grounding conductor, and ground all pole bases.

F. Ballasts for exterior HID and fluorescent lamps: UL approved, high power factor, designed for -20 degF temperature starting.

G. Diffusers: 100 percent virgin acrylic Plexiglas.
   1. All hardware and fasteners corrosion resistant finished.
   2. Clear Plexiglas diffusers or lenses are required for certain luminaires, see Schedule.

H. Pole wiring from base to ballast: No.12 type TW, each phase protected by a 30 A, 600 volt type Tron waterproof fuseholder, Bussmann "Limitron" type, size rating 3-times load current.

I. Contactors: Electrically held type, rated at 480 volts AC, 30 ampere lighting load, minimum with number of poles required, 120-volt operating coil, designed for tungsten, fluorescent metal halide, high pressure sodium or mercury lamp loads.
   1. Provide NEMA 1 sheet metal case.
   2. Schneider Electric/Square D, Class 8903.

J. Exterior lighting control: Two photo electric cells which will turn on 3 circuits at sunset and time switch which will turn off Part Night circuit at time desired by Owner.
   1. Time switch circuits to receive 120 volt control voltage from photo electric cell.
   2. All Night and exterior emergency circuits turned on and off by photo electric cells.
   3. Control system: 120 volts.
   4. Control wiring: No.14 AWG minimum.

K. Photo-cells: 120 V, 60 cycles, enclosed weatherproof type for outdoor application.
   1. 1/2 IN conduit entrance.
   2. Fail-safe operation.
   3. Provide time delay device to eliminate nuisance switching.
   4. Controls: Temperature compensated, spectrum response permitting cell to face any direction except south.
   5. Provide unit with surge protection.
   6. Switch: SPST rated for 1,000-watts incandescent lamp load.
   7. Operating point field adjustable from 2 to 50 foot candles.
   8. Tork Model No.2101.

L. Time switch: 120 V, 60-cycle synchronous, motor operated, 24-dial, one circuit type with switches rated 40 A at 120/240 V.
   1. 16 hour electric rewind reserve power.
   2. Indoor flush mounting case.
   3. Provide separate manual on and off levers and arrange terminals to receive 120 volt control voltage from photo cell for on operation.
   4. Tork Model No.7100L.

M. Time switch cabinet: 12 x 12 x 6 IN hinged door, flush, steel, cabinet.
   1. Provide with 2 terminal strips for distribution of control wiring for 2 circuits, 1 All Night, and 1 Part Night.

2. Provide heavy duty type H-O-A selector switch in door and connect to control output lead from photo-cell to serve as master control.
3. Selector switch: Allen-Bradley Bulletin 800.
4. Label selector switch Exterior Lighting with engraved black phenolic nameplate.

N. Emergency circuit cabinet: Hinged-door flush cabinet for emergency All Night exterior exitway lights, complete with terminal strips and selector switch on door to permit manual operation of control circuit in event photo cell becomes inoperative.
1. Provide engraved nameplate reading Exterior Emergency Lighting.
2. Cabinet to contain only emergency circuit control wiring.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all roadway, walkway and parking lighting, and their wiring as indicated.

B. Make conduit bends without injuring conduit or reducing internal diameter.

C. Install photo cells approximately 6 FT above roof with cells facing north.

D. Install time switch and emergency circuit cabinets 5 FT above floor in _____.

E. Exterior lighting control circuits as follows, including various lighting systems as scheduled.
1. All Night circuit No.1.
2. Part Night circuit No.2.
3. Emergency circuit No.3.

F. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.2 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 26 90 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description
B. Responsibilities
C. Related Work
D. Test Equipment
E. Submittals
F. Startup
G. Functional Performance Tests
H. Testing Documentation, Non-Conformance and Approvals
I. Operation and Maintenance Manuals
J. Training of Owner Personnel
K. Deferred Testing
L. Written Work Products

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 26 responsibilities in the commissioning process that are being directed by the CA. Other electrical systems testing are required under the direction of the GC.

B. The list of commissioned equipment and systems is found in Section 01 91 00.

C. Commissioning requires the participation of Division 26 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 26 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Electrical Contractors. The commissioning responsibilities applicable to the Electrical Contractor are as follows *(all references apply to commissioned equipment only)*:

1. Construction and Acceptance Phases:

a. Include the cost of commissioning in the contract price.
b. In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.
c. Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Cx process.
d. Contractors shall provide normal cut sheets and shop drawing submittals to the CA of commissioned equipment.
e. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.

1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, fan and pump curves, full factory testing

reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

2) The Commissioning Agent may request further documentation necessary for the commissioning process.

3) This data request may be made prior to normal submittals.

f. Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review and approval.

g. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

h. Provide assistance to the CA in preparation of the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

i. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.

j. During the startup and initial checkout process, execute and document the electrical-related portions of the prefunctional checklists provided by the CA for all commissioned equipment.

k. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.

l. Address current A/E punch list items before functional testing.

m. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

n. Perform functional performance testing under the direction of the CA for specified equipment in Section 01 91 00. Assist the CA in interpreting the monitoring data, as necessary.

o. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, GC and A/E and retest the equipment.

p. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

q. During construction, maintain as-built red-line drawings for all drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built drawings for all drawings and final as-builts for Contractor-generated coordination drawings.

r. Provide training of the Owner's operating personnel as specified.

s. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period

a. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

1.4 RELATED WORK

A. Refer to Section 01 91 00 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 01 91 00 for systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 26 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 00 for additional Division 26 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Division 26 shall provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 for additional Division 26 requirements.

3.2 STARTUP

A. The Electrical Contractor shall follow the start-up and initial checkout procedures listed in the Responsibilities List in this section and in Section 01 91 00. Division 26 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the CA. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3 CONTRACTOR TESTS

A. Subcontractors/installers shall forward to the Commissioning Authority, through the GC, a list and schedule of specified contractor tests. The tests shall include at least the following:

Section 26 00 10	Electrical Gen Requirements	3.6	Field Quality Control
		3.7	Performance Tests
Section 26 05 13	Medium Voltage Cable	3.4	Cable Testing
Section 26 05 19	Low Voltage Wire and Cable	3.3	Cable Testing
Section 26 05 26	Grounding & Bonding	3.3	Testing
Section 26 09 13	Power Monitoring and Control	3.2	Testing
Section 26 11 16	Secondary Unit Substation	3.1	Factory Tests
Section 26 24 13	Switchboards	3.2	Ground Fault Tests
Section 26 32 13	Engine Generator	3.2	Factory Performance Tests
		3.3	Field Performance Tests
Section 26 36 23	Automatic Transfer Switches	3.2	Factory & Field Tests

B. Unless specified otherwise, provide a minimum one week prior notice to the Commissioning Authority and A/E, through the GC for each specified Contractors' test.

C. Submit Contractors' test reports to the Commissioning Authority and A/E, through the GC within one week of the successful completion of each test. Contractors shall document and issue a test report for each required test. The test report shall contain all information required by the respective specification section including the test date, start time, stop time, test duration, initial values, final values, expected result, and acceptable test values (per individual specification sections). The person(s) conducting each test and the local code authority (if applicable) shall sign and date each test report indicating that the test has been successfully completed and the results are within acceptable parameters.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 00 for a list of systems to be commissioned. Samples are included at the end of this section for representative test formats and examples.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01 91 00 for specific details on non-conformance issues relating to prefunctional checklists and tests.

B. Refer to Section 01 91 00 for issues relating to functional performance tests.

3.6 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Division 26 shall compile and prepare documentation for all equipment and systems covered in Division 26 and deliver to the GC for inclusion in the O&M manuals, according to Section 01 70 00.

B. The CA shall receive a copy of the O&M manuals for review.

3.7 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.

B. The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems. Refer to Section 01 70 00 for additional details.

C. Electrical Contractor. The Electrical Contractor shall have the following training responsibilities:

1. Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00.

2. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.

3. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment that shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

7. Training shall include:

   a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discuss relevant health and safety issues and concerns.
   d. Discuss warranties and guarantees.
   e. Cover common troubleshooting problems and solutions.
   f. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discuss any peculiarities of equipment installation or operation.
   h. Classroom sessions shall include the use of overhead projections, slides, video and audio taped material as might be appropriate.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and maintenance of all pieces of equipment.

9. The Electrical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central control system.

10. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

11. Duration of Training. The Electrical Contractor shall provide training on each piece of equipment according to Division 26 specifications.

3.8 DEFERRED TESTING

A. Refer to Section 01 91 00 for requirements of deferred testing.

3.9 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the startup and initial checkout plan described in Section 01 91 00 and the filled out startup, initial checkout and prefunctional checklists.

END OF SECTION

SECTION 27 05 28
COMMUNICATIONS CONDUIT ROUGH-IN

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 the work of this Section.

1.2 SUMMARY

A. Comply with the requirements of Section 27 51 00.

B. Provide all materials and labor for the installation of a pathway system for inside plant communications circuits. This section includes requirements for horizontal and building backbone raceways, fittings, and boxes specific to communications cabling circuits for voice and data, etc.

C. In the event of conflicting documentation (including specifications, drawings or details), standards, references, or requirements, the most stringent requirement shall apply.

1.3 REFERENCES

A. Comply with the requirements in ANSI/TIA/EIA-607: Commercial Building Grounding and Bonding Requirements for Telecommunications.

B. Comply with the requirements in BICSI: BICSI Telecommunications Distribution Methods Manual (TDMM).

C. Comply with all applicable local, state and federal law.

1.4 DEFINITIONS

A. "EMT shall mean Electrical Metallic Tubing.

B. "RMC" shall mean Rigid Metal Conduit.

C. "Raceway" shall mean any enclosed channel for routing wire, cable or busbars.

D. "TMGB" shall mean Telecommunications Main Grounding Busbar. There is typically one TMGB per building, located in the main telecommunications room. This busbar is directly bonded to the electrical service ground.

E. "TGB" shall mean Telecommunications Grounding Busbar. There is typically one TGB per telecommunications room. The TGB is connected both to the TMGB and to building structural steel or other permanent metallic systems.

F. "TBB" shall mean Telecommunications Bonding Backbone. The TBB is a conductor used to connect TMGB's to the TGB's.

G. "Pullbox" shall mean a metallic box with a removable cover having no more than two conduits attached that is used to facilitate pulling cable through conduit runs longer than 100 ft. or in which there are more than 180 degrees of bends.

H. "Junction box" shall mean a metallic box with a removable cover wherein a conduit run transitions from a feeder conduit to multiple distribution conduits, and is used to facilitate pulling cable through the conduits.

1.5 SYSTEM DESCRIPTION

A. The work shall include materials, equipment and apparatus not specifically mentioned herein or noted on the Contract Documents but which are necessary to make a complete working Raceway system.

B. Furnish, install, and place into satisfactory and successful operation all materials, devices, and necessary appurtenances to provide a complete Raceway system as hereinafter specified and/or shown on the Contract Documents. The Raceway system shall support an ANSI/TIA/EIA and lSO/IEC compliant communications Structured Cabling System (SCS).

1.6 SUBMITTALS

A. Submittals shall include general administrative requirements (e.g. schedule, number of copies, distribution, etc.).

B. The Contractor shall apply Contractor's stamp, sign, or initial certifying that review, verification of required Products, and coordination of information is in accordance with the requirements of the work and Contract Documents.

C. Any deviations from the Contract Documents or specified product data shall be clearly noted, and must be approved by the Engineer/Designer prior to start of construction.

D. If the deviation is not approved by the Engineer/Designer it remains the Contractor's responsibility to provide what is required in the Contract Documents.

E. Product Data: Provide submittal information for review before materials are delivered to the job site. Provide product data submittals for all products at the same time.
   1. Provide standard manufacturer's cut sheets and the operating and maintenance (O&M) instructions at the time of submittal review for each device in the system, regardless of whether it is submitted as specified or as an approved equal. These instructions shall detail how to install and service the equipment and shall include all information necessary for rough-in and preparation of the building facilities to receive the materials.
   2. Submit a letter stating that the materials will be provided as specified, and specifically listing any items that will not be provided as specified. The letter shall also state that the Contractor has reviewed the specified items and agrees that they are applicable to this project in all respects.
   3. For those items noted as allowing "or equal," and which are not being provided as specifically named, submit standard manufacturer's cut sheets or other descriptive information, along with a written description detailing the reason for the substitution.

F. Contract Closeout Information: Provide submittal information for review as follows:
   1. O&M Manual for Communications - At the completion of the project, submit O&M information from product data submittals which shall be updated to reflect any changes during the course of construction, to the Engineer/Designer in the telecommunications-specific O&M Manual for Communications binder labeled with the project name and description.

1.7 QUALITY ASSURANCE

A. Comply with National Electrical Contractors Association: "Standard of Installation."

B. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in NEC, Article 100.
   2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

1.8 RECORD DOCUMENTS

A. Maintain at the job site a minimum of one set of Record Drawings, Specification, and Addenda. Record Drawings shall consist of redline markups of drawings, specifications and spreadsheets, including maintenance hole/handhole butterfly drawings.
   1. Document changes to the original system that was shown on the Contract Documents and clearly identify system component labels and identifiers on the Record Drawings.
   2. Keep Record Drawings at the job site and make available to the Owner at any time.
   3. Keep Record Drawings current throughout the course of construction, defined as not more than one week behind actual construction. Show identifiers for major infrastructure components on Record Drawings.
   4. Provide the Owner of a letter stating that conduit clean out was completed for all conduit sections except conduit stub outs under 15 ft. as required in this specification section.

1.9 PROJECT CONDITIONS

A. It is the responsibility of the contractor to coordinate all work with other trades for scheduling, rough-in, and finishing all work specified. The Owner will not be liable any additional costs due to missed dates or poor coordination of the supplying contractor with other trades.

B. Coordinate layout and installation of raceways and boxes with other construction elements and trades to ensure adequate headroom, working clearance, and access.

1.10 WARRANTY

A. Provide a Contractor-endorsed one (1) year service warranty against defects in materials and workmanship.
   1. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
   2. The Contractor Warranty period shall commence upon Owner final acceptance of the work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials shall consist of conduit, outlet boxes, fittings, enclosures, pull boxes, and other raceway incidentals and accessories as required for inside plant communications circuits.

B. The Contractor shall be responsible for properly sizing conduit and pathways to support the proper amount of cabling including fill ratio, growth factors and overall spare capacity in accordance with Division 27 specifications and the Contract Documents.

2.2 MATERIALS

A. Conduit:
   1. Conduit shall be sized to allow for a 40% fill ratio.
   2. EMT. 1 in. minimum conduit size unless noted otherwise on the Contract Documents. Flexible metal conduit (FMC) is not acceptable unless otherwise specified on Contract Drawings.
      a. Conduit: Galvanized steel tubing meeting ANSI C80.3.
      b. Couplings: Steel, cast iron, or malleable iron compression type employing a split, corrugated ring and tightening nut, with integral bushings and locknuts. Indent-type and setscrew-type couplings are not permitted.
   3. RMC. 1 in. minimum conduit size unless noted otherwise on the Contract Documents.
      a. Conduit: Hot dipped galvanized steel with threaded ends meeting ANSI C80.1.
      b. Couplings: Unsplit, NPT threaded steel cylinders with galvanizing equal to the conduit.
      c. Nipples: Same as conduit, factory-made up to 8 inches in diameter, no running threads.

B. Outlet boxes:
   1. Minimum four (4) in. by four (4) in. size, 2 1/8 in. minimum depth, with extension rings (if needed) and single gang covers (i.e. mud rings), unless otherwise noted on the Contract Documents.
   2. An extra deep device box shall have a minimum depth of 2.75-in. (70mm).
   3. Combined interior depth of outlet box, extension ring and cover shall be a minimum 2-1/2 in., stamped steel, deep drawn one piece (without welds or tab connections), galvanized, with knockouts for one (1) in. trade size conduit or connector entrance, meeting NEMA OS 1.
   4. Conduit boxes shall connect via properly sized conduit (with no more than a 40 percent fill ratio) stubbed up above the ceiling level and routed to a telecommunications wiring cable tray.
   5. The end of the conduit (by the cable tray) shall use an insulated bushing to prevent cabling damage.
   6. Outlet boxes in close proximity to each other are permitted to share conduit stub ups to accessible ceilings. Contractor shall be responsible for proper sizing of conduits to support all current and future cabling.

C. Indoor Wireless Access Point Boxes and Brackets
   1. Indoor Wireless Access Point Enclosure shall be a minimum of 4 11/16 in. by 4 11/16 in. by 2 1/8 in. minimum depth with extension rings (if needed) and single gang covers (i.e. mud rings), unless noted otherwise on the Contract Documents.
   2. Outlet box shall have knockouts and (1) 1 in. conduit stubbed to nearest accessible ceiling.
   3. Outlet box shall meet NEMA OS1 ratings.
   4. Outlet box may be ceiling mounted or wall mounted. Refer to the Contract Documents for locations.
   5. Provide universal mounting brackets for each indoor wireless access point box. Coordinate size with Owner Provided Wireless Access Point.

D. Outdoor Wireless Access Box Enclosure
   1. Enclosure shall have the minimum following dimensions: 13.5 in. by 13 in x 6.5 in depth.
   2. Enclosure shall be NEMA 4X and IP66 rated to protect against the elements and hose-directed water.
   3. Enclosure shall be of fiberglass construction and have aluminum mounting for installation and come with pre-configured mounting templates.
   4. Enclosure shall be UL508A Listed and approved.
   5. Enclosure shall have provisions for padlocks.
   6. Enclosure shall be silicone sealed.

E. Junction Boxes and Pull Boxes: Stamped steel, deep drawn one piece (without welds or tab connections), galvanized, with knockouts for conduit or connector entrance. Boxes six (6) in by six (6) in by four (4) in or larger may be code gauge fabricated steel continuously welded at seams and painted after fabrication.
   1. Dry locations: NEMA OS 1.
   2. Wet locations: NEMA OS 3R.

F. Miscellaneous Fittings:
   1. Locknuts: Malleable iron
   2. Conduit bushing: plastic
   3. Through wall seals and floor seals shall be:
      a. As required

G. Pull Strings: Plastic or nylon with a minimum test rating of 200 lb.

2.3 FIRESTOPPING

A. A firestop system is comprised of the item or items penetrating the fire rated structure, the opening in the structure and the materials and assembly of the materials used to seal the penetrated structure. Firestop systems comprise an effective block for fire, smoke, heat, vapor and pressurized water stream.

B. All penetrations through fire-rated building structures (walls and floors) shall be sealed with an appropriate firestop system. This requirement applies to through penetrations (complete penetration) and membrane penetrations (through one side of a hollow fire rated structure). Any penetrating item i.e., riser slots and sleeves, cables, etc. shall be properly firestopped.

C. The Contractor shall provide cable penetrations of fire rated walls.

D. Penetrations shall be sleeved with a built-in fire stop system that automatically adjusts to the number of cables installed and in compliance with NEC and the local fire codes.

E. Provide and install additional fire stop assemblies where necessary for cable routing if available pathways or conduit sleeves do not exist such as transition for cable tray systems.

F. Provide and install the proper amount of firestop assemblies with a 40% fill ratio, a 35% growth factor and an overall 25% spare capacity.

G. Any wall penetration shall not decrease the original fire rating of the wall.

H. Firestop systems shall be UL Classified to ASTM E814 (UL 1479) and shall be approved by a qualified Professional Engineer (PE), licensed (actual or reciprocal) in the state where the work is to be performed. A drawing showing the proposed firestop system, stamped/embossed by the PE shall be provided to the Owner's Technical Representative prior to installing the firestop system(s).

2.4 LABELING AND ADMINISTRATION

A. Labels: As recommended in ANSI/TIA/EIA 606.

B. Provide labeling and administration in accordance with Specification Section 27 51 00.

C. Permanent and not subject to fading or erasure, permanently affixed, typed, and created by a hand-carried label maker or an approved equivalent software-based label making system.

D. Handwritten labels are not acceptable.

PART 3 - EXECUTION

3.1 GENERAL

A. All work shall comply with applicable safety rules and regulations including OSHA.

B. All work shall comply with the requirements of the National Electrical Safety Code (NESC) and the NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.

C. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.

D. All work shall comply with the standards, references and codes listed in PART 1 — REFERENCES, above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.

E. Install the raceway system in a manner ensuring that communications circuits, when installed, are able to fully comply with the ANSI/TIA/EIA and other references listed in Part 1 — References, above.

F. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.

G. Replace and/or repair to original or better condition any existing structures, materials, equipment, etc. which was inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.

H. Remove surplus material and debris from the job site and dispose of legally.

3.2 EXAMINATION

A. Examine surfaces and spaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.

B. Provide a raceway for each circuit indicated.

C. Do not gang raceway into wireways, pullboxes, junction boxes, etc., without specific approval from the Engineer/Designer.

D. Each circuit should be specific to that device. Do not group home runs or circuits without approval from the Engineer/Designer.

E. Conduit:
   1. Install EMT unless other conduit is shown on the Contract Documents, is required by Code, or is permitted under these specifications. Where EMT size is not shown on Contract Documents, the conduit shall be sized so the quantity of cable placed inside the conduit shall not exceed the 40% fill limitation. For cable types not identified or questions, contact the Engineer.
   2. Install conduit as a complete, continuous system without wires, mechanically secured and electrically connected to metal boxes, fittings and equipment. Blank off unused openings using factory-made knockout seals.
   3. Run conduit in the most direct route possible, parallel to building lines as shown on Contract Documents.
   4. Install horizontal conduit runs as close to the intended routing as possible.
   5. Run parallel or banked conduits together, on common supports where practical.
   6. Make bends in parallel or banked runs from same centerline to make bends parallel.
   7. Conduits concealed above ceilings, furred spaces, etc., which are normally inaccessible may be run at angles not parallel to the building lines.
   8. Where conduits cross building expansion joints, use suitable sliding or offsetting expansion fittings. Unless specifically approved for bonding, use a suitable bonding jumper.
   9. Do not install conduit below grade/slab unless specifically shown on the Contract Documents as being installed below grade/slab.
   10. Install any exposed conduit in lines parallel or perpendicular to the building or structural member's lines except where the structure is not level. Follow the surface contours as much as practical. Do not install crossovers or offsets that can be avoided by installing the conduit in a different sequence or a uniform line.
   11. Support conduits as specified:
      a. Provide anchors, hangers, supports, clamps, etc. to support the conduits from the structures in or on which they are installed. Do not space supports farther apart than five (5) ft.

b. Provide sufficient clearance to allow conduit to be added to racks, hangers, etc. in the future.
c. Support conduit within three (3) ft. of each outlet box, junction box, gutter, panel, fitting, etc.

12. Install a pull string in each conduit.
13. For conduits entering through the floor of a telecommunications room, terminate conduits four (4) in. above the finished floor.
14. Do not install communications conduits in wet, hazardous, or corrosive locations.
15. Where conduit is shown embedded in masonry, embed conduit in the hollow core of the masonry. Horizontal runs in the joint between masonry units are not permitted.
16. Where conduit is shown embedded in concrete, embed conduit a minimum of two (2) in. from the exterior of the concrete. Do not place conduit in concrete less than five (5) in. thick.
    a. Run conduit parallel to main reinforcement.
    b. Conduit crossovers in concrete are not permitted.
17. Where conduit exits from grade or concrete, provide a rigid steel elbow and adapter.
18. Ream conduits to eliminate sharp edges and terminate with metallic insulated grounded throat bushings. Seal each conduit installed below grade after installation with a removable mechanical-type seal to keep conduits clean and dry and prevent foreign matter from entering conduits.
19. Bend and offset metal conduit with standard factory sweeps or conduit fittings. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
    a. Conduit sweeps:
        1) Sweeps shall not exceed 90 degrees.
        2) Do not exceed 180 degrees for the sum total of conduit sweeps between conduit termination points for a section of conduit.
        3) Sweep radius shall be at least 10 times the internal diameter of the conduit.
        4) 90-degree condulets (LB's) and standard electrical elbows are not acceptable.
    b. Factory-manufactured sweeps are required for bends in conduit larger than one (1) in. trade size.
    c. For bends in one (1) in, trade size conduit, the minimum radius shall be 10 in. Field-manufactured bends shall only be made using a hydraulic bender with a one (1) in. boot, shall be without crimping or flattening, and permitted only when factory-manufactured sweeps are not suitable for the conditions. All other cases, factory-manufactured sweeps are required.
20. Raceway terminations and connections:
    a. Join conduits with fittings designed and approved for the purpose and make joints tight. Do not use set indent-type or screw-type couplings.
    b. Make threaded connections waterproof and rustproof by applying a watertight, conductive thread compound. Clean threads of cutting oil before applying thread compound.
    c. Make conduit terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
21. Where conduit enters a space through the floor and terminates in that space, terminate the conduit at four (4) in. above the finished floor.
22. Where several circuits follow a common route, stagger pullboxes or fittings.
23. Where several circuits are shown grouped in one box, individually fireproof each conduit.
24. Connect conduit to hub-less enclosures, cabinets, and boxes with double locknuts and with insulating type bushings. Use grounding type bushings when connecting to concentric or eccentric knockouts.
25. Penetrations for raceways:
    a. Do not bore holes in floor and ceiling joists.

b. Penetrate finished walls and finished surfaces with a PVC or sheet metal sleeve with an interior diameter (ID) at least 1/4 in. greater than the outer diameter (OD) of the conduit, set flush with walls, pack with fiberglass, seal with silicone sealant and cover with escutcheon plate.
c. Penetrate poured-in-place walls and free slabs with a cast iron sleeve with retaining ring or washer. Set sleeves flush with forms or edges of slab. Pack around conduit with fiberglass and seal with silicone sealant.
d. Cut ends of conduit square using a hand saw, power saw or pipe cutter. Ream cut ends to remove burrs and sharp ends. Where conduit threads are cut in the field, cut threads to have same effective length, same thread dimensions and same taper as specified for factory-cut threads.
e. Provide double locknuts and insulating bushings at conduit connections to boxes and cabinets. Align raceways to enter squarely and install locknuts with dished part against the box. Use grounding type bushings where connecting to concentric or eccentric knockouts.
f. Where conduits are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

26. Install conduit sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed conduits, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
    a. Where conduits pass from warm to cold locations, such as the boundaries of air conditioned or refrigerated spaces and where conduits enter or exit buildings from outdoor areas, including underground ducts or conduit runs.
    b. Where otherwise required by the NEC.
27. Prove out each conduit with a minimum 16 in. long test mandrel that is 1/4 in. smaller than the inside diameter of the conduit. Repair or replace any conduit that does not prove out at no cost to the Owner.

F. Outlet Boxes:
1. Provide outlet boxes and covers as shown on the Contract Documents and as needed. Verify that the appropriate cover type and depth is provided for each type of wall and finish. Provide extension rings as needed.
2. Coordinate box locations with building surfaces and finishes to avoid bridging wainscots, joints, finish changes, etc.
3. Install boxes in dry locations (not wet, corrosive, or hazardous).
4. Attach boxes securely to building structure with a minimum of two (2) fasteners. Provide attachments to withstand a force of 100 pounds minimum, applied vertically or horizontally.
5. Install boxes at the following heights to the bottom of the box, except where noted otherwise:
    a. Wall mounted telephones: 48 in. above finished floor.
    b. Workstation outlets: 18 in. above finished floor.
    c. Place boxes for outlets on cabinets, countertops, shelves, and similar boxes located above countertops two (2) in, above the finished surface or two (2) in. above the back splash. Verify size, style, and location with the supplier or installer of these items prior to outlet box installation.
6. Recessed mounted outlet boxes:

a. Recess boxes in the wall, floor, and ceiling surfaces in finished areas. Set boxes plumb, level, square and flush with finished building surfaces within 1/16 in. for each condition. Set boxes so that box openings in building surfaces are within 1/8 in. of edge of material cut-out and fill tight to box with building materials. Single gang opening shall extend at least to the finished wall surface and extend not more than 1/8 in. beyond the finished wall surface. Provide backing for boxes using structural material to prevent rotation on studs or joists.
b. Wall phone and conference room signs outlet boxes shall be recessed.

7. Surface mounted outlet boxes:
   a. For boxes surface mounted on unfinished walls (i.e. electrical rooms, mechanical rooms), provide four (4) in. by four (4) in. (minimum) outlet box with single gang cover.

G. Junction Boxes:
1. Provide junction boxes as shown on the Contract Documents and as required.
   a. Where sizing is not shown on the Contract Documents, minimum junction box sizes are as follows:

Maximum Trade Size of Conduit	Junction Box Width	Junction Box Length	Junction Box Depth	For Each Additional Conduit Increase Width
1”	4”	16”	3”	2”
1-¼”	6”	20”	3”	3”
1-½”	8”	27”	4”	4”
2”	8”	36”	4”	5”
2-½”	10”	42”	5”	6”
3	12”	48”	5”	6”
3-½”	12”	54”	6”	6”
4”	15”	60”	8”	8”

2. A junction box may not be substituted for a 90-degree bend. 90 degree condulets (LB’s) are not acceptable.
3. Install junction boxes in an accessible location, readily accessible both at time of construction and after building occupation. Do not install junction boxes in inaccessible interstitial building space.
4. Where junction boxes are to be mounted on ceiling structure above ceiling grid, do not mount higher than four (4) ft. above grid (mount on wall instead).
5. Install hinged-cover enclosures and cabinets plumb. Support at each corner.
6. Install junction boxes so that the access door opens from the side where the cable installer will normally work (typically from the bottom, or floor side, of the box).
   a. Where a junction box is installed in a ceiling space, provide full access to the junction box door and adequate working room for both the installation personnel and for proper looping of cable during installation.
   b. Provide a lockable access cover (or junction box door if exposed) in hard pan ceilings.
7. Install junction boxes such that conduit enters and exits at opposite ends of the box only. Conduits exiting out sides is not permitted.

H. Pull Boxes:
1. Provide pull boxes as shown on the Contract Documents and as required.
   a. Outlet boxes shall not be used as a pull box.
   b. Do not confuse pull boxes with junction boxes.
   c. Where sizing is not shown on the Contract Documents, minimum pull box sizes are as follows:

Maximum Trade Size of Conduit	Pull Box Width	Pull Box Length	Pull Box Depth
1”	4”	12”	4”
1-¼”	4”	12”	4”
1-½”	4”	12”	4”
2”	4”	24”	4”
2-½”	6”	24”	6”
3	6”	36”	6”
3-½”	6”	48”	6”
4”	6”	60”	6”

2. A pull box may not be substituted for a 90-degree bend. 90 degree condulets (LB’s) are not acceptable.
3. Install pull boxes in an accessible location, readily accessible both at time of construction and after building occupation. Do not install pull boxes in inaccessible interstitial building space.
4. Install hinged-cover enclosures and cabinets plumb. Support at each corner.
5. Install pull boxes so that the access door opens from the side where the cable installer will normally work (typically from the bottom, or floor side of the box).
   a. Where a pull box is installed in a ceiling space, provide full access to the junction box door and adequate working room for both the installation personnel and for proper looping of cable during installation.
   b. Provide a lockable access cover (or pull box door if exposed) in hard pan ceilings.
6. Pull boxes shall have only two conduits, one entering and one exiting. Install pull boxes such that conduit enters and exits at opposite ends of the box.

I. Firestopping:
   1. Maintain fire rating of penetrated fire-rated walls. Firestop and seal each penetration made during construction.
      a. Provide firestopping material for through and membrane penetrations of fire-rated barriers.
      b. Installation shall be performed in strict accordance with manufacturer’s detailed installation procedures.
      c. Install firestops in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer’s recommendations, local fire and building authorities, and applicable codes and standards referenced in PART 1 – REFERENCES. Application of sealing material shall be in a manner acceptable to the local fire and building authorities.

J. Grounding/Bonding: Grounding and bonding work shall comply with the Uniform Building Code, Uniform Fire Code, UL 467, ANSI/TIA/EIA standards and the references listed in PART 1 – REFERENCES above, as well as local codes which may specify additional grounding and/or bonding requirements.
   1. Bond metallic raceway together and to the nearest TGB (as provided under Division 26). Ensure that bonding breaks through paint to bare metallic surface of painted metallic hardware.

3.4 LABELS:

A. Conduits: Label each conduit end in a clear manner by designating the location of the other end of the conduit (i.e. room name, telecommunications room name, pull box identifier, outlet identifier).

1. Where a conduit is intended for future cabling use outside of the Contract, the conduit shall be labeled in a clear manner by designating the location of the other end of the conduit (i.e. room name, telecommunications room name, pull box identifier, etc.) along with a sequential number for each spare conduit terminated into a single room.

B. Pull Boxes: Label each pullbox with a unique identifier. Identifiers shall be of the form "RN-Y" where "RN" is the room name of the room closest to (or containing) the pull box, and "Y" is the sequential number of the pull box for each "RN".
   1. Example: The second pull box in the vicinity of room "100" would have the label "100-2".

3.5 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and in accordance with accepted industry practice, that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

B. Cleaning
   1. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION

SECTION 27 05 29
COMMUNICATIONS CABLE TRAY SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Comply with the requirements of Section 27 51 00.

B. This section defines the requirements for the provision and installation of a complete Cable Tray System including hardware, all associated grounding equipment, firestop assemblies and support hardware, to provide a complete cable tray infrastructure throughout the facility.

C. Provide cable tray locations as shown on the drawings to permit easy access, installation and rearrangement of voice, data, wireless access points and other low voltage system cables.

D. In the event of conflicting documentation (including specifications, drawings or details), standards, references, or requirements, the most stringent requirement shall apply.

1.2 CONTRACT DRAWINGS

A. Coordinate installation of cable tray with mechanical ductwork and sprinkler system piping so that tray remains accessible (minimum one (1) ft. clearance above tray bottom, or eight (8) in. above the top of the rail) after installation.

B. Adequate separation from heat sources shall be maintained as well. Coordinate exact routing with all trades to avoid interferences.

1.3 INSPECTION AND FINAL ACCEPTANCE

A. Examine drawings and existing conditions.

B. Contractor shall include all bends, offsets, transitions and the like to avoid ducts, pipes, conduits, and other obstructions as part of this work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturer: Subject to compliance with these specifications, wire basket support systems to be installed shall be as manufactured by a company which has, as a primary product, cable tray systems and has been in the business of manufacturing cable tray systems for more than one (1) year.

B. General:
1. The contractor shall install a cable tray system for backbone cables and horizontal cables as required for a complete telecommunications pathway system in accordance with TIA-569-B.
2. Cable tray shall be grounded according to the TIA/EIA/ATIS-J-STD-607-A standard.
3. Provide wire basket of types and sizes indicated with connector assemblies, clamp assemblies, connector plates, splice plates and splice bars as required.
4. Construct units with rounded edges and smooth surfaces, in compliance with applicable standards, and with the additional construction features listed in this specification.
5. Ladder rack installed in the Communication Rooms shall have ladder rack guide posts installed on 90 degree corners.
6. The contractor shall design the cable tray to accommodate a maximum calculated fill ratio of 50 percent. The initial installation fill ratio shall be limited to allow for 20 percent growth.

C. Materials and Finishes: Material and finish specifications for each wire basket type are as follows:
   1. Yellow Zinc Dichromate: Straight sections shall be made from steel meeting the minimum mechanical properties of ASTM A510 and shall be electro-plated yellow zinc dichromate in accordance with ASTM B633 SC2.
   2. Pre-Galvanized Zinc: Wall brackets and other pre-galvanized accessories shall be coated with zinc in accordance with ASTM A653.

D. Wire basket cable tray system shall conform to the following requirements.
   1. All straight section longitudinal wires shall be straight (with no bends) and shall be furnished in standard 118 in. lengths.
   2. Wire basket shall be made of high strength steel wires and formed into a standard 2 in. by 4 in. wire mesh pattern with intersecting wires welded together. All wire ends along wire basket sides (flanges) shall be rounded during manufacturing for safety of cables and installers.
   3. The usable loading depth of the wire basket shall be 4 in. and 18 in. wide.
   4. All fittings shall be field formed as needed.

E. All splicing assemblies shall be the bolted type using serrated flange locknuts. Hardware shall be either yellow zinc dichromate in accordance with ASTM B633 SC2 or AISI Type 304 Stainless Steel.

F. Wire basket supports shall be trapeze hangers or wall brackets as manufactured by the manufacturer.

G. Trapeze hangers shall be supported by 1/4 inch diameter rods.

H. Special accessories shall be furnished as required to protect, support and install a wire basket support system.

I. Cable Trays shall conform to NEMA VE-1.

2.2 SUPPORTS

A. Single channel supports shall be formed steel shapes with finish as specified by the Engineer.

B. The use of cable tray hanger supports shall be as shown on drawings.

C. Supports shall be fixed to the selected wall or overhead and attached to areas specified and reinforced by blocking and backing.

D. The supports shall be attached to the overhead as much as practical.

E. Wall attachments shall be kept to an absolute minimum and shall only be considered where overhead hanger support system is impractical.

PART 3 - EXECUTION

3.1 GENERAL

A. In corridors, mount bottom of tray at elevations indicated on Architectural sheets. Finished tray shall be located above ceiling and shall have a minimum clearance of 12 in. of access between the open side of the tray and the ceiling.

B. Cable tray shall be installed as straight as possible. Cable tray shall not parallel high voltage electrical power due to frequency interference. No part of cable tray shall be closer than 1 foot from fluorescent ballast or similar electrical sources.

C. Cable tray shall be installed utilizing manufacturer's factory fabricated transitions (intersections, waterfalls, corners, etc.).

D. Corridor tray and telecom closet tray shall be connected utilizing manufacturer's factory fabricated intersections or transitions. These transitions shall not be smaller than 90 degrees. The transition opening shall be a minimum eight (8) in. high and the width to accommodate an 18" wide cable tray. Field or job site fabricated transitions shall be considered non-compliant and shall not be accepted.

E. Additional requirements for Telecommunication Rooms (also referenced as "TR" and "IDF") and Building Distribution Frame Equipment Room (also referenced as "MDF' and "Main Distribution Frame" Rooms) are defined below.
   1. The contractor shall install overhead cable trays along walls in all telecommunications rooms and in the building distribution frame equipment room as shown on the Contract Documents.
   2. The cable tray shall connect to cable tray over the equipment racks.
   3. The TR and BDF cable trays shall connect to the horizontal backbone cable tray pathways within the building.
   4. Cable trays shall provide a minimum of 12 inches of vertical clearance above and to the side of installed cable tray.
   5. The contractor shall install overhead cable trays over all installed equipment racks in all telecommunications rooms. Cable trays above equipment racks shall interconnect with the trays on supported along the walls in the TRs and the BDF equipment room.
   6. Cable trays shall be installed to extend over all installed equipment racks in the building distribution frame equipment room as well as over a future racks locations if defined on the Contract Documents. The overhead cable tray shall interconnect with a down channel to the designated wall in the telecommunications room shall be mounted for building riser terminations.

3.2 PENETRATIONS OF BUILDING FIRE SEPARATIONS

A. Where cable tray penetrates rated occupancy or area fire separations, seal penetration with a U.L. listed fire stopping assemblies.

B. All firestopping shall comply with Division 07 84 00.

3.3 GROUND CABLE

A. Bond to tray once on each length or section of tray using clamps manufactured for this purpose.

B. Equipment grounding conductor connections to the tray shall be made using a U.L. listed mechanical connection.

C. Sheet metal or TEK screws shall not be used for grounding.

3.4 TESTING

A. Test wire basket support systems to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance. See NFPA 70B, Chapter 18, for testing and test methods.

B. Manufacturer shall provide test reports witnessed by an independent testing laboratory of the "worst case" loading conditions outlined in this specification and performed in accordance with the latest revision of NEMA VE-1.

END OF SECTION

SECTION 27 05 32
STRUCTURED CABLING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This specification covers requirements for a telecommunications structured cabling system consisting of copper and fiber optic cabling infrastructure for the Energy Sciences Building (ESB) at Argonne National Laboratory.
   1. Inside building copper cabling infrastructure shall extend from designated work area telecommunications outlets (information outlet/jacks) to a telecommunications room (TR) distribution patch panel. The copper cabling system shall consist of a color-coded set of components (includes the horizontal cabling, station jacks, termination patch panel jacks and patch cables) that can support local area network connectivity for both voice and data.
   2. A second copper cabling infrastructure shall be designated for direct hardwire connections (riser cabling) and shall exist as a separate termination field on patch panels in telecommunications rooms.
   3. A fiber optic cabling system shall also be installed as per this specification for intra-building connectivity between telecommunication rooms and the building distribution frame equipment room.

B. Supply and install a complete Structured Cabling System for this construction project, consisting of the following components.
   1. Plenum rated single-mode and multi-mode fiber optic backbone cable.
   2. Plenum rated horizontal Unshielded Twisted Pair (UTP) CAT 6A cable for voice and data applications.
   3. Fiber and copper termination hardware.
   4. Modular Patch Panels.
   5. CAT 6A connectors, jacks and faceplates.
   6. Equipment racks, wire supports, cable runway, etc. in data rooms/closets.

C. In the event of conflicting documentation (including specifications, drawings or details), standards, references, or requirements, the most stringent requirement shall apply.

1.3 RELATED SECTIONS

A. All work shall be completed in accordance with the requirements in Section 27 51 00.

1.4 STANDARDS AND REFERENCES

A. All system installations shall be in accordance with all of the latest references indicated in Section 27 51 00.

B. Telecommunication Industry Association (TIA), Electronic Industries Association (EIA):
   1. TIA/EIA-455 – Fiber Optical Test Procedures.
   2. TIA/EIA-568-C.1 – Commercial Building Telecommunications Cabling Standard Part 1: General Requirements
   3. TIA/EIA-568-C.2 – Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components
   4. TIA/EIA-568-C.3 – Optical Fiber Cabling Components Standard
   5. EIA/TIA-569 –A-98 – Commercial Building Standard for Telecommunications Pathways

6. EIA/TIA-598-A-95 – Optical Fiber Cable Color Coding
7. TIA/EIA-606 – Administration Standard for the Telecommunications Wiring Standard
8. TIA/EIA-607 - Commercial Building Grounding and Bonding Requirements for Telecommunications

C. Building Industry Consulting Services International (BICSI):
   1. Telecommunications Distribution Methods Manual.

D. American Society for Testing and Materials (ASTM):
   1. ASTM E 814 – Fire Tests of Through-Penetration Fire stops.

E. Underwriters Laboratories, Inc. (UL):
   1. UL 1479 – Fire Tests of Through-Penetration Fire stops.

F. National Fire Protection Association (NFPA):
   1. NFPA 70 – National Electrical Code.

G. Americans with Disabilities Accessibility Guidelines:
   1. G. Code of Federal Regulations, Title 29, Chapter XVII, Part 1910 (OSHA).

H. All local, state and federal codes.

1.5 DEFINITIONS

A. Alien crosstalk is undesired signal coupling from one cable to another or one channel to another most commonly affecting pairs with similar twist lays.

B. ARMM is a type of riser cable used in riser shafts where a fire-retardant sheath is necessary to meet NEC low-flame requirements.

C. Backbone is a facility (e.g., pathway, cable, or conductors) between the entrance facilities and the telecommunications rooms within buildings.

D. Building core is a three-dimensional space, permeating one or more floors, and is used for the extension and distribution of utility services (e.g., elevators, washrooms, stairwells, mechanical and electrical systems, and telecommunications) throughout the building.

E. Building Distribution Frame Equipment Room in this document represents the main telecommunications room (D079) located on the ground level in the Energy Sciences Building and represented in the HDR building drawings as the “MDF”.

F. Intermediate Distribution Frame Room in this document represents the telecommunication rooms for horizontal distribution located on all levels in the Energy Sciences Building and represented in the HDR building drawings as the “Telecom Room” and also referenced as “Telecommunications Room” and “TR”.

G. Category 6A cable is 100 ohm twisted-pair copper cable that meets or exceeds specifications in ANSI/TIA/EIA-568-C.2-10, and is used for transmissions up to 500 MHz. The near-end crosstalk loss and return loss requirements are more severe than those of Category 5e or Category 6 cables. Transmission in the 500 MHz range introduces alien crosstalk concerns not associated with lower frequency transmission; refer to manufacturers’ literature for detailed discussions of installation methods to reduce alien crosstalk.

H. Cross-connect enables the mechanical termination and interconnection of horizontal cabling, backbone cabling, and entrance cabling

I. Entrance facility (EF) is an entrance to a building for both public and private network service cables (including antennae) including the entrance point at the building wall and continuing to the entrance telecommunication room.

J. Horizontal cable extends from the telecommunications outlet/connector in the work area to the horizontal cross-connect in the telecommunications room.

K. Pathway is the vertical and horizontal route of the telecommunications cable.

L. Telecommunications room is an enclosed space for housing telecommunications equipment, cable terminations, and cross-connects. Telecommunications rooms house the cross-connects between (1) entrance cable and backbone cable and/or (2) backbone cable and horizontal cabling.

1.6 WARRANTIES

A. The Structured Cabling System (SCS) Contractor shall provide a Certified Warranty on the cabling system channel warranty covering all parts, labor and performance to all applied standards for a period of not less than one (1) year from the date of acceptance by the Owner.

B. The system must be a certified manufacturer System, with end-to-end system product and minimum installation warranty of twenty (20) years that shall meet or exceed the performance specifications of EIA/TIA 568-C.2-10. End-to-end system product shall include but not limited to the following components.
   1. All station jacks shall be covered as part of the manufacturer's 20 year extended cabling system warranty.
   2. All patch panels shall be covered as part of the manufacturer's 20 year extended system warranty.
   3. All fiber installed shall be provided by the same manufacturer and be part of a 20 year extended end to end system warranty.

C. The SCS contractor shall perform and document tests on all structured cabling (including riser) and shall submit documentation to ANL which shows manufacturer's acceptance of each cabling system as a 20 year extended system warranty or a group of warranties for all wiring systems.

D. Installation personnel shall meet manufacturer's training and education requirements for implementation of extended warranty program.

E. The Owner has the option to randomly select installation locations to evaluate and retest copper cables and/or fiber optic cables for the quality of installation, workmanship, damage and verification of the contractor summary reports.

F. The SCS contractor shall be responsible for all cable until the installation has been qualified as "ANL CERTIFIED" by the Owner.

G. The SCS contractor shall agree to repair or replace defective components/materials and correct defective work when given notice by the Owner during the warranty period. This shall include all cable performance, parts and labor.

   NOTE: Ensure that defects in cabling require for the cabling to be replaced unless problem with termination.

1.7 CONTRACTOR QUALIFICATIONS

A. The SCS contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type of size.

B. The Contractor shall provide all tools and equipment necessary for successful installation and testing of optical fiber and Augmented Category 6 (also known as 6A) copper cabling distribution system. The Contractor shall have personnel who are trained in the use of such tools and equipment.

C. Installation personnel shall also have manufacturer installer training.

D. All Contractor installed structured cabling and termination components shall comprise a complete system installed according to published references and manufacturer design and installation guidelines.

E. Only sub-contractors who have the same training and certifications as the Contractor shall assist the contractor in the performance of this work.

F. The Contractor shall perform all work under safe work conditions.

1.8 SUBMITTALS

A. Product Data:
   1. For each product specified.

B. Shop Drawings:
   1. Name plate identification for all outlets.
   2. Riser Diagrams with copper and fiber.
   3. Enlarged telecommunication spaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All communications material and equipment furnished shall be new and unused and free of defects. They shall be clean and free of damage or corrosion and shall be of the best quality obtainable for the purpose intended.

B. Cabling, equipment and hardware manufacturers shall have a minimum of five years experience in the manufacturing, assembly, and factory testing of components which comply with TIA/EIA-568-C.1, TIA/EIA-568-C.2 and TIA/EIA-568-C.3

C. The products specified in this specification shall be supplied by a single manufacturer or manufacturer partnership which comprises a complete system that provides transmission performance across the system guaranteed to 10 Gbps with performance that meets or exceeds EIA/TIA 568-C.2-10 specifications.
   1. Excluded components from the channel performance criteria are; data riser patch panels and other hardware that is not defined as part of the channel test configuration of EIA/TIA 568-C.2-10.

D. The manufacturer shall be ISO 9001 certified.

E. The Contractor shall submit a letter from the manufacturer stating that all system parts (all parts shall be listed separately) shall be available for a minimum period of 7 years from the date of the completed installation.

F. All communications materials used shall be UL listed with a visible UL label.

2.2 HORIZONTAL DISTRIBUTION CABLE

A. All horizontal data station cable and voice cable shall terminate on modular patch panels in their respective Telecommunications Room or Equipment Room as specified on the drawings.

B. Horizontal cabling installations shall be limited to a maximum distance of 90 meters or 295 feet. The total length of the horizontal cabling and all patch cords shall be 100 meters (328 feet) or less.

C. Station cable shall conform to the following specifications.
   1. Cable shall conform to ANSI/TIA/EIA Category 6A requirements.
   2. Copper cable shall be a 4 pair, 8 conductor, 23 AWG copper conductor gauge.
   3. Cable jacket transmission characteristics shall comply to ANSI/TIA/EIA-568-C.2
   4. Cable jackets shall be blue unless noted otherwise.
   5. Cable jacket shall be a maximum thickness of 0.051 inches.
   6. The maximum diameter over jacket shall be a maximum of 0.300 inches. This requirement supersedes the requirement of the TIA Standard.
   7. The cables shall be suitable for the environment in which they are to be installed.
      a. Riser rated cable shall be third party certified to conform to UL 1666, CMR, CMG, and IEC 332-1 and shall be marked as such.

2.3 COPPER BACKBONE CABLE

A. Riser cables shall be installed between each telecommunication room (TRs) and the building distribution frame (BDF) equipment room.

B. Riser cables shall be ARMM type 24 AWG cable.
   1. Installed riser cable shall be 25 pair copper.
   2. ARMM riser cables shall be terminated directly to riser patch panel jacks in each telecommunications room and shall be designated as intermediate distribution frames (IDFs).
   3. Each riser pair shall be terminated directly to pins 4 and 5 of the riser patch panel jacks.
   4. Riser pairs shall be terminated sequentially according to the cable pair color code.

C. All ARMM riser pairs shall be terminated in telecommunications rooms on patch panels.
   1. Patch panels may be either 24 port or 48 port with modular station jacks.
   2. The patch panels shall be designated as intermediate distribution frames (IDFs).

D. All ARMM riser cables shall route and terminate at the building distribution frame (BDF) equipment room on 110 blocks mounted on a telecommunications distribution frame measuring 39 inches by 86 inches by 16.5 inches.
   1. The frame shall have vertical cable management channels (6”x6”x7’ and 4”x6”x7”) on both external sides of the frame.
   2. The frame shall use horizontal rack mount panel sections (up to 5 rack mount panel sections per distribution frame, each measuring 34.25” x 12.22” (without trough) and 34.25” x 14.54” with trough) that allow for optional horizontal cable management troughs (6.5 inch deep) as well as the ability to add up to 3 mounting panels per horizontal rack mount panel section.
   3. Each mounting panel shall have the ability to mount different size building entrance terminals, M66 blocks and 110 blocks.
   4. The panels must accommodate 100 and 300 pair blocks.
   5. The distribution frame shall support front and rear mounting.
   6. The telecommunications frame shall support a total capacity of 9,000 pairs.
   7. The frame shall be colored black and have an overhead built-in wire tray in the top of the distribution frame.

2.4 FIBER BACKBONE CABLE

A. The following general requirements shall apply to both multimode and single mode fiber optic cabling.
   1. All individual fiber strands shall have exterior protective coatings and shall use industry standard color codes for easy identification.
   2. Fiber optic cable runs shall be continuous from end to end without cable splices except for pre-terminated pigtails at each end.
   3. Fusion splices loss shall be 0.1db or less.
   4. Fiber optic distribution cables in each of the Telecommunication Rooms (TRs) and at the building distribution frame (BDF) equipment room shall be factory terminated with LC connector fusion splice pigtail cartridges with LC fiber optic adapters..

B. Optical Fiber NON CONDUCTIVE Plenum (OFNP) Tight Buffered With 10 Gigabit Laser Optimized 50/125 Optical Fibers.
   1. Each Multimode Fiber shall be:
      a. Graded-index optical fiber wave-guide with nominal 50/125µm-core/cladding diameter.
      b. The fiber shall comply with the latest revision of ANSI/EIA/TIA-4920000 or as specified beyond the TIE/EIA specifications..
      c. Attenuation shall be measured in accordance with ANSI/EIA/TIA-455-46, 53 or 61.
      d. Information transmission capacity shall be measured in accordance with ANSI/EIA/TIA-455 - 204 for overfilled launch.
      e. The measurements shall be performed at 23 degrees C +/- 5 degrees.
      f. Maximum attenuation dB/Km @ 850/1300 nm: 3.0/1.0

g. Bandwidth: > 3500 MHz-km @ 850nm for overfilled launch,
h. Bandwidth 500 MHz-km @ 1300nm.
i. Bandwidth 47000 MHz-km characterized using FOTP 220
j. Optical Fiber shall be laser optimized and guaranteed for 10 Gigabit Ethernet distances of 500m/500m for 850nm and 1300nm respectively
k. Guarantee Gigabit Ethernet distances of 1000m/550m for 850nm and 1300nm respectively
l. Optical Fiber shall be laser optimized
m. Fiber optic cables shall be constructed with dry water-block materials.

2. Physical Characteristics:
   a. Shall be suitable for use in risers, plenums and horizontal applications.
   b. 900µm tight-buffered construction
   c. Shall be 12 strands.
   d. Shall be OFNR for non-plenum installations or OFNP for plenum installations.
   e. Suitable for underground or above ground conduits.
   f. Tight buffered fibers shall be color coded in accordance with EIA/TIA 598 with an overall aqua jacket.
   g. Suitable for operation between -20 degrees C to 75 degrees C.
3. Fusion Splice Requirements
   a. Fiber optic fibers shall be fusion spliced with an automatic x, y, z axis alignment fusion splicing machine using electric arc fusion.
   b. Connecting fiber ends to be spliced together shall be flat and parallel to each other.
   c. Splice shall have low insertion value and a back reflection value of less than 0.1 dB.

C. Fusion splices shall be done by an automatic machine specifically designed for fusion splicing. Optical Fiber Non Conductive Plenum (OFNP) Tight Buffered with Singlemode optical fiber.
1. Each Singlemode Fiber shall have:
   a. nominal 8.3/125µm-core/cladding diameter
   b. Maximum attenuation dB/Km @ 1310/1550nm: 0.5/0.5
2. Physical Characteristics:
   a. Shall be 12 strands.
   b. Shall be OFNR for non-plenum installations or OFNP for plenum installations.
   c. Strength members shall be FGE/Aramid yarn.
   d. Suitable for underground or above ground conduits.
   e. Tight buffered fibers shall be color coded in accordance with EIA/TIA 598 with an overall yellow jacket.
   f. Suitable for operation between -20 degrees to 75 degrees C.
   g. Fiber optic cable shall be a zero water-peak design.
   h. Fiber optic cables shall be constructed with dry water-block materials.

2.5 WORK AREA OUTLETS

A. General Requirements for work area cables and outlets shall be as follows:
1. Work area cables shall each be terminated at their designated work area location in the connector types described in the subsections below.
2. Included are modular telecommunication jacks. These connector assemblies shall snap into a faceplate.
3. Installations shall leave a minimum 4 inches of cable coiled within the station outlet mounting box. Coils shall not exceed the manufacturer's bend radius specification.
4. Service loops (typically 4 to 5 feet and not exceeding the total horizontal cable length of 90 meters) shall be left in cable trays where possible.

B. The Telecommunications Outlet Assembly shall accommodate:
1. A minimum of three (3) modular jacks unless noted otherwise.
2. Two positions on the outlet shall be used for jacks and one position shall remain available for any required future installation.
3. White colored blank filler will be installed when extra ports are not used.

4. A white colored dust cap shall be provided on all modular jacks with the circuit number on the identifier strip.
5. Multiple jacks that are identified in close proximity on the drawings (but not separated by a physical barrier) may be combined in a single assembly. The Telecommunications Contractor shall be responsible for determining the optimum compliant configuration based on the products proposed.
6. The same orientation and positioning of jacks and connectors shall be utilized throughout the installation. Prior to installation, the Telecommunications Contractor shall submit the proposed configuration for each outlet assembly for review by the Owner.
7. The modular jack shall incorporate printed label strip on the dust cap module for identifying the outlet. Printed labels shall be permanent and compliant with ANSI/TIA/EIA-606-A standard specifications. Labels shall be printed using a printer. Hand printed labels shall not be accepted.

C. Voice / Data Jacks:
1. Voice/Data jacks shall be 8-position/8 conductor style modular jacks and shall be Category 6A or higher performance as defined by the references in this document including ANSI/TIA/EI-568-C.2.
2. All Category 6A cabling shall be terminated using a 568B jack termination wiring designation as specified below for the physical plant end-to-end link terminations.
3. All cable pairs shall be terminated at both cable ends.
4. All pair combinations must be considered, with the worst-case measurement being the basis for compliance.
5. Modular jack performance shall be third-party verified by a nationally recognized independent testing laboratory.
6. Dust covers shall be used on each termination.

D. Faceplates: The faceplates shall:
1. Be UL listed and CSA certified.
2. Be constructed of high impact, ABS plastic UL 94V-0 construction (except where noted otherwise).
3. Be available as single-gang or dual-gang.
4. Provide easy access for adds, moves, and changes by front removal of jack modules.
5. Possess recessed designation windows to facilitate labeling and identification.
6. Include a clear plastic cover to protect labels in the designation window.
7. Have mounting screws located under recessed designation windows.
8. Comply with ANSI/TIA/EIA–606-A work area labeling standard.
9. Allow for the UTP modules to be inverted in place for termination purposes.
10. Be manufactured by an ISO 9001 registered company.

E. Outlet mounting locations shall comply with the following requirements.
1. A minimum of two information outlet faceplates (on opposite walls) are required in each standard office area.
2. Each office faceplate shall be separated by approximately 50 percent of the total horizontal office wall measurement.
3. Larger offices or laboratory areas will require more faceplate locations and possibly including overhead service panels over experiment work areas.

F. Station jacks and Cabling System (Information Outlets) shall comply with the following requirements.
1. All in-wall, floor, ceiling (wireless) or wire mold mounted modular station jacks (mounted in faceplates) shall be colored light grey.
2. Station jacks shall be wired in accordance with the **EIA-TIA 568B wiring designation.**
3. The configuration of station cables is 2 (two) Category 6A cables per 3 port faceplate except for the following locations.
   a. wall phone outlets
   b. wireless outlets
   c. conference room outlets

d. laboratory workbenches

G. Wireless Data System Cabling
1. Data station jacks shall be required at designated ceiling or wall locations for wireless access points.
2. Each location shall receive one (1) Category 6A cable tested and terminated and one (1) jacks and one (1) faceplate.
3. The faceplate shall be white.

H. Conference Rooms
1. Two station jacks shall be required at designated floor locations in conference rooms. These locations shall use in-floor conduit boxes designed for installation in poured concrete floors that are connected with conduit back to the nearest pathway.
2. Each telecommunications designated in-floor location shall require 2 (two) Category 6A station jacks per each two gang floor box. Two station jacks shall be installed on a two port faceplate per single gang position in an outlet box. Single gang reduction ring may be necessary to accommodate the mounting of the single gang faceplate. Floor box faceplates shall be a duplex (2 port) and be colored white.
3. Floor box assemblies shall use floor-type specific flanges and duplex covers with lift lids.
4. Conference room tables installed shall be able to support the installation of cabling directly from the floor to table-top installed jacks.

I. Laboratory Environments
1. Each laboratory workbench shall require the installation of a quad port faceplate with four jacks (information outlets) and four Category 6A cables installed.
2. The laboratory workbench faceplates shall consist of two duplex (2 port) for a total of four modular faceplates and colored white.

J. Wall Phones
1. There will be some locations where a voice telephone jack will be installed on a single information outlet. Refer to the Contract drawings for wall phone locations.
2. All wall phones shall be wired with a Category 6a cable.
3. All wall phone conduit boxes and jacks shall be installed in order that telephones can be mounted at approximately 48” above the floor level.
4. Faceplates used to mount wall phone jacks shall be a single port Flush Mounted Stainless Steel Faceplate.
5. This faceplate shall use the standard Category 6A jack (information outlet) and the jack shall be colored blue.

K. The Elevator Outlets shall comply with the following requirements.
1. The contractor shall install ¾ inch (minimum) conduit from the nearest telecommunications room to the elevator suitable device box.
2. This shall apply to freight and passenger type elevators and shall be coordinated with the elevator contractor.

2.6 MODULAR PATCH PANELS

A. Intelligent Patch Panels
1. Patch panels shall be “intelligent”.
2. The patch panels shall have the ability to monitor each port in every patch panel by sensing insertion and removal of patch cord plugs.
3. The patch panels shall report back to monitoring software with recording capabilities.
4. The patch panel shall have a trace button and an LED above each port to illuminate all patch panel connections to assist in troubleshooting.
5. The patch panel shall require no proprietary patch cords or other specially designed hardware.

B. Modular Copper Patch Panel
1. The modular copper patch panels shall be mountable on a 19” rack.

2. Patch panel shall be either 24 port or 48 port and rated for Category 6A termination panels.
3. Modular connectors shall be terminated as **wiring designation 568B**.
4. The Contractor shall purchase the newest available version patch panels prior to installation.

C. Modular Fiber Optic Patch Panel
1. The modular fiber optic patch panels shall be mountable on a 19" rack.
2. Contractor shall supply a minimum of one fiber optic patch panel in each TR. In the MDF, the Contractor shall supply a minimum of two fiber optic patch panels.
3. Fiber optic riser cable shall be terminated in fiber optic modular cartridges with pigtails. This shall be the slide out shelve type.
4. Contractor shall supply all necessary kits, splice trays, splice organizers, cable protector kits, fusion splice sleeves and all other necessary parts and preparation materials in order to provide a working fiber optic system.
5. Blanks shall be used in any open and unused module openings in shelf.
6. All LC bulkheads shall have protective caps installed.
7. All rack mounted fiber termination panels shall be installed in a separate equipment rack with riser cable terminations.

2.7 RACKS

A. General Requirements for Racks
1. Equipment racks shall be cable management racks with vertical cable management cages with doors between each rack and on the outside ends of racks.
2. The equipment rack shall provide vertical cable management and support for the patch cords at the front of the rack and wire management, support, and protection for the horizontal cables inside the legs of the rack.
3. Waterfall cable management shall be provided at the top of the rack for patch cords and for horizontal cables entering the rack channels for protection and to maintain proper bend radius and cable support.
4. Horizontal wire management shall also be mounted below each patch panel on the rack. The Contractor shall leave a 4RU (7 inch) space between the bottom of the cable management panel and the top of the next patch panels installed.
5. The rack shall include mounting brackets for cable tray ladder rack to mount to the top of the rack.
6. Velcro cable ties shall be provided inside the rack channels to support the horizontal cable.
7. Rack shall be black in color to match the patch panels and cable management.
8. Equipment racks shall be bonded together and shall be grounded to the building busbar grounding system.
9. Equipment racks shall be located in a dry, temperature controlled environment.

B. Free-Standing Rack: Free-standing rack shall:
1. Provide the necessary strain relief, bend radius and cable routing for proper installation of high performance cross connect products, meeting all specifications of ANSI/TIA/EIA-568-C.
2. Have cable management including
   a. Top cable trough with waterfall and built in patch/horizontal cable distribution separator.
   b. Hook and loop straps for securing bulk cables inside the vertical U-channels.
   c. Provide floor and ceiling access for cable management and distribution.
3. Have 19" pre-threaded equipment rails to accept standard 19" rack mount equipment.
4. Have EIA hole pattern on front and rear.
5. Be available with a 16.25" (412.75 mm) channel depth for racks holding patch panels.
6. Be available with a 16.25" (165 mm) channel depth for racks holding network electronics.
7. Be installed as a 19" (483 mm) rack that is expandable to 23" (584 mm).
8. Provide pre-drilled base for floor attachment of rack. Equipment racks shall be anchored to the floor.
9. Be available in standard color of black.

10. Be manufactured by an ISO 9001 registered company.
11. Be available with 45 rack units and 7'-0" high.
12. Have electrical power for each rack.

C. Building Distribution Frame Room – BDF Room (Main Distribution Frame - MDF)
1. The Contractor shall provide a minimum of four (4) equipment racks in the building distribution frame equipment room.
2. One rack shall be provided for the riser cabling patch panel and the fiber optic closet connector housing panel.
3. Two equipment racks shall be used for structured cabling patch panels and networking equipment.

D. Telecommunication Rooms (TRs)
1. The Contractor shall provide a minimum of four (4) equipment racks in each telecommunication room.
2. One (1) rack shall be provided for exclusive use by the Owner.
3. Three (3) equipment racks shall be used for fiber optic and copper riser cablings, structured cabling patch panels and all required and necessary wire managers.

2.8 PATCH CORDS

A. General Requirements: All patch cords shall conform to the following.
1. The contractor shall provide factory terminated and tested UTP and optical fiber patch cords and equipment cords for the complete cabling system. The UTP patch cables shall meet the requirements of ANSI/TIA/EIA-568-B for patch cord testing.
2. The Contractor shall provide one patch cable per installed patch panel jack.
3. The patch cords do not have to be installed but shall be made available or stored at each telecommunication room and at the building distribution frame made available in the bottom of the rack housing the patch panels.

B. Copper (UTP) patch cords shall conform to the following requirements.
1. Copper patch cords shall be Augmented Category 6 (6A).
2. Approximately 60% of the copper patch cords shall be a length of 3 feet. The remainder of the copper patch cords shall be a length of 5 feet. All of the copper patch cords within the telecommunication spaces shall be colored blue.
3. The Contractor shall provide 2 patch cords, ten feet in length each, for every workstation area. Patch cord shall be colored light grey.
4. Copper patch cords shall be ANSI/TIA/EIA 568-B compliant, use 8 position connector, un-keyed and be capable of universal T568-A or T568-B wiring schemes.
5. Modular connector shall maintain the paired construction of the cable to facilitate minimum untwisting of the wires.
6. Patch cords shall have a performance marking indelibly labeled on the jacket (by the manufacturer).
7. Patch cords shall have the ability to accept color-coded labels compliant with TIA/EIA-606 labeling specifications.
8. Patch cords shall have "snagless" protection for the locking tab to prevent snagging and to protect locking tab in tight locations.
9. Patch cords shall have strain relief boot to protect UTP cable from excessive bending stress.
10. Patch cords shall be manufactured by an ISO 9001 registered company.
11. Patch cords shall match the horizontal backbone cabling from the workstations.

C. Optical Fiber patch cords shall conform to the following requirements.
1. One patch cable for corresponding multimode or single mode terminated cables shall be provided by the Contractor.
2. Cable shall be placed in the bottom of the fiber optic racks.
3. Fiber optic patch cords shall be manufacturer factory assembled.
4. Multimode patch cables shall:
   a. have LC connectors on both end.

b. Be 50 micron laser optimized.
c. Be 10 feet in length.
d. Be colored aqua.

5. Single mode patch cables shall
   a. Have LC connectors on both ends.
   b. Be 10 feet in length.
   c. Be colored yellow.

2.9 GROUNDING AND BONDING

A. The facility shall be equipped with a Telecommunications Bonding Backbone (TBB). This backbone shall be used to ground all telecommunications cable shields, equipment, racks, cabinets, raceways, and other associated hardware that has the potential to act as a current carrying conductor. The TBB shall be installed independent of the building's electrical and building ground and shall be designed in accordance with the recommendations contained in the ANSI/TIA/EIA-607 Telecommunications Bonding and Grounding Standard.

B. The main entrance facility/equipment room in each building shall be equipped with a telecommunications main grounding bus bar (TMGB). Each telecommunications room shall be provided with a telecommunications ground bus bar (TGB). The TMGB shall be connected to the building electrical entrance grounding facility. The intent of this system is to provide a grounding system that is equal in potential to the building electrical ground system. Therefore, ground loop current potential is minimized between telecommunications equipment and the electrical system to which it is attached.

C. All racks, metallic backboards, cable sheaths, metallic strength members, splice cases, cable trays, etc. entering or residing in the TR or ER shall be grounded to the respective TGB or TMGB using a minimum #6 AWG stranded copper bonding conductor and compression connectors.

D. All wires used for telecommunications grounding purposes shall be identified with a green insulation. Non-insulated wires shall be identified at each termination point with a wrap of green tape. All cables and busbars shall be identified and labeled in accordance with the System Documentation Section of this specification.

E. The telecommunication grounding busbars shall be a predrilled copper busbar with holes for use with standard size lugs and be a minimum of 0.25 inches thick by 4 inches wide by a minimum of 12 inches in length. One inch insulated mounting standoffs shall be installed on the busbar. Busbars shall have rounded corners.

2.10 FIRESTOP

A. A firestop system is comprised of the item or items penetrating the fire rated structure, the opening in the structure and the materials and assembly of the materials used to seal the penetrated structure. Firestop systems comprise an effective block for fire, smoke, heat, vapor and pressurized water stream.

B. All penetrations through fire-rated building structures (walls and floors) shall be sealed with an appropriate firestop system. This requirement applies to through penetrations (complete penetration) and membrane penetrations (through one side of a hollow fire rated structure). Any penetrating item i.e., riser slots and sleeves, cables, etc. shall be properly firestopped.

C. The Contractor shall provide cable penetrations of fire rated walls.

D. Penetrations shall be sleeved with a built-in fire stop system that automatically adjusts to the number of cables installed and in compliance with NEC and the local fire codes.

E. Provide and install additional fire stop assemblies where necessary for cable routing if available pathways or conduit sleeves do not exist such as transition for cable tray systems.

F. Provide and install the proper amount of firestop assemblies with a 40% fill ratio, a 35% growth factor and an overall 25% spare capacity.

G. Any wall penetration shall not decrease the original fire rating of the wall.

H. Firestop systems shall be UL Classified to ASTM E814 (UL 1479) and shall be approved by a qualified Professional Engineer (PE), licensed (actual or reciprocal) in the state where the work is to be performed. A drawing showing the proposed firestop system, stamped/embossed by the PE shall be provided to the Owner's Technical Representative prior to installing the firestop system(s).

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS FOR COMMUNICATIONS CABLE

A. All installation personnel shall exercise good judgment and installation techniques when installing cabling and hardware. Personnel shall not only consider their own safety, but also any conditions which may endanger others.

B. Pulling tension on communications cable shall not exceed 100 Newton or 25 foot-pounds.

C. Installation of the cable shall comply with the following requirements.
   1. The length of each individual run of horizontal UTP cable for Voice/Data shall not exceed 295 feet.
   2. The 4-pair UTP cable shall be installed using a star topology format from the telecommunication spaces.
   3. All installations shall be carefully routed and neatly installed.
   4. Splices and bridge taps are not allowed in the horizontal copper cabling.
   5. The contractor shall leave a minimum of 4 inches of cable slack spooled within the outlet box at the station jack end (for structured cabling).
   6. Each station/backbone cable run shall be placed as an uninterrupted conductor section from origination to termination point.
   7. All wire and cable installed shall be "LISTED" by Underwriters Laboratory (UL).
   8. Voice and data cables shall not be installed within 16 inches of power cables in order to avoid induced voltages.
   9. Installations in plenum areas, ducts, or other air-handling areas shall use plenum rated cabling (fire resistant and low smoke-producing characteristics). Any non-plenum rated cable, installed in a plenum area, shall be installed in conduit and by the Owner prior to the installation.

D. All communications cable, cable supports, conduit and trays shall be supported to the structure, independent of other services.
   1. Cable shall be supported at a maximum of every four (4) feet by contractor-provided cable supports, sized to adequately contain communications cables only, which are affixed to the building structure.
   2. Cables shall not obstruct passageways nor prevent doors from closing.
   3. All installations shall be supported by appropriate hardware supports fastened to the building structure or clearly defined building pathways.
   4. Cables shall not be fastened to any other building system (examples: electrical, water, fire sprinklers etc.).
   5. Cables or wires shall not rest on suspended ceilings, be fastened to ceiling support structures or be installed near steam piping or electrical fixtures.
   6. No cable or attachments shall be installed that inhibit access to any steam line, electrical or communications cable or device or mechanical equipment.

E. Cable should be placed in conduit or cable tray provided for this use.
   1. Cables shall be installed in cable trays within the horizontal backbone pathway.
   2. Cables shall not share a tray with power cables.
   3. Typically when cables leave cable trays the cable shall route through conduits to office areas.

4. When trays and conduit are not available for wire and cable, ladder or "D" rings shall be installed every 4 feet.
5. When installed in cable rings, the cabling size and the total cable weight must be considered as not to cause any cable damage.
6. Cables shall not sag more than 7 inches between points of tie. Points of tie shall not be over tightened or implemented in any way that might cause damage to installed cabling.

F. The contractor shall avoid cable stress from cable twist during installation and tension from suspended cable runs and from tightly cinched cable ties.
   1. Cables ties shall be plenum rated.
   2. Cable installations shall avoid sharp edges and tight bends.
   3. Installation locations that subject wire and cable to abrasion, corrosion, electro-mechanical interference or moisture shall be avoided.
   4. Installed fiber optic cables shall not exceed the specification for bend radius.

G. All cabling installations shall be labeled at both ends with unique cable and wire numbers.
   1. All jacks shall be labeled.
   2. Permanent laminated machine labels are required for all installations.

H. Installation in telecommunication rooms shall comply with the following requirements.
   1. All exposed cable in the Communications Room shall be secured to the plywood backboards or freestanding frames and routed through wire management hardware. All work should be neat and professionally done.
   2. Ladder rack guide posts shall be installed to all ladder rack 90 degree corners in the Communication Rooms.

I. Penetrations shall comply with the following requirements.
   1. When placing cable through floor or wall sleeves or penetrations, the vendor shall patch and seal all holes and gaps around the cable in accordance with floor fire rating.
   2. All sleeves shall be filled with a UL approved flexible fire caulking that will not permanently block sleeves or conduits.
   3. Floor and wall sleeves and penetrations shall be used exclusively for the Structured Cabling System. No other communications systems or electrical cabling shall be housed in these sleeves and penetrations.

J. Notify the Owner or Owner's rep of any horizontal cable run exceeding TIA/EIA specifications.

K. System inspection shall be provided through pre-construction, in-progress and final inspections by the Owner. The owner or authorized representative or the Contractor may, at his/her discretion, perform tests in addition to those specified in this document if there is any reason to question the condition of the material as furnished and installed.

L. After installation is complete, in addition to any other required testing, and at such time as the Owner directs, the Contractor shall conduct an operational test for approval. The installation shall be demonstrated to be in accordance with the requirements of this specification. Any defects revealed shall be promptly corrected at Contractor's expense and the tests re-conducted. Operational testing is defined for the following circuit types:
   1. Station cable:
      a. Color code compliance.
      b. Labeling.
      c. Routing.
      d. Workmanship.
      e. Compliance with EIA/TIA 568-C.1 and 568-C.2 requirements.
   2. Backbone cable:
      a. Color code compliance.
      b. Labeling.
      c. Equipment room and distribution closet jumpers.
      d. Grounding/bonding.
      e. Workmanship.

f. Continuity of termination block layout.
g. Installation and routing.

3. Fiber optic cable:
   a. Labeling.
   b. Patch panel connections.
   c. Loss measured in dB/km.
   d. Workmanship.
   e. Splice loss.
   f. Connector loss.
   g. Circuit length.

3.2 OPTICAL FIBER CABLE

A. Installation:
1. Any bend in any optical fiber cable at any point shall have a radius of not less than ten times the outside diameter of that cable.
2. All optical fiber cable and pathways shall be clearly identified as housing optical fiber cable at intervals not greater than 50 feet.
3. Each fiber cable routed to a Communication Room will contain twelve (12) strands of 50/125 um multimode optical fiber and twelve (12) strands of 8.3/125 um single mode optical fiber.
4. No splices are allowed other than the pre-terminated pigtails from the fiber modules.

B. Termination:
1. All fibers will be properly broken out and buffered prior to termination.
2. Fibers will be installed with factory terminated LC connector pigtail cartridges.
3. The connectors shall be housed in fiber patch panels described in the product section of this specification.
4. Any slack in the optical fiber shall be stored in the fiber tray or enclosure. No slack loops shall be permitted external to the fiber termination panel.

C. Testing and Inspection:
1. Fiber testing shall be preformed and documented on all terminated fiber strands.
2. Optical time-domain reflectometer (OTDR) testing and power meter testing shall be completed on the end-to-end terminated fiber optic cabling system.
   a. The OTDR testing shall use a standardized length launch cable and test in one direction at a wavelength of 850 nanometers for multimode fibers and 1310 nanometers for single mode fibers.
   b. The contractor shall locate the OTDR in the BDF equipment room and test towards each telecommunications room (TR).
   c. The OTDR shall have a valid calibration certificate within 1 year of the date that the installed fiber is tested.
3. The maximum acceptable link loss shall be the expected loss due to cable attenuation at the wavelength being measured plus 0.5 dB per connector.
4. A hard copy of the display screen shall be provided for each link.
5. The Owner retains the right to conduct random testing of installed components during any phase of the installation. The Contractor shall notify the Owner when portions of the installation have progressed far enough to allow for end-to-end testing.

3.3 HORIZONTAL CABLE

A. Installation:
1. All cables installed from the workstation to Communications Room shall be a continuous run. Splicing is not permitted.
2. Quantities of cables per workstation shall be provided as indicated on the construction drawings and within the specifications.

3. All cables shall be installed in accordance with TIA/EIA and manufacturer recommendations. Strict attention shall be paid to maintaining sheath integrity, avoiding cable kinks and sharp bends and proper use of cable ties.
4. Cables shall be bundled in groups of no more than 50 cables.
5. Cable shall be installed above fire-sprinkler systems and shall not be attached to any part of the system.

B. Installation: Wireless Data System Cabling
1. The wireless data system cabling and corresponding receptacles shall be tested and terminated inside a surface mount box and placed in the ceiling space in locations specified on the drawings.
2. Provide 5 inches of additional slack. The spare cable shall be neatly coiled in the surface mount box at the locations specified on the drawings.

C. Termination - Voice & Data Cable:
1. At the Communications Room, cables shall be terminated on modular patch panels described in the product section of this specification. Cables shall be terminated in numerical ascending order.
2. At the workstation outlet location, horizontal cable shall be terminated on jacks described in the product section of this specification. Jacks shall be wired in a 568B configuration. Pair untwist should be as short as possible and shall not exceed manufacturers installation specifications.
3. Install all communications device plates in full contact with the wall surface.
4. No more than 12” of cable slack shall be left in the box.

D. Testing and Inspection:
1. All cables will be tested for opens, shorts, polarity reversals, transpositions and presence of AC voltage. Any cable failing these tests must be repaired or replace and retested at no cost to the Owner.
2. All tests shall be preformed with a qualified and certified cable test set which verifies Augmented Category 6 (6A) compliance as a minimum. The test meter shall always be located in the telecommunication room (TR) and the injector shall always be located in office, work area, or conference room location when performing testing.
3. The overall pass/fail channel performance test shall be preformed by the Contractor with certified Category 6A test equipment. The Contractor shall use the certified Category 6A test equipment to perform the following channel performance measurements.
   a. Insertion Loss (attenuation)
   b. Wire Mapping
      1) Miswiring
      2) Pin to pin termination
      3) Reversed pairs
      4) Transposed pairs
      5) Shorts
      6) Split pairs
      7) Continuity (end to end)
   c. Grounds
   d. Resistance
   e. NEXT
   f. ACR
   g. PSum NEXT
   h. PSum ACR
   i. ELFEXT
   j. PSum ELFEXT
   k. Return Loss
4. Any cable failing this test must be repaired or replaced and retested at no cost to the owner.
5. Printed test results must be provided for each cable.

6. The Owner reserves the right to conduct random testing of all installed components at any phase during installation.

3.4 TEST RESULTS

A. The installation contractor shall perform and document tests on all structured cabling (including riser) and shall submit documentation to the Owner which shows manufacturer's acceptance of each cabling system as a 20 year extended system warranty.

B. At the end of the project after issuance of any applicable registered warranty, the Contractor shall turn over all required and supporting documentation (including fiber optic and copper cable test summary reports and manufacturer's factory fiber optic cable test specification sheets) to the Owner technical representative.
   1. Once all relative documentation has been received by the Owner technical representative, a review and evaluation shall be made by Owner of the received documents.

C. The Owner has the option to randomly select installation locations during any phase of the installation to evaluate and retest copper cables and/or fiber optic cables for the quality of installation, workmanship, damage and verification of the contractor summary reports.

D. The Contractor shall notify the Owner when portions of the installation have progressed far enough to allow for end-to-end testing

E. All non-conformances shall be reported to the contractor. The contractor shall correct all non-conformances.

F. The Contractor shall be responsible for all cable until the installation has been qualified as "OWNER CERTIFIED" by the Owner. Once random evaluations, verifications and all non-conformances have been completed one hundred percent (100%), the documentation and test results shall be declared as "OWNER CERTIFIED".

G. Testing Equipment Requirements
   1. Contractor shall submit a certificate showing that the test equipment has been calibrated within one year of the date that the data cabling system is tested.
   2. The field test equipment shall meet the requirements of ANSI/TIA/EIA-568-C including applicable TSB's and amendments.

H. General Cable Testing Requirements
   1. All pairs of all cables shall be tested.
   2. Three test reports (one each for structured cabling, fiber optics cabling and riser cabling) shall be prepared and submitted by the Contractor.
   3. All cabling documentation and overall pass/fail test results shall be submitted in the Microsoft Excel files that were provided by Owner.
   4. The contractor shall submit the completed test reports in pdf compatible documents and Microsoft Excel format after all installation work and testing has been completed.
   5. The Contractor shall provide test equipment files containing the end to end performace testing on all installed cabling. The submitted files shall be in a pdf compatible format.

I. Copper Testing Requirements
   1. For example, the data cabling spreadsheet information to be completed by the Contractor includes entries such as;
      a. Personnel conducting the test
      b. Type of equipment used (manufacturer, model number, serial number)
      c. Date of testing
      d. Last certification date of test equipment
      e. Direction of the test
      f. Telecommunications Room Location
      g. Patch Panel ID
      h. Patch Panel Port Number
      i. Room Number

j. Jack Number
k. Cable Label Office End
l. Cable Label TR End
m. Patch Panel ID Number
n. Patch Panel Label
o. Channel Length (in feet)
p. Overall Channel Performance

J. Fiber Testing Requirements
1. A copy of the OTDR certification shall be submitted to the Owner Technical Representative.
2. The Contractor shall provide electronic files in a pdf compatible format for the OTDR test reports.
3. A fiber optic riser summary report shall be prepared by the Contractor and submitted to the Owner technical representative.
4. The Owner shall provide the contractor a Microsoft Excel file that shall be used as the summary report to document the fiber optic cabling and testing.
5. The summary report shall include the following test information and labeling documentation.
   a. Personnel conducting the test
   b. Type of equipment used (OTDR manufacturer, model number and serial number).
   c. Date of test
   d. Last certification date for the OTDR
   e. Locations of end points (building, floor, room, outlet number) for each fiber strand.
   f. Location of OTDR tester (TR or BDF)
   g. Patch Panel ID (near end with reference to the OTDR)
   h. Connector Number (near end)
   i. Strand Color (near end)
   j. Patch Panel ID (far end with reference to the OTDR)
   k. Connector Number (far end)
   l. Strand Color (far end)
   m. Span loss (in db) across the terminated ends of each fiber strand performed with the power meter test
6. Acceptance of the fiber cable installation is partially contingent on the review and approval of the OTDR and power meter test data submitted.

3.5 LABELS

A. All cabling installations shall be labeled with unique cable numbers per building.
1. Jack numbers shall be unique numbers per floor.
2. Building location numbers (room numbers) for offices, conference rooms, work areas and laboratory areas shall be referenced from the building construction drawings.
3. The Telecommunication Contractor shall modify building diagrams to include Jack Numbers.

B. All jacks, cables, patch panels, station outlet faceplates and termination frames shall be labeled.

C. Permanent laminated machine labels are required for all installations.

D. All Category 6A cables shall be labeled at each cable end. All Category 6A cabling shall be labeled according to the following format (note: patch panels located within the office/workstation do not need to be labeled):

Office End of Cable	Example
Description of Cable	CAT 6A
Near End of Cable (Office or area location) A unique voice jack # 01, 02, 03 etc. (per floor	L159.01
Far End of Cable (TR Room # Location)	B101.01

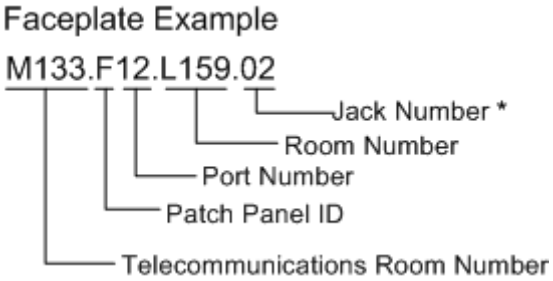
A unique voice jack number from office or area location	

Patch Panel End of Cable (in the TR)	Example
Description of Cable	CAT 6A
Near End of Cable (TR Location) A unique voice jack number from office or area location (per floor).	M133.01
Far End of Cable (Office or area location) A unique voice jack # 01, 02, 03 etc. (per floor)	L159.01

E. The following shall apply to all data patch panels.

Patch Panel: (above each port)	Example
Office End Location XX - indicates unique jack numbers per floor. Ex: 01, 02 03 etc.	L159.02 (Office. XX)

F. The following format shall apply to all station jack (information outlet) faceplates.



** Unique Jack numbers shall be used per floor.*

G. The Owner's Network Communications Group is available to provide the contractor assistance on labeling issues.
   1. The following table shows valid identification information for typical types of building numbers, floors, jack numbers and room numbers used at Argonne National Laboratory.

Building	3 to 5 - alpha-numeric characters	ex... 301 360T1
Floor	1 - alpha-numeric character	ex... S-service Floor B-basement F- fan loft T-tunnel 1-2-3 floors
Jack No.	2 - numeric digits (typically)	01 to 99
Room No.	5 - alpha/num characters max	ex... B252 M061C

H. Riser Termination Frame (IDF) Labeling
   1. The designation for an intermediate distribution frame (IDF) for direct wire riser terminations shall be compiled from the following permanent labeling and documentation reference.
   2. The contractor shall label each riser termination frame (patch panel) in each TR location with an IDF identification number.

Type Frame	3 - character function	IDF	riser to BDF
Frame Identification	4 - alpha/numeric characters max	Example: 2050 or 108A	1st 3 char = building last char = sequence 1-9 or A-Z 0 is always reserved for the BDF

I. Riser Cable Labeling
   1. The Contractor shall label each riser cable at both cable ends following the format below. Each cable pair count series shall be unique per building.

Cable Pair Count	2 - 5 digits "from-to" numbers	ex... 0601 to 01199	Next series available per building
Cable Size	5 - numeric digits	ex... 01200 (pair)	Actual cable size in pairs
Feed From	Typically 4-5 digits	ex... 2210	Location ID of the far end frame
Location (where the feed is from)	Typically up to 20 characters	ex... Bldg 221 svc floor	Building and Floor where the feed is from

J. All fiber optic cable installations shall be labeled with unique cable numbers using a specific labeling format.
   1. All elements of the installation shall be labeled.
   2. The contractor shall use a professional label maker for all labels including; patch panels, all cable ends, points of termination and office information outlets.
   3. Labels shall be a permanent laminated label.
   4. Building location numbers (room numbers) for offices, conference rooms, work areas and laboratory areas shall be referenced from the building construction drawings.

K. The following shall apply to all fiber optic patch panels located in the telecommunications rooms (TRs)

TR Patch Panel: (above each port)	Example
Description of Cable	FOMM (Fiber Optic Multimode) or FOSM (Fiber Optic Singlemode)
Point of Origination (TR)	L152A-XX
Point of Destination (BDF)	L159-XX
XX - indicates a unique number for each fiber optic strand per cable.	Ex: 01, 02 03 etc

L. The following shall apply to all fiber optic patch panels located in the building distribution frame equipment room.

BDF Patch Panel: (above each port)	Example
Description of Cable	FOMM (Fiber Optic Multimode) or FOSM (Fiber Optic Singlemode)
Point of Origination (BDF)	L152A-XX
Point of Destination (TR)	L159-XX
XX - indicates a unique number for each fiber optic strand per cable.	Ex: 01, 02 03 etc.

3.6 OBSERVATIONS

A. On-going Observations shall be performed during construction by the Project Manager and /or System Manager. All work shall be performed in a high quality manner and the overall appearance shall be clean, neat and orderly. The following are some points that will be examined.

1. Is the design documentation complete? Are cables properly labeled from end to end?
2. Have all terminated cables been properly tested?
3. Is the cable type suitable for its pathway?
4. Have the pathway's manufacturer's guidelines been followed?
5. Have potential EMI and RFI sources been considered?
6. Is the cable fill correct?
7. Are hanging supports (J-hooks) within the specification limits?

3.7 EQUIPMENT RACKS

A. Equipment racks shall be provided and installed in all communications rooms as specified in this document and on the construction drawings.

B. Vertical and horizontal cable management hardware shall be installed on the racks as specified and shown on drawings.

C. Racks shall be secured to the floor, using as a minimum 3/8" hardware, in such a manner that the rack will remain stable when loaded with communications equipment.

D. Comb straight and form in a neat and orderly manner all conductors located within equipment racks. Tie as required using Velcro cable ties of appropriate type and size.

E. Racks shall be located within the room so as not to block access to any existing equipment or backboard space. The racks shall be located in the center of the room as shown on the drawings to allow maximum access.

F. The racks shall be properly grounded to the telecommunications ground bus bar (TGB).

G. Cable runway shall be placed as indicated on the construction drawings to support copper and fiber cables being terminated in or routed through each communications room.

H. The cable runway shall be properly grounded to the telecommunications ground bar (TGB).

3.8 INSTALLATION ACCEPTANCE

A. The system shall be accepted when the contractor has met the following conditions.

B. If fiber optic cable or copper cable is damaged during movement, storage, or during installation, the Contractor shall repair or replace cable at Contractor's expense. Damage includes but not limited to:
   1. Breaks in fiber or copper
   2. High copper resistance shorts or opens
   3. Abrading the cable jack to expose the fibers or conductors
   4. Bending the cable more than the manufacturer's specifications for bend radius
   5. Exceeding the manufacturer's tensile load installation specification

C. Any connector (fiber or copper) damaged or improperly installed shall be removed and replaced with a new connector. Damaged conditions will be determined by visual inspection and/or by certified meters for copper testing and fiber optic power meter testing. The Owner Representative or approved designate shall make final decisions on the replacement of questionably damaged connectors.

D. The Contractor shall be financially responsible for damage to any surfaces or work disrupted as a result of his work. Cost of repair of surfaces, including painting, shall be included as necessary. The Owner shall determine the extent and cost of repairs.

E. All elements of this specification shall be 100 percent compliant to these standards, specifications, and Contract Documents.

F. All materials, equipment, documentation, summary reports including fiber optic test data, copper cable test data and deliverables have been 100% completed and submitted to the Owner. Once these elements have been received and verified, the Owner will declare the installation as, "OWNER CERTIFIED"

G. Delivery of the manufacturer's end-to-end channel system warranty to the Owner. These warranties offer an extended 20 year end to end system warranty or group of warranties for all wiring systems (Example: 2 -Category 6A, 1 singlemode and 1 multimode fiber optic wiring system).

H. The contractor shall provide a certified end-to-end channel of products purchased from and installed by the manufacturer.

I. If the contractor fails to meet these conditions, the contractor shall take whatever actions are necessary to fully comply with specifications and reports of non-conformance by Owner.

3.9 AS-BUILT DRAWINGS

A. The drawings are to include cable routes and outlet locations.
   1. Outlet locations shall be identified by their label as required in these specifications.
   2. Numbering, icons, and drawing conventions used shall be consistent throughout all documentation provided.
   3. The Owner will provide floor plans in paper and electronic (DWG, AutoCAD) formats on which as-built construction information can be added.
   4. These documents will be modified accordingly by the telecommunications contractor to denote as-built information as defined above and returned to the Owner.

B. The Contractors shall annotate the base drawings and return a hard copy (same plot size as originals) and electronic (AutoCAD 2008) form.

C. All drawings, test results, project documents and certifications shall be delivered to the Owner technical representative as electronic copies on CD or DVD.

D. All drawings shall be in an AutoCAD or Visio editable (.DWG, .DXF, .VSD) format. All cabling documentation and overall pass/fail test results shall be submitted in the Microsoft Excel files that were provided by Owner.

E. All drawings, project documentation and certifications shall be detailed in accordance with accompanying written specifications.

F. Details for materials of different sizes, listings and locations shall be referenced and noted in the design drawings.

G. Documentation shall include "As Built" records indicating exact cable routes, layout of patch panels, station positions and pathway routes.

END OF SECTION

SECTION 27 51 00
LOW VOLTAGE SYSTEMS GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section defines the requirements for the provision and installation of any system specified in Division 27.

B. The specifications sections "General Conditions," "Special Requirements" and "General Requirements" form a part of this section and other Division 27 sections by this reference thereto and shall have the same force and effect as if printed herewith in full.

C. The Low Voltage System Contractor shall be certified by the Manufacturer to install all systems related devices and systems utilized in this project.

D. In the event of conflicting documentation (including specifications, drawings or details), standards, references, or requirements, the most stringent requirement shall apply.

1.2 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.
   1. Section 27 05 28 – Communications Conduit Rough-In
   2. Section 27 05 29 – Communications Cable Tray System
   3. Section 27 05 32 – Structured Cabling System

B. Low Voltage Reference Symbols:
   1. Symbols used on the drawings are defined in the symbols legend of the ET series drawings. Some of the symbols scheduled may not be required for the project symbols.

1.3 REFERENCES AND COMPLIANCES TO THE LATEST EDITIONS, AS RELATED:

A. National Electrical Code (NEC).

B. National Electrical Safety Code (NESC).

C. National Fire Protection Agency (NFPA).

D. United States Department of Energy (DOE)

E. American National Standards Institute (ANSI).
   1. 568-B.1 – Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements
   2. 568-B.2 – Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling Components
   3. 568-B.3 – Optical Fiber Cabling Components Standard
   4. 569-A – Commercial Building Standard for the Telecommunications Pathways and Spaces
   5. 758 – Customer Owned Outside Plant Telecommunications Cabling Standard
   6. 606(A) – The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   7. 607-A-2002 – Commercial Building Grounding and Bonding Requirements for Telecommunications

F. Underwriters Laboratories (UL).

G. Americans with Disabilities Act (ADA).

H. Occupational Safety and Health Act (OSHA).

I. Uniform Building Code (UBC).

J. Federal Communications Commission (FCC).

K. American Institute of Architects (AIA).

L. IEEE.

M. BICSI (Building Industry Consulting Services International).

N. Argonne National Laboratory Construction and Environment, Safety and Health (ANL-ESH) requirements

O. All State of Illinois and local county codes and ordinances

P. Should the requirements of this specification or the construction drawings conflict with governing codes and regulations, the more stringent shall apply. Nothing in the construction drawings nor this section shall be construed to permit work not conforming to all governing codes and regulations.

1.4 SYSTEMS DESCRIPTION

A. Design Requirements:
   1. Provide and install all related devices, equipment and appurtenances necessary to complete the work as a fully operational system.
   2. Drawings for this work is diagrammatic, intended to convey the extent, general arrangement and locations of the work. Because of the scale of the drawings, certain basic items such as conduit fittings, access panels, cabinet sizes, sleeves, pull boxes, back boxes and junction boxes may not be shown. Include all items where required by code, other sections and for proper installation of the work.

B. The scope of work shall include cable and termination hardware, panels, equipment racks and associated rack equipment, and support hardware and software, which provides for a complete and operational system. Network switches and wireless access points will be purchased and installed by the Owner outside of the scope of the Contract Documents.

C. The Project Drawings and Specifications are complementary, and what is required by any one shall be as binding as if required by both.

D. Product specifications, general design considerations, and installation guidelines are provided in this document. Quantities of devices, typical installation details, cable routing and outlet types for a specific facility shall be coordinated and determined through consulting with the engineer and IT representatives.

E. The Contractor shall furnish all parts, labor, supervision, tools, miscellaneous mounting hardware and consumables for each system installed.

1.5 SUBMITTALS

A. Refer to Division 01, General requirements, Submittals, for Submittal Transmittal and Preparations of Submittals.

B. Submittal review is considered as general acceptance of the basic applicability of the equipment. Contractor is responsible for the installation of the equipment and/or alternate arrangement of the equipment within a given space. When the Contractor desires to use substituted equipment, he shall be responsible for producing his own coordinated working drawings which depict the substituted equipment accommodated in the space. Where substituted equipment creates the need for alterations to any portion of the work depicted in the contract documents, it shall be the Contractor's responsibility to notify all the affected parties and coordinate these items with all other trades. Further, it shall be the contractor's responsibility to assume any additional cost to the contract created by the substituted equipment.

C. All materials and equipment the Contractor proposes to furnish shall be submitted to the Architect/Engineer for review and shall comply with the requirements of Division 01 Submittals. Data shall be complete in all respects and shall reference, where applicable, the unit symbol utilized on the Drawings and Specifications. Partial or incomplete submittals are not acceptable.

D. Contractor further agrees that if deviations, discrepancies or conflicts between shop drawings/submittals and the Specifications are discovered either prior to or after shop drawing submittals are processed by the Engineer, the design Drawings and Specifications shall control and be followed. Review of submittal data shall in no way relieve the Contractor of his duty to perform all work and provide all equipment in strict compliance with the requirements set forth on the drawings herein.

E. The Contractor shall submit detailed shop drawings for approval of all equipment to be constructed and installed. Such shop drawings shall be complete, giving all required information, and shall be properly checked and coordinated with the work of other trades before submission. No work shall be performed until application shop drawings and layout drawings have been approved by the Architect/Engineer.

F. Shop Drawings:
   1. Include dimensions, wiring and block diagrams, conduit sizes, performance data, ratings, control sequences, site plan(s), floor plans, mounting details and all other descriptive data necessary to describe the item proposed and its operating characteristics.
   2. Shop drawings shall be rejected if shop drawings that are submitted contain project architect and/or project engineer of record title block information, company logo or design team members names. Submitting bid or contract drawing(s) details, diagrams and/or notes will not be acceptable and will be cause to reject shop drawings.

G. Product Data:
   1. Submit complete technical data necessary to evaluate the material and equipment. Include a complete technical specification for the submitted equipment, noting differences and adherence to this section.

H. Contract Closeout Information:
   1. Warranty.
   2. Maintenance Data.
   3. Certificates.

1.6 QUALITY ASSURANCE

A. Qualifications of manufacturer: Documented successful work experience of at least 10 facilities of equivalent size and technical requirements utilizing the equipment proposed to be used.

B. System Integrator/Installer shall have no less than five (5) years of documented work experience on projects of equivalent size and similar scope.
   1. "Experience" is defined as the completion of an operational system, with the system being successfully operated by the Owner for its intended purpose for at least one year.

C. The system and its components must be manufactured by a company engaged in the manufacturing of the specific equipment for a minimum of five (5) years.
   1. Use the products of a single manufacturer for similar type equipment, i.e., motion detectors, magnetic contacts, etc.
   2. Use products made by companies regularly engaged in the manufacture of the type equipment specified.

D. Equipment specifications may not deal individually with every part, control, or device, which may be required to produce the equipment performance specified or as required to meet the equipment warranties. Include such items, as required, for a complete operational system, whether or not specifically indicated.

E. Coordinate with other applicable trades in submittal of shop drawings.
   1. Shop drawings shall detail space conditions to accommodate other concerned trades, subject to final review by the Architect.

F. If installation of equipment, raceways, cable trays and/or conduit is performed prior to coordination with other trades, which interferes with the work of other trades, make necessary changes to correct the condition at no additional cost to the Owner.

G. Regulatory Requirements:
   1. National Electric Code (NEC).
   2. National Fire Protection Association (NFPA).
   3. Underwriters Laboratories (UL).
   4. Americans with Disabilities Act (ADA).
   5. Uniform building code (UBC).
   6. American Institute of Architects (AIA).
   7. Regulations of the:
      a. Federal Government.
      b. State of Illinois
      c. local county codes and ordinances

H. Coordinate equipment submittals with construction schedules.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Protect materials stored on the job site. Protect materials during construction and after installation, provide protection of equipment until time of substantial completion.

B. Provide and apply protective material immediately upon receiving the products and maintain throughout the construction process.

C. Keep products clean and dry, elevating equipment above ground and floor.

D. Take precautions to protect apparatus and materials from damage.

E. Failure to protect materials constitutes sufficient cause for rejection of the apparatus or material.

F. Protect factory finish from damage during construction operations and until final acceptance. Restore finishes that become stained, scratched, or damaged.

1.8 RECORD DOCUMENTS

A. To the requirements of Division 01, provide complete schematic drawings depicting location of interface, number of conductors, types of connectors, circuit requirements and type of enclosure.

1.9 PROJECT CONDITIONS

A. Active Services: Protect existing active services, water, gas, sewer, and electric, when encountered, against damage. If active services are encountered which require relocation, notify Architect promptly in writing, with copy to Owner's designated representative.

1.10 CONTRACT DRAWINGS

A. The contract drawings indicate the general nature of the components required but do not necessarily show all components required. The drawings are intended to aid the Contractor and/or sub-contractors and suppliers in providing the complete systems required. Raceways, routing, and cabling are not always shown on the drawings; however the Contractor shall provide a complete system.

B. Drawings shall include a legend for telecommunication outlet symbols.

1.11 AS-BUILT DOCUMENTS

A. It shall be the responsibility of the Telecommunication Contractor to obtain an additional set for As-Built documentation. The set will be designated as "AS-BUILT" working documents. This set shall be maintained by the Telecommunication Contractor Superintendent daily to document all as-built information as it occurs throughout the project.

B. The AS-BUILT drawings shall be available to the Owner Designated Representative upon request during the course of the project.

C. The Systems Contractor shall provide the AS-BUILT documents in accordance with the front end documents. A draft copy shall be made available as a requirement to substantial completion.

D. Drawings shall be prepared in the current AutoCAD Release.

1.12 WARRANTY

A. The SCS Contractor shall provide a system warranty covering all parts, labor and performance to all applied standards for a period of not less than one (1) year from the date of acceptance by the Owner.

B. Manufacturer's Warranty
   1. Provide all Manufacturer extended product, performance, application, and labor warranties that apply to any system provided.

C. Installation personnel shall meet manufacturer's training and education requirements for implementation of extended warranty program.

D. The contractor shall agree to repair or replace defective components/materials and correct defective work when given notice by the Owner during the warranty period.

E. Damage caused to completed work shall be replaced or repaired to the original condition or better by the contractor at no additional cost to the Owner.

F. The warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrently with, and not limiting, other rights and warranties the Owner may have under provisions of the Contract Documents.

1.13 INSPECTION AND FINAL ACCEPTANCE

A. The Telecommunication Contractor shall request interim inspections by the Owner or Owner's designated IT design representative throughout the course of the installation.
   1. Owner shall inspect all cabling when cables are pulled and not yet terminated.
   2. Owner shall inspect all terminations including test data sheets for Category cabling.

B. Test Verification:
   1. Notify Architect and Owner's representative in writing, in advance of testing to prevent delays in construction schedules.
   2. Test all systems and place in proper and specified working order prior to demonstration of the systems.
   3. Test system grounds to demonstrate that the ground resistance does not exceed the requirements of the transient voltage surge suppression (TVSS) or the National Electric Code (NEC).
   4. Perform tests, as required, by authorities having jurisdiction over the site. In addition to required tests by authorities having jurisdiction, the Contractor shall
      a. Test cabling when cables are pulled and not yet terminated.
      b. Test cabling after termination.
   5. The Owner reserves the right to either be present or have a designated representative, Architect, or representative of the authorities having jurisdiction present during the testing.

C. Testing and Acceptance shall comply with the requirements in the individual specification sections.

D. Final Acceptance: At the completion of the project and prior to final acceptance of the work, provide evidence of final inspections and approvals to the Owner, as required by the authorities having jurisdiction to requirements of Division 01.

1.14 PRODUCTS

A. See individual sections

1.15 CABLING

A. Provide all cabling needed to complete the system per requirements. Install all conductors in raceway, unless noted otherwise. Provide numbered cable markers on each terminated end of all cables, in accordance with shop drawings, using permanent pressure sensitive or sleeve type markers.

1.16 O & M MANUAL (OPERATION & MAINTENANCE)

A. Provide all information as and when required per Section.

B. Include record drawings, letter of certification, and test results.

1.17 MATERIALS AND WORKMANSHIP

A. In the absence of specifications, the Building Industry Consulting Service International/Telecommunication Distribution Manual (BICSI/TDMM) shall prevail and first quality materials and workmanship shall be supplied to building cabling for all Low Voltage Systems cabling.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 27 51 10

AUDIO - VIDEO DISPLAY 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 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.
   1. Division 26 – Electrical Requirements
   2. Section 27 51 00 – Low Voltage Systems General Requirements
   3. Section 27 05 28 – Communications Conduit Rough-In
   4. Section 27 05 32 – Structured Cabling System

1.3 REFERENCES AND COMPLIANCES TO THE LATEST EDITIONS, AS RELATED:

A. All system installations shall be in accordance with the requirements in Section 27 51 00.

B. American National Standards Institute (ANSI).
   1. 568-B.1 – Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements
   2. 568-B.2 – Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling Components
   3. 568-B.3 – Optical Fiber Cabling Components Standard
   4. 569-A – Commercial Building Standard for the Telecommunications Pathways and Spaces
   5. 758 – Customer Owned Outside Plant Telecommunications Cabling Standard
   6. 606(A) – The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   7. 607-A-2002 – Commercial Building Grounding and Bonding Requirements for Telecommunications

C. Occupational Safety and Health Act (OSHA).

D. BICSI (Building Industry Consulting Services International).

E. Argonne National Laboratory Construction and Environment, Safety and Health (ANL-ESH) requirements

F. All State of Illinois and local county codes and ordinances

G. Should the requirements of this specification or the construction drawings conflict with governing codes and regulations, the more stringent shall apply. Nothing in the construction drawings nor this section shall be construed to permit work not conforming to all governing codes and regulations.

1.4 DESCRIPTION OF WORK

A. The work of this Section consists of the provision of all materials, labor, equipment, devices and all appurtenances necessary and/or required for the complete execution of all audiovisual equipment and related work for this project as required by the schedules, keynotes and drawings, including, but not limited to the following:
   1. Unless otherwise specified, supply only new equipment, parts and material, and protect all equipment from construction dust and debris until final acceptance. Operate only as required for testing as part of installation procedure. Provision of all manufactured components, installation, wiring, and testing is the responsibility of a single contractor.

2. The system drawings indicate the general layout of the various items of equipment and their functional relationships. However, layout of equipment, accessories, and conduit systems are diagrammatic unless specifically detailed and do not necessarily indicate every item required for a complete installation. Provide any incidental equipment needed in order to result in a complete and operable system even if not specified or shown on drawings without claim for additional payment.
3. Quantities of all major installed and all portable equipment, including any add- or deduct- alternates, are indicated on the system and electrical drawings. Quantities of portable equipment are indicated in schedules contained in the drawings or specifications; quantities of installed equipment are determined by examining the functional diagrams, plans, and riser diagrams.
4. Refer to ET series drawings for receptacle backbox location and quantity information. Also refer to architectural reflected ceiling plans for exact location of ceiling-mounted devices.
5. Verify correctness of parts lists and equipment model numbers and conformance of each component with manufacturer's specifications.
6. Obtain all permits necessary for the execution of the work. Comply with all applicable local codes and regulations.
7. Supply and install miscellaneous steel, such as Unistrut, above finished ceiling for mounting each video projector.
8. All primary conduit and wireways as shown on the AV drawings are included in the General Contractor’s scope of work and are not to be provided in the Audiovisual Contract. Supply and install all miscellaneous conduit and wireways to the extent not included in Division 26 and Division 27 in order to provide a complete and operable system.
9. Millwork: Schematic details of the conference tables are included for the purpose of facilitating coordination of the installation of audiovisual components in these millwork items to be provided by the General Contractor.
10. Coordinate conduit, power, and grounding requirements with the electrical sub-contractor for the building project. All power wiring required as part of this work is to be performed by licensed electricians. Contractor may subcontract such work to a qualified electrical contractor.

1.5 FUNCTIONAL REQUIREMENTS OF SYSTEMS

A. Typical Conference Room:
   1. A flip top box will be designed into the conference table to provide connectivity to the presenter’s lap top computer or other A/V source.
      a. Video and Audio will be output to an Owner Furnished wall mounted large screen LCD display. LCD Display is Owner Furnished and NOT IN SCOPE.
   2. Rough-in requirements for Owner Provided LCD Display shall include:
      a. Flush mounted wall box with conduit as indicated on ET series drawings.
      b. Provide DVI and HDMI cable as indicated in this section. Coordinate and verify exact cable requirements with Owner.

B. Conference Room A323:
   1. A flip top box will be designed into the conference table to provide connectivity to the presenter’s lap top computer or other A/V source.
      a. Video will be output to a ceiling mounted video projector.
      b. Audio will be output to ceiling mounted loud speakers.

1.6 SUBMITTALS

A. Comply with the requirements in accordance with Division 01 for Submittals, Submittal Transmittal and Preparations of Submittals.

B. Comply with requirements in accordance with Section 27 51 00, 1.5.

1.7 OPERATIONS AND MAINTENANCE MANUALS

A. Provide Operations and Maintenance manuals in accordance with the requirements of Division 01.

1.8 QUALITY ASSURANCE

A. Comply with requirements in accordance with Section 27 51 00, 1.6.

1.9 WARRANTY

A. Comply with the requirements in accordance with Division 01.

B. Comply with requirements in accordance with Section 27 51 00, 1.12.

1.10 TRAINING

A. The Owner may assign personnel to participate with the contractor during installation. Without delaying the work, familiarize the Owner's personnel with the installation, equipment, and maintenance.

B. During tests and adjustments, permit the Owner's personnel to observe. When feasible explain the significance of each test.

C. Provide sufficient training to personnel selected by the Owner on operation and basic maintenance of all systems and equipment. Explain operation of control systems, set-up and operation of individual pieces of equipment and functions of overall systems.

D. Provide training for the Audio/Visual System: Min. 3-hour technical training session and two min. 3-hour user training sessions approximately one month after system acceptance.

1.11 INSPECTION

A. Notify the Architect of any defects in work by other trades affecting installation.

B. Comply with requirements in accordance with Section 27 51 00, 1.13.

PART 2 - PRODUCTS

2.1 MANUFACTURER REQUIREMENTS

A. All audio and video material and equipment shall be furnished new, unused and free of defects. They shall be clean and free of damage or corrosion and shall be of the best quality obtainable for the purpose intended.

B. Cabling, equipment and hardware manufacturers shall have a minimum of five years experience in the manufacturing, assembly, and factory testing of components.

C. The Contactor shall submit a letter from the manufacturer stating that all system parts (all parts shall be listed separately) shall be available for a minimum period of 7 years from the date of the completed installation.

2.2 MULTIMEDIA INTERFACE EQUPMENT

A. Multimedia Interface Transmitter Panel
   1. Multimedia Interface Transmitter Panel shall be provided and comply with the following minimum requirements.
   2. The transmitter panel shall be mounted in the table top box.
   3. The transmitter panel shall have the following video signal types:
      a. Analog RGBHV, RGBS, RGsB, RsGsBs.
      b. Component video (YUV bi-level or tri-level sync).
      c. S-video.
      d. Composite video.
   4. The transmitter panel shall have the video signal connectors:
      a. One (1) - female 15-pin HD (RGB, RGBS, RGsB, RsGsBs).
      b. Three (3) - RCA (component video).
      c. One (1) - female 4-pin mini DIN (S-video).
      d. One (1) - RCA (composite video).
      e. One (1) - female 15-pin HD (RGB buffered loop through).
      f. One (1) - female HDMI type A.
   5. The transmitter panel shall have the audio signal types:
      a. Stereo, unbalanced.
   6. The transmitter panel shall have the audio signal connectors:

a. Two (2) - 3.5 mm mini stereo jack.
b. Two (2) - pair female RCA.

7. The transmitter panel shall have the control signals:
   a. RS 232 input/output.
8. The transmitter panel shall have the power requirements:
   a. External Power Supply: 100 VAC to 240 VAC, 50-60 Hz, 6 W max.
   b. Power input: 12 VDC, 0.5 A.
9. Contractor shall furnish one 6 foot (2m) patch cord for each audio and video connector on the Interface Panel.

B. Multimedia Interface Receiver

1. Provide a Multimedia Interface Receiver that shall comply with the following minimum requirements.
2. The receiver shall be securely fastened to the back of the owner provided wall mounted large screen flat panel display or on the Video Projector low profile HDMI Extender shelf.
3. The receiver shall have the following Video Signal Types:
   a. Analog RGBHV, RGBS, RGsB, RsGsBs.
   b. Component video (YUV bi-level or tri-level sync).
   c. S-video.
   d. Composite video.
4. The receiver shall have the following video signal connectors:
   a. One (1) - female 15-pin HD (RGB, RGBS, RGsB, RsGsBs).
   b. Three (3) - RCA (component video).
   c. One (1) - female 4-pin mini DIN (S-video).
   d. One (1) - RCA (composite video).
   e. One (1) - female 15-pin HD (RGB buffered loop through).
   f. One (1) - female HDMI type A.
5. The receiver shall have the following audio signal types:
   a. Stereo, unbalanced.
6. The receiver shall have the following audio signal connectors:
   a. Two (2) - 3.5 mm mini stereo jack.
   b. Two (2) - pair female RCA.
7. The receiver shall have the following control signals:
   a. RS 232 input/output.
8. The receiver shall have the following power requirements:
   a. External Power Supply: 100 VAC to 240 VAC, 50-60 Hz, 6 W max.
   b. Power input: 12 VDC, 0.5 A.
9. Contractor shall furnish one 6 foot (2m) patch cord for each audio and video connector on the Interface Receiver.

2.3 VIDEO PROJECTOR AND ASSOCIATED EQUIPMENT

A. Provide a Video Projector that shall comply with the following requirements.

1. The video projector shall be a color video projector utilizing a Single 0.7" DLP chip.
2. The projector shall have the following inputs and outputs:
   a. One (1) – HDMI.
   b. Two (2) - Component (mini D-sub 15 pin).
   c. One (1) - S-Video (mini DIN 4 pin).
   d. One (1) – Composite Video (RCA pin type).
   e. One (1) – Stereo connections.
   f. Two (2) - Audio 3.5mm stereo mini jacks
   g. One (1) - Stereo Audio connection (RCA L/R).
3. The projector shall have the following features.
   a. Hand Held remote control.
   b. RS-232 remote control.
   c. USB (type B) remote control.
   d. Be controllable via a Local Area Network (LAN) via a RJ-45 connector.

4. Provide a projector with the following minimum performance requirements.
    a. 4,000 ANSI lumens.
    b. 2,200:1 contrast ratio.
    c. Built in DSP for curved screen correction.
    d. 1280 x 800 native panel resolution.
    e. Compatibility with HDTV sources includes 1080p,1080I, 720p.
5. Power requirements:
    a. External Power Supply: 100 VAC to 240 VAC, 50-60 Hz, 10.8 W max.

B. Video Projector Mount and Accessories
1. Contractor shall provide a video projector mount and the following minimum mounting accessories.
2. Provide a drop ceiling projector mount that shall:
    a. Be compatible with suspended (drop) ceilings with 2' x 2' or 2' x 4' tile grids.
    b. Be adjustable mounting pole adapter plate for correct alignment.
    c. Have knockout openings for two (one 1-gang and one 2-gang) junction boxes to facilitate the Division 26 electrical power outlet.
    d. Have equipment support for up to 50 pounds (23 kgs) of A/V equipment and 3" deep, ¼ rack devices.
    e. Support the Multimedia Interface Receiver.
3. The projector and associated mounting accessories shall be of Aluminum construction.
4. The projector pipe dimension: 25”x 1.5”.
5. The projector pipe shall have 11.5 National Pipe Thread (NPT).
6. The mounting accessories include but not limited to:
    a. Anti-vibration pads for projector mount.
    b. All fasteners, anchors, tie-wire, turnbuckles and associated equipment per manufacturer requirements and recommendations.

2.4 AUDIO EQUIPMENT

A. Power Amplifier
1. Provide a power amplifier with the following minimum requirements.
2. Power amplifier shall have the following minimum connectors, inputs, and outputs.
    a. One (1) - stereo/mono, balanced/unbalanced input
    b. Two (2) - stereo/mono, unbalanced inputs
    c. One (1) - 3.5 mm captive screw connector, 5 pole (main input)
    d. One (1) - 3.5 mm mini audio jack (tip, ring, sleeve)
    e. One (1) - pair RCA
3. Impedance: >10k ohms balanced/unbalanced, DC coupled
4. Maximum level: +20 dBu (balanced, captive screw), +4 dBV (unbalanced, RCA) at 1% THD+N
5. Input sensitivity: RCA inputs -10 dBV.
6. Captive screw input +4 dBu if driven by one input, -2 dBu if both inputs are summed.
7. Output power: 70V 40 watts (rms), 70 V, 1 kHz, 1% THD
8. External power supply: 100 VAC to 240 VAC, 50-60 Hz, external; to 12 VDC, 3 A (min.), regulated
9. Power input requirements: 12 VDC, up to 5 A
10. Co-located with the Multimedia Interface receiver.

B. Recessed Ceiling Loud Speakers:
1. Ceiling loud speakers shall comply with the following minimum requirements.
2. Speaker shall be a 4" coaxial loudspeaker, ported bass reflex enclosure and press-fit grille for conventional ceiling installation.
3. The cone shall be constructed of polypropylene with a butyl rubber surround.
4. The19mm tweeter shall be constructed of PEI.
5. The magnet shall be a minimum of 10oz. (264g) with a voice coil diameter shall be 1".
6. Frequency response: 75Hz to 20kHz (±7dB).
7. The transformer shall be (70.7/100V) volt type with 1, 2, 4, 8 and 16 watt primary taps (@70.7V) with a front mounted tap selector switch to include transformer bypass setting for 8 ohm direct coupled operation.

8. The speaker enclosure shall be a deep drawn steel enclosure, acoustically treated with a fiberglass lining.
9. With each speaker furnish a tile bridge for speaker housing support on the drop ceiling.

2.5 MISCELLANEOUS EQUIPMENT

A. Floorbox:
1. The floor box shall be located as indicated on the Contract Drawings.
2. The floor box shall have the following minimum features:
   a. 11 gauge finished steel cover with carpet edging.
   b. Mitered brass carpet edging .25 inch high with a beveled profile.
   c. Stainless steel compression latches.
   d. 14 - 1” conduit knockouts.

B. Table Top Box:
1. The table box shall be located as indicated on the Contract Drawings.
2. The table top box shall facilitate the installation of the Multimedia Interface Transmitter Panel and the installation of the electrical power outlet.
3. The table box shall have the following minimum features.
   a. Finger Lift cable access door.
   b. Brown anodized aluminum hinged cover.
   c. Provisions for mounting standard electrical back boxes.

C. Interface Cable
1. Contractor shall provide ANSI/TIA/EIA Category 6A cables in quantities indicated on the Contract Drawings and in accordance with Specification 27 05 32.
2. The Category 6A cable shall be color coded with RED, Blue, and White. Each cable shall be individually dedicated for each port on the Multimedia Interface.
3. All cables shall terminate to a Multimedia Interface data outlet that will be co-located at the Multimedia Interface at the conference table. The co-located outlet shall have (3) RJ-45 jacks. Jack colors shall be red, blue, and white and mated to the corresponding color cable.

PART 3 - EXECUTION

3.1 GENERAL

A. All types of equipment installed by competent workers at locations shown on the drawings in strict accordance with approved shop drawings and manufacturer's instructions.

B. All equipment except portable equipment shall be firmly held in place. This shall include loudspeakers, enclosures, amplifiers, cables, etc. Fastenings and supports adequate to support their loads with a safety factor of at least three unless otherwise stated.

C. Take such precautions as necessary to prevent and guard against electro-magnetic and electro-static hum and to install the equipment so as to provide safety for the operator.

D. Protect all equipment, including patch panels, connectors, receptacles, racks, consoles, and video projectors, from construction dust and debris until final acceptance of the system.

3.2 TRAINING

A. The Owner may assign personnel to participate with the contractor during installation. Without delaying the work, familiarize the Owner's personnel with the installation, equipment, and maintenance.

B. During tests and adjustments, permit the Owner's personnel to observe. When feasible explain the significance of each test.

C. Provide sufficient training to personnel selected by the Owner on operation and basic maintenance of all systems and equipment. Explain operation of control systems, set-up and operation of individual pieces of equipment and functions of overall systems.

3.3 VIDEO PROJECTOR MOUNTING

A. Video Projector and associated mounting procedures shall comply with the following requirements.

B. DO NOT DISCARD ANY SHIPPING OR PACKING MATERIALS. SHIPPING CONTAINERS AND MATERIALS SHOULD BE TURNED OVER TO OWNER.

C. Install projector mount at location and elevation indicated on the Contract Documents and approved shop drawings.

D. Projector mounts must meet all applicable safety and code requirements for ceiling mounted equipment.

E. Provide all necessary display brackets, fittings, pipes, miscellaneous hardware and wireways.

F. Use specified connection box located at the projector pipe mount and route signal and power cables to the table connection location via mount pipe and associated for a neat installation. Refer to the Contract Drawings for additional routing information.

G. Provide anti-vibration pads for projector mount as specified in the Contract Documents.

3.4 SYSTEM PERFORMANCE TESTS AND ADJUSTMENTS

A. Test all equipment to verify conformance with manufacturer's performance specifications and with this specification.

B. Any defects revealed during the following tests shall be promptly corrected at the Contractor’s expense and the tests shall be re-conducted.

C. Testing of the audio and video systems shall be made with commercially available computers and laptops.

D. Tests shall include various forms of input including laptop speaker outputs, presentation software and videos using the installed system components.

E. Testing shall be in the presence of the Owner's designated representatives, Contractor, Architect and representatives of the authorities having jurisdiction.

F. The Audio System shall be tested for the following items.
   1. Absolute Impedance:
      a. Set any loudspeaker level controls at zero attenuation.
      b. Measure absolute impedance value of each loudspeaker line at 250, l000, and 4000 Hz, without amplifier connected but with all loudspeakers connected.
      c. Impedance shall be at least 90% of rated load impedance of respective amplifier.
      d. Check resistance of lines to all loudspeaker and microphone receptacles, with receptacles open and short circuited.
   2. Hum and Noise Level:
      a. Adjust gain controls for optimum signal-to-noise ratio and full amplifier output with -55 dBm level at a microphone input and 0 dBm at line-level input.
      b. Without changing gain, terminate microphone and line-level inputs with shielded resistors of l50 and 600 ohms, respectively.
      c. Measure overall hum and noise level at each power amplifier output for each input channel. Level shall be at least 80 dB below rated power output of amplifier over a bandwidth of 20-20,000 Hz.
   3. Electrical Distortion:
      a. Load power amplifiers with resistors matching nominal impedance of output terminals used in system in place of actual loudspeaker loads.
      b. Adjust gain controls as for hum and noise level tests.
      c. Apply 1000 Hz size-wave signal from an oscillator having less than 0.l% total harmonic distortion to each microphone and line-level input at level required to produce measured full amplifier output.
      d. Distortion shall measure less than 0.l%.
   4. Parasitic Oscillation and RF Pickup:
      a. Set up system for each specified mode of operation.
      b. Use 50 - 100 MHz bandwidth oscilloscope and loudspeaker monitoring.

c. Check to ensure that system is free of spurious oscillation and RF pickup in the absence of any input signal and also with system driven momentarily to full output at l60 Hz.

5. Buzzes, Rattles, Distortion:
   a. Apply high-quality music signal to the system. Adjust the system for frequent peaks at its specified maximum sound pressure level.
   b. Apply sine-wave sweep from 50-50,000 Hz at 6 dB below full amplifier power.
   c. In both cases, listen carefully for buzzes, rattles, and objectionable distortion.
   d. Correct all causes of such defects. If cause is outside the system, promptly notify the Owner or Owner's authorized representative and his Consultant, indicating cause and suggested corrective procedures.
6. Level Balance: Adjust level controls for all items of similar equipment for identical measured voltage gain.

G. Video Systems: After all system components are installed, perform the following tests.
1. Contractor shall test that the video system complies wit the following standards.
   a. Frequency Response: ± 0.5 dB, 60 to 4.l8 MHz.
   b. Crosstalk: -40 dB at 3.58 MHz.
   c. S/N Ratio: 45 dB, DC to 4.l8 MHz, unweighted, peak to RMS.
   d. Hum: <10 mV peak to peak.
   e. Line and Field Tilt: 2% with 60 Hz square wave.
   f. Differential Gain: 1% at 3.58 MHz, l0-90% APL.
   g. Differential Phase: ± 1° at 3.58 MHz, l0-90% APL.
   h. Envelope Delay: ± 0.l microseconds, 0.2 to 2.1 MHz; ± 0.05 microseconds at 3.58 MHz.
   i. Color Production: Primary and Complementary Colors (R, G, B, Cy, Yl, Mg) at 75% saturation within inner 50% of the of inner boxes (± 2.5°) when viewed on vectorscope.
   j. Signal Levels: 1 V p-p, ± l IRE, at 100% peak white color bar.
2. Audio Standards:
   a. Frequency Response: ± l dB, 30-l5,000 Hz.
   b. Hum and Noise: -80 dBu, 30-l5,000 Hz, unweighted.
   c. Distortion: 0.25% THD, 30-l5,000 Hz.
   d. Signal Levels: +4dBu.

H. Test Reports and Certificates:
1. Submit results of all tests and adjustments conducted above and certification that the installation is complete and ready for checkout as specified under, and in accordance with Division 01 and Section 27 51 00, 1.13.

END OF SECTION

SECTION 28 05 00
BASIC ELECTRONIC SECURITY REQUIREMENTS

PART 1 - GENERAL

1.1 STIPULATIONS

A. The specifications sections “General Conditions,” “Special Requirements” and “General Requirements” form a part of this section and other Division 28 sections by this reference thereto and shall have the same force and effect as if printed herewith in full.

B. The Security System Integrator (SSI) shall be certified by the state of Illinois to install all security related devices and systems utilized in this project.

C. The Argonne National Laboratory (ANL) may be referred to as 'Owner' from this point forward.

1.2 SUMMARY

A. Section Includes:
   1. This section includes basic design requirement specifications for the integrated security management system. This section contains requirements that pertain to all Division 28 security sections, and includes the design basis, as well as requirements for submittals, quality assurance, product handling, record documents, project conditions, installation, demonstrations and training.

B. Related Sections:
   1. Division 01 – General Requirements
   2. Division 08 – Door Hardware
   3. Division 26 – Electrical
   4. Section 28 13 13 – Card Access Control System

C. Security Reference Symbols:
   1. Symbols used on the drawings are defined in the security symbols schedule of the drawings. Some of the symbols scheduled may not be required for the project symbols.
   2. Because of the scale of the drawings, symbols are shown on drawings as close as possible to the mounting location. Verify exact locations with the Architect and Owner’s Representative.

D. The Contractor shall provide the labor, materials, equipment, appliances, services and transportation, and perform operations in connection with the construction and installation of the Work.

E. Definitions:
   1. ACP Access Control Panel
   2. BMS Balanced Magnetic Switch.
   3. CACS Card Access Control System
   4. CCVE Closed Circuit Video Equipment.
   5. CPU Central Processing Unit.
   6. DOTL Door Open Too Long.
   7. DVR Digital Video Recorder.
   8. EIA Electronic Industries Alliance
   9. LAN Local Area Network
   10. LCD Liquid Crystal Display.
   11. EMI Electromagnetic Interference.
   12. FDD Floppy Disk Drive.
   13. GUI Graphical User Interface.
   14. HDD Hard Disk Drive.

15. HRMS Human Resources Management System.
16. ICM Input Control Module
17. IDS Intrusion Detection System.
18. LAN Local Area Network.
19. LED Light Emitting Diode.
20. NFPA National Fire Protection Agency
21. NDVR Network Digital Video Recorder.
22. OCM Output Control Module
23. PLC Programmable Logic Controller.
24. PTZ Pan-Tilt-Zoom.
25. RAM Random Access Memory.
26. REX Request To Exit.
27. SSI Security System Integrator/Installer.
28. TIA Telecommunications Industry Association
29. UL Underwriters Laboratories.
30. UPS Uninterruptible Power Supply.
31. UTP Unshielded Twisted Pair
32. WAV Waveform Audio File

1.3 REFERENCES AND COMPLIANCES TO THE LATEST EDITIONS, AS RELATED:

A. International Building Code (IBC).

B. National Electric Code (NEC).

C. National Fire Protection Agency (NFPA).

D. Underwriters Laboratories (UL).

E. Building Industry Consulting Service International (BICSI)

1.4 SYSTEM DESCRIPTION

A. Design Requirements:
   1. The security systems installation shall include the Argonne National Laboratory, Energy Sciences Building 241.
   2. Provide and install all related devices, equipment and appurtenances necessary to complete the work as a fully operational system as described in the following conditions:
      1) This project shall include installation of the expansion of an existing card access control system and testing of the owner system programming.
   3. Drawings for this work is diagrammatic, intended to convey the extent, general arrangement and locations of the work. Because of the scale of the drawings, certain basic items such as conduit fittings, access panels, cabinet sizes, sleeves, pull boxes, backboxes and junction boxes may not be shown. Include all items where required by code, other sections and for proper installation of the work.
   4. All copper cable splices not terminating at a terminal strip shall be joined with solder and electrical tape utilizing methods indicated in the latest edition of the adopted by the authority having jurisdiction or by Scotch Lok IDC connectors.
   5. All security cables including fiber optics shall be supervised against intentional or accidental tampering, or deterioration of wiring or connections. Any of the above conditions shall result in an audible and visual indication at central control.
   6. Security conductors shall be a minimum 22 AWG unless otherwise noted. Size conductors in accordance with the equipment manufacturer's recommendations, and NEC to ensure proper control operations and alarm notifications.

7. All security cabling shall be routed through concealed raceways and/or cable tray. All devices will be provided with appropriate electrical back boxes, and conduit raceway. All interior/indoor conduit raceways shall be a minimum 3/4 inch unless otherwise noted. All exterior/outdoor conduit raceways shall be a minimum 1 inch unless otherwise noted. Size raceways and install conductors in accordance with the NEC and NFPA and Division 26 requirements.
    a. EMT conduit with compression fittings.
    b. Rigid metal conduit shall be used in exposed exterior applications.
    c. PVC conduit shall be used in underground applications; stub-ups shall be rigid metal conduit.
    d. Rigid metal conduit shall be used in all interior accessible areas where concealed conduit requirements cannot be met. Submit drawings, diagrams and information to Owner's Representative and Architect for review prior to work.
8. Any and all conduit/raceway required by the Security System Integrator for a complete and operating system that is not shown on the ET Series project drawings shall be the responsibility of the Security System Integrator.

B. Mounting heights and accessibility to equipment requiring access by individuals with disabilities shall comply with ADA requirements.

C. The SSI shall provide all materials and labor for the installation of 120VAC circuits from the closest available power distribution panel to the electronic security equipment. Furnish additional circuit breakers where spares are not available. "Tapping" existing "in service" power circuits is not permitted. The SSI is required to visit the project site prior to bid to survey the power distribution panel locations with available circuit capacity.

D. The SSI shall provide an uninterruptible power source (UPS), which shall supply 120 volts AC power for selected security equipment as indicated below. The UPS system shall have the capacity to furnish total power for at least 30 minutes in the event of failure of the normal and emergency power source. No signal, alarms or indications shall be lost during switch-over from normal to emergency power. The UPS system shall have visual and audible trouble indicators.
    1. Selected equipment shall include:
        a. All security devices.
        b. Access Control System.
    2. Standby batteries shall be utilized at the security equipment panel locations for the power supplies and other associated equipment to ensure uninterrupted operation for at least 30 minutes in the event of failure of the normal and emergency power source. No control functions, signals, alarms or indications shall be lost during the standby time.
    3. The voltamp ratings of the UPS units shown on drawings are for reference only.
        a. Size UPS voltamp capacity for actual load requirements.
        b. Minimal run time of thirty minutes on load test, running on batteries shall be required.
        c. Provide UPS voltamp capacity for twenty five percent future expansion.
        d. Provide UPS load calculations to for review and approval by the architect.
            1) Calculations shall document wattage of each piece of equipment.
            2) Calculations shall document total volt amps per location.
            3) Calculations shall document total volt amps with time formula per location.
        e. Provide and install all electrical raceway, electrical boxes, wire, and wiring devices for a complete power UPS distribution system.
        f. Provide emergency power circuits for all UPS primary power.
    4. The SSI shall be allowed to use the critical power circuits where available.
    5. The SSI shall supply and install all wire and cable for a complete and operational system.
    6. Outdoor enclosures shall be NEMA 4 rated.
    7. Fiber optic communication systems shall operate as the communication link between the outdoor devices and buildings or communication between buildings.

1.5 SUBMITTALS

A. Refer to Division 01, General requirements, Submittals, for Submittal Transmittal and Preparations of Submittals.

B. Submittal review is considered as general acceptance of the basic applicability of the equipment. Contractor is responsible for the installation of the equipment and/or alternate arrangement of the equipment within a given space. When the Contractor desires to use substituted equipment, he shall be responsible for producing his own coordinated working drawings which depict the substituted equipment accommodated in the space. Where substituted equipment creates the need for alterations to any portion of the work depicted in the contract documents, it shall be the Contractor's responsibility to notify all the affected parties and coordinate these items with all other trades. Further, it shall be the contractor's responsibility to assume any additional cost to the contract created by the substituted equipment.

C. All materials and equipment the Contractor proposes to furnish shall be submitted to the Architect/Engineer for review and shall comply with the requirements of Division 01 Submittals. Data shall be complete in all respects and shall reference, where applicable, to the unit symbol utilized on the Drawings and Specifications. Partial or incomplete submittals are not acceptable.

D. Contractor further agrees that if deviations, discrepancies or conflicts between shop drawings and the Specifications are discovered either prior to or after shop drawing submittals are processed by the Engineer, the design Drawings and Specifications shall control and be followed. Review of submittal data shall in no way relieve the Contractor of his duty to perform all work and provide all equipment in strict compliance with the requirements set forth on the drawings herein.

E. The Contractor shall submit detailed shop drawings for approval of all equipment to be constructed and installed. Such shop drawings shall be complete, giving all required information, and shall be properly checked and coordinated with the work of other trades before submission. No work shall be performed until application shop drawings and layout drawings have been approved by the Architect/Engineer.

F. Submit Shop Drawings:
   1. Include dimensions, wiring and block diagrams, conduit sizes, performance data, ratings, control sequences, and all other descriptive data necessary to describe the item proposed and its operating characteristics.
   2. Shop Drawings shall include facility site plan(s) and floor plan(s) layouts indicating locations of all proposed equipment.
   3. Shop Drawings shall include enlarged equipment room and control room layouts indicating locations of security equipment, cabinets and enclosures, and all security equipment to be installed.
   4. Shop Drawings shall include elevations and layouts of all security equipment enclosures, cabinets, racks, panels and security control stations/workstations. Include schematic detailed layouts of equipment enclosure components, devices, backplane mounted equipment and associated power supplies.
   5. Shop Drawings shall not be acceptable if shop drawings that are submitted contain architect and/or engineer of record title block information, company logo or design team members names. Submitting bid or contract drawing(s) details, diagrams and/or notes will not be acceptable and will be cause to reject shop drawings.

G. Submit complete technical data necessary to evaluate the material and equipment. Include a complete technical specification for the submitted equipment, noting differences and adherence to this section.

H. Submit a list of at least 5 facilities of equal size and technical requirements utilizing the equipment submitted.
   1. For each facility, list:
      a. Name and location of facility.
      b. Date of Occupancy by Owner.
      c. Owner’s representative to contact and telephone number.

d. Construction Manager or General Contractor.
e. Architect.
f. Provide information on the installed locations with operational equipment.

I. Submit a certified financial statement from the equipment manufacturer and Security System Integrator/Installer.

J. For equipment mounting requiring coordination with other trades, obtain templates and equipment anchor bolts for mounting preparation, e.g. pedestals or other devices requiring mounting on concrete pads or other materials. Coordinate delivery of templates and equipment anchor bolts to preclude any delay in the construction schedule or the work of the affected trade.

K. Prior to substantial completion, provide 'project record' schematic drawings depicting location of interface, number of conductors, and types of connectors, circuit requirements and type of enclosure.

1.6 QUALITY ASSURANCE

A. Qualifications of manufacturer: Documented successful work experience of at least ten facilities of equivalent size and technical requirements utilizing the equipment proposed to be used.

B. Security System Integrator/Installer shall have no less than 5 years of documented work experience on projects of equivalent size and similar scope.
1. "Experience" is defined as the completion of an operational security management / control system, with the system being successfully operated by the Owner for its intended purpose for at least one year.

C. The Security System Integrator (SSI) shall be certified and licensed by the State of Minnesota to install all security related devices and systems utilized in this project.

D. The system and its components must be manufactured by a company engaged in the manufacturing of the specific equipment for a minimum of five years.
1. Use the products of a single manufacturer for similar type equipment, i.e., motion detectors, magnetic contacts, etc.
2. Use products made by companies regularly engaged in the manufacture of the type equipment specified.

E. Equipment specifications may not deal individually with every part, control, or device, which may be required to produce the equipment performance specified or as required to meet the equipment warranties. Include such items, as required, for a complete operational system, whether or not specifically indicated.

F. Coordinate with other applicable trades in submittal of shop drawings.
1. Shop drawings shall detail space conditions to accommodate other concerned trades, subject to final review by the Architect.

G. If installation of equipment, raceways, cable trays and/or conduit is performed prior to coordination with other trades, which interferes with the work of other trades, make necessary changes to correct the condition at no additional cost to the Owner.

H. Regulatory Requirements:
1. International Building Code (IBC).
2. National Electric Code (NEC).
3. National Fire Protection Association (NFPA).
4. Underwriters Laboratories (UL).
5. Americans with Disabilities Act (ADA).
6. Uniform building code (UBC.)
7. Telecommunications Industry Association (TIA)
8. Regulations of the:
a. State of Illinois.

I. Coordinate equipment submittals with construction schedules.

J. Commissioning of equipment or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Commissioning Authority. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Division 01, Contract Closeout, for substantial completion details. Refer to Division 01 and Division 26 for detailed commissioning requirements. Refer to Division 01 for Operations and Maintenance Data requirements.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Protect materials stored on the job site. Protect materials during construction and after installation, provide protection of equipment until time of substantial completion.

B. Provide and apply protective material immediately upon receiving the products and maintain throughout the construction process.

C. Keep products clean and dry, elevating equipment above ground and floor.

D. Take precautions to protect apparatus and materials from damage.

E. Failure to protect materials constitutes sufficient cause for rejection of the apparatus or material.

F. Protect factory finish from damage during construction operations and until final acceptance. Restore finishes that become stained, scratched, or damaged.

1.8 RECORD DOCUMENTS

A. To the requirements of Division 01, provide complete schematic drawings depicting location of interface, number of conductors, types of connectors, circuit requirements and type of enclosure.

1.9 PROJECT CONDITIONS

A. Active Services: Protect existing active services, water, gas, sewer, and electric, when encountered, against damage. If active services are encountered which require relocation, notify Architect promptly in writing, with copy to Owner's designated representative.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
   1. Products of manufacturers in conformance with the specifications. Where manufacturers have been named, use one of those named.

2.2 MATERIALS

A. Raceways, Boxes/Enclosures: Comply with Division 26 Electrical for security systems.

B. Identification:
   1. Provide identification for wiring systems and equipment.
   2. Color code junction boxes and enclosures per NEC.
      a. Color for security circuits: White.
   3. Lettering for Identification: Sign painters' quality or stencil lettering, using fast drying sign enamel.
   4. Identify control and sub-control, motor and equipment controls, remote relay cabinets, security equipment panels, system interface cabinets, and similar equipment with 12mm red lettering. Letter flush panels inside the door or cover.
   5. Letter pull boxes and junction boxes in service areas, tunnels, above accessible ceilings, and in accessible chases with 12mm red lettering identifying the circuit and system. Example: Security Alarms "SY," Circuit Number SY-126.
   6. Engraved laminated plastic tags may be used for identification in lieu of painted lettering.

7. Provide typewritten circuit directories installed in 3-ring binders with transparent page protectors in each control and subcontrol cabinet.
8. Each conductor of each circuit shall be identified and labeled by one of the following methods.
   a. Computer printed utilizing industry standard wire marker labeling software.
   b. Industry standard portable hand held labeling system.
9. As a minimum the component/wire label shall meet the following criteria:
   a. The label shall be made of Polyvinylfluoride material.
   b. Self adhesive.
   c. Self Laminating.
   d. The printable surface shall be white in color for ease of legibility.
   e. Text shall be a minimum of 8 pt bold type, and black in color for ease of legibility.
10. All conductors/cables shall be bundled per NEC and secured by the following method:
    a. Conductors/cables bundled and secured using single weather resistant nylon cable ties of sufficient length, on a minimum of 12 inch centers.
    b. Cable ties shall be of one piece construction – up to 250 lbs minimum loop tensile strength.
    c. Cable ties shall be installed by the use of a hand operated, “tool controlled” tension and cut off cable tie installation tool. (Design Basis: Panduit GS Series).
11. Cable ties shall be secured to the security equipment enclosures by the use of screw mount devices.
    a. The cable tie mounting device shall not be of adhesive mount construction unless manufactured in combination with the screw mount device.

C. General Conductor/Cable label configuration.
   1. Facility Code:
      a. The facility code is made up of two alphanumeric characters describing a type of Utility facility or infrastructure. This code is not included in the physical tag attached to the equipment. The code is also not normally used on equipment tag numbers shown on drawings and specifications, unless the project documents encompass more than one facility.
   2. Equipment Type:
      a. One character used to identify the type of equipment. For electrical and instrumentation, the following are used:
         1) A - Access Control Equipment.
         2) D - Intrusion Detection Equipment.
         3) L - LAN Equipment.
         4) F - Fiber Optic Equipment.
   3. Control Identifier:
      a. This number is three digits in length and identifies a unique piece of control equipment. The numbering precedence for equipment shall be established as a panel address or switcher address for each control instrument. If no standard exists, the precedence shall be coordinated between the contractor and Owner's representative.
   4. Device Identifier:
      a. This number is three digits in length and identifies field devices. The numbering precedence for equipment shall be established as a subtext to the control identifier, such as panel circuit number or switcher port number.

D. The layout of the Conductor/Cable label is as follows:
   1. Facility Code -Equipment Type - Control Identifier - Device Identifier.
   2. XX – X – XXX – XXX.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate with all other trades in submittal of shop drawings. Shop drawings shall detail space conditions to the satisfaction of all concerned trades, subject to final review by the Architect. If installation of equipment, raceways, cable trays and/or conduit is performed prior to coordination with other trades, which interferes with work of other trades, make necessary changes to correct the condition at no additional cost to the Owner.

B. Comply with requirements Division 03 for equipment concrete bases and pads.

C. Provide coordination with other Divisions of this project manual for the installation of components for a completely operational system.

D. Comply with requirements of Division 02 – Existing Conditions.
   1. Coordinate and disconnect existing electronic/electrical equipment, services and/or controls to items being removed by others.

E. Excavation, Trenching and Backfilling:
   1. Coordinate requirements with Division 31 - Earthwork.

3.2 INSTALLATION

A. Provide tamper-resistant installation utilizing “torx with peg” security fastening devices.

B. Repair or replace any defective or damaged equipment as required to provide complete and fully operational system(s). Retest system as necessary and ensure proper operation of system(s).

3.3 SOURCE QUALITY CONTROL

A. Tests
   1. Notify Architect and Owner's representative in writing, in advance of testing to prevent delays in construction schedules.
   2. Test all systems and place in proper and specified working order prior to demonstration of the systems.
   3. Test system grounds to demonstrate that the ground resistance does not exceed the requirements of the transient voltage surge suppression (TVSS) or the National Electric Code (NEC).
   4. Perform tests, as required, by authorities having jurisdiction over the site.
   5. Testing shall be in the presence of the Owner's designated representatives, Contractor, Architect and representatives of the authorities having jurisdiction.

B. Verification of Performance:
   1. Prior to acceptance of the work, the security system integrator/installer shall demonstrate to the Owner, designated representatives, Contractor, Architect and representatives of the authorities having jurisdiction, all subsystems, features and functions of the system, and shall instruct the Owner in the proper operation and event sequences of the system.
   2. Where systems have been expanded and/or upgraded, the SSI shall provide the personnel and labor to completely test and demonstrate all new, existing, and upgraded software and hardware.
   3. Demonstrate each system and subsystem. The demonstration is to consist of no less than the following:
      a. Designate actual location of each component of a system or subsystem and demonstrate its function and its relationship to other components within the system.
      b. Demonstrate the systems and subsystems operations by actual “START/STOP-ON/OFF-OPEN/CLOSE” cycling showing how to work controls, how to reset devices, how to replace fuses and emergency operating/operations procedures.
      c. Demonstrate communication, signaling and intrusion detection equipment/devices by actual operation of such devices.
   4. Systems to be demonstrated are to include, but not be limited to the following:
      a. UPS power and distribution system. (Coordinate with Division 26)
      b. Alarm detection and signaling equipment.
      c. Door control / monitoring system.

d. Access control system.
e. Fire alarm interface (coordinate test with Division 26).
f. Cable supervision system (random points to be selected by Architect).

5. Security System Integrator/Installer (SSI) shall furnish the necessary trained personnel to perform the demonstration and instructions and arrange to have the manufacturer's representatives present to assist with the demonstrations. Training time shall include, as a minimum, the total time determined by the sum of the times specified in each section, for performing the prescribed demonstrations/training.
6. SSI shall arrange with the Owner's designated representative the date and times for performing the demonstrations. The Owner will select date and time for demonstration.
7. Comply with requirements of Division 01 - Systems Demonstrations:
   a. Provide Mpeg2 format DVD of training sessions and maintenance procedures. These tapes or DVD's shall be a detailed description of a fully functional system including all maintenance procedures and training instructions. Tapes or DVD must have high quality video and clear audio and be labeled clearly for owner's future reference.
8. Training of the owner's operation and maintenance personnel is required in cooperation with the Commissioning Authority. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Division 01, Demonstration and Training, for contractor training requirements. Refer to Division 01 and Division 26 for further contractor training requirements.

C. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements. Refer to Division 01 and Division 26 for further details.

D. System functional testing is part of the Commissioning Process. Functional testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority. Refer to Division 01, Commissioning, for system functional tests and commissioning requirements

3.4 INSPECTIONS

A. At the completion of the project and prior to final acceptance of the work, provide evidence of final inspections and approvals to the Owner, as required by the authorities having jurisdiction to requirements of Division 01.

END OF SECTION

SECTION 28 13 13
CARD ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
All necessary components to provide a complete and fully functional card access control system, which allows access to authorized personnel within pre-determined areas of the site, based on time and/or clearance level. The basis of this design is to incorporate a CPU driven system with multi-technology proximity card access, and to accommodate multiple pedestrian door locations as well as future system expansions.

B. New card access control system shall integrate / interface with Owner's existing security system server. The new card access control system shall be an extension of the Owner's existing system. Coordinate with Owner's representative for programming and installation scheduling.

C. Related Sections:
1. Division 01 – General Requirements
2. Division 02 – Existing Conditions
3. Division 03 – Concrete
4. Division 04 – Masonry
5. Division 08 – Door Hardware Schedule
6. Division 08 – Finish Hardware
7. Division 11 – Laser Safety Equipment
8. Division 26 – Electrical
9. Division 31 - Earthwork
10. Section 28 05 00 – Basic Electronic Security Requirements

1.2 DESCRIPTION

A. Provide a stand-alone microprocessor-based networked security card access control and alarm monitoring system. System components shall have as a minimum: field intelligent devices, remote I/O modules, device /lock power supplies, multi-technology proximity card readers, and all the required hardware and software for a completely operational system.

B. The Card Access Control System server is currently Owner's existing equipment and resides at a remote location.

C. Operator Control and Monitoring Workstation computer hardware and software will be furnished, installed, and configured by the owner.

1.3 DESIGN REQUIREMENTS

A. The access control system field intelligent devices furnished under this scope of work shall be compatible with the existing DSX Access Systems, Inc card access control system.

B. The access control system field intelligent devices shall be connected to the building Ethernet LAN. All components that communicate to the existing server shall be connected to the building LAN utilizing a category 6a cable infrastructure. Install and terminate the LAN cabling infrastructure in accordance with the requirements specified in Division 27.
1. Coordinate Ethernet switch port assignments with the owner.

C. Card access control field intelligent devices shall have an onboard UPS enabling them to operate independently during power loss periods.

D. The system shall be capable of accommodating a variety of multi-technology proximity card readers, and support for biometric technologies.

E. The system shall be capable of serial communications with other systems and running and supporting multiple network protocols.

F. The system shall have data import/export capability and be of open architecture design nature.

G. Equipment enclosures in all areas shall be equipped with key locks, and monitored tamper switches which activate alarms at the control stations.

H. The intent of the Project Drawings and Specifications is to include all items necessary for the proper execution and completion of the Work.

I. The Project Drawings and Specifications are complementary, and what is required by any one shall be as binding as if required by both.

J. All access control system components shall be designed and built for commercial use and shall be UL 294 listed.

1.4 PERFORMANCE REQUIREMENTS

A. Provide all necessary hardware to install a complete and operational Card Access Control System.

B. ANL will perform all DSX Access Systems software programming and configuration for the card access control system expansion under this scope of work.

C. Division 11 Laser Safety Equipment Interface:
   1. Interface the card access control system with doors equipped with the Laser Safety Equipment Entry Interlock System as specified in Section 11 53 33 and shown on the QL series drawings. The card access control system shall monitor the Entry Interlock System for the secure/unsecure position of the associated door.
   2. When the Entry Interlock system executes a valid entry/exit, the card access system shall shunt the door position switch to allow unimpeded entry/exit without creating a door forced open alarm.
   3. When the Entry Interlock system is active the card access control system shall not override an active Interlock regardless of a valid access attempt.

1.5 SUBMITTALS.

A. Submittals shall comply with the requirements of Division 01.

B. Submittals shall comply with requirements of Section 28 05 00, Part 1.5.

1.6 QUALITY ASSURANCE

A. Quality Assurance shall comply with requirements of Section 28 05 00, Part 1.6.

1.7 RECORD DOCUMENTS

A. Record Documents shall comply with the requirements of Division 01.

B. Provide schematic drawings depicting type and location of interface equipment/components, number of cables and conductors, types of connectors, circuit requirements and type and dimensions of enclosures.

1.8 WARRANTY

A. Warranty shall comply with the requirements of Division 01.

B. Warranty Period: One year commencing from the date of final acceptance.

C. Contractor shall agree to repair or replace defective components/materials and correct defective work when given notice during the warranty period at no cost to the Owner.

D. Warranty response time to be within 12 hours upon receipt of request from Owner during normal working hours.

E. User Cards: User cards are Owner provided and NOT PART OF SCOPE.

1.9 EXTRA MATERIALS

A. Provide Owner with the following spare equipment:
   1. One (1) card reader head as a spare.
   2. One (1) field intelligent Panel as a spare.
   3. One (1) I/O board of each type used as spare.
   4. One (1) power supply, for each type used, as a spare
   5. One (1) factory box for each component, addressed to the manufacturer to facilitate factory return for repair authorizations.
   6. Written procedures for obtaining return authorizations. (If not required, state so in writing.).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All security equipment furnished shall be new and unused and free of defects. All equipment shall be clean and free of damage or corrosion and shall be of the best quality obtainable for the purpose intended.

B. All security equipment shall be commercial off the shelf (COTS) components that are readily available from multiple sources. Custom fabricated equipment shall not be allowed.

2.2 SYSTEM ARCHITECTURE AND DESCRIPTION:

A. The Card Access Control System (CACS) shall be an integrated system that utilizes a single, industry-standard relational database management system for the storage and manipulation of related data. The CACS shall include a server with operating system and applications software, operator and administrator terminals with appropriate software, hard copy printers and fixed magnetic storage media. The security devices shall communicate with the field panels via a dedicated cable network. The field panels shall communicate to the server via a Fast Ethernet 10/100/1000, TCP/IP network.

B. The CACS shall allow for growth and scalability from a low-end or entry level system to a high end or enterprise system by increasing CPU power, memory and database. The CACS shall be modular in nature, allowing system capacities to be easily expanded without requiring major changes to system operation. All defined system data as well as historical information shall be maintained. Customizable user interfaces shall allow management of system information and activity for administrators and operators.

C. The CACS shall allow for integration and networking with Owner's remote CPU's and Enterprise system(s) located on and off site.

2.3 SECURITY APPLICATION SERVER AND WORKSTATIONS

A. The Card Access Control System Server is existing and currently resides at an ANL remote location. It shall be the responsibility under this scope of work to connect all card access control system components to the ANL-ESB Ethernet LAN for communication to the existing card access control system server.

2.4 FIELD HARDWARE COMMUNICATIONS

A. The system shall support an Ethernet LAN. The LAN shall be implemented using unshielded twisted pair category 6a, or fiber optic cabling.

2.5 SYSTEM CONTROLLER REMOTE DIAL UP SUPPORT

A. The system controller shall support Remote Dial Up operations to and from the System server. The dial up connection shall be either a constant connection or a scheduled connection.

B. Dial–up sessions shall occur under any of the user defined scenarios:
   1. On Demand Connection – A System Operator shall have the ability to automatically initiate a dial in session to a system controller via the alarm monitoring module.
   2. Scheduled Connection – System Administrators shall have the ability to configure the system so that the ISC dials into the system at a pre-determined times through use of time zones.

2.6 SYSTEM CONTROLLER

A. All controllers shall be compatible and communicate with the existing system as specified in this section's Design Requirements.

B. Any System Controller shall link the Security Software to all other field hardware components (Card Readers and Input Modules). The System Controller shall provide full distributed processing of access control & alarm monitoring operations.
   1. The controller shall have spare card slots for interchangeable control modules.
   2. The controller shall be scalable by the addition of up to three expansion control modules, including Input Control Modules, Output Control Modules, and Card Reader Control Modules.

C. The System Controller is required to continue to function normally (stand-alone) in the event that it loses communication with the system host server.

D. Each system controller shall be paired up with a Power Distribution Panel.

2.7 INPUT MODULE

A. The Input Module shall be capable of monitoring 32 dry contacts. Each of the 32 inputs shall be capable of providing 2, 3, and 4 state supervision. All alarm inputs shall be 4 state supervised. The Input Modules must be able to operate independently and in conjunction with Output Control Modules, which will send an output signal to a corresponding output device upon alarm input activation. Multiple modules shall be able to be installed to each system controller.

2.8 OUTPUT CONTROL MODULE

A. The Output Control Module shall incorporate 16 Form C relays that are capable of flexible I/O linking upon any input activation or on command from the system.

2.9 CARD READERS

A. The system shall support a variety of card readers that must encompass a wide functional range. The system may combine any compatible card readers for installations requiring multiple types of card reader capability (i.e., card only, card and/or PIN, supervised inputs, etc.). These card readers shall be available in Wiegand output format. All card readers shall include card reader back boxes for conduit installations.

B. All card readers shall be compatible with the following card formats:
   1. 125 kHz Proximity
   2. HID proximity cards, key fobs, and tags.
   3. AWID Credentials
   4. 13.56 MHz contactless smart cards
   5. ISO 15693 - read only; 2k bit (256 Byte), 16k bit (2k Byte) and 32k bit (4k Byte); serial number

6. ISO 14443A - read only; MIFARE (serial number)
7. ISO 14443B - read only; 2k bit (256 Byte) and 16k bit (2k Byte)

C. Card Readers must be able to support a user defined downloadable off-line mode of operation (locked, unlocked, or facility code), which will go in effect during loss of communication with the system controller.

D. All card readers shall provide audible feedback to indicate access granted/denied decisions. Upon a card swipe, two beeps shall indicate access granted and three beeps shall indicate access denied.

E. Standard door.
1. Up to 5 inch read distance.
2. 5inch x 5inch x 1inch Dimension.

F. Coordinate the color selection of each card reader with the architect prior to procuring the card readers.

G. Typical read ranges for the following HID credentials:
1. ISOProx® II card: 2.5-3.5"
2. ProxKey® II keyfob: 1.0-1.25"
3. Microprox® Tag: 1.0 – 1.25"
4. iCLASS® card: 3.5-4"
5. iCLASS Key: 1.0"
6. iCLASS Tag: 1.0"
7. MIFARE® Card (serial number only): 2-2.5"

2.10 PIN INTERFACE OPTION

A. Readers shall allow for the addition of an optional keypad.

B. Keypad shall be utilized for either interior or exterior use.

C. The use of keypads with the card reader will require the user to enter a personal identification number and then use the card to obtain automated access.

2.11 PROXIMITY CARDS

A. Procurement of proximity access cards is not included under this scope of work.

2.12 SERIAL DATA ETHERNET SERVER

A. Provide and install the Ethernet server administration software on the card access control server.

B. Provide serial data Ethernet servers for each card reader for card reader administration communication from the card access control server via the security Ethernet network.

C. The Ethernet Serial Servers shall transparently connect, configure, and communicate with serial devices over the Ethernet network using a single IP address.
1. The serial server shall be provided with management software for server configuration from a standard web browser.
   a. The management software shall have the ability to auto detect all associated serial servers residing on the LAN and display the serial servers found.
2. Telnet and Console mode may also be used to configure the server.

D. The serial server shall be rated for industrial use and shall be compatible for use with the connected serial device. The server shall meet or exceed the following specifications:
1. Auto-detecting 10/100/1000 Mbps Ethernet
2. Ports shall be software selectable for RS-232, 422 or 485
3. Shall support TCP Server, TCP Client, UDP, and virtual COM modes.
4. Shall supports web and telnet consoles
5. LAN connections: 10/100/1000 Mbps, RJ45.

6. Serial connections: DB9 male
7. The server shall support multiple TCP client connections
8. Software Configurable, and shall control the following functionality remotely
    a. Select RS-232, RS-422 or RS-485 serial port settings
    b. Remotely upgrade or restore to default settings
    c. Manual and remote management of console mode
9. A built-in Web Server shall allow serial server management from a web browser anywhere on the LAN/WAN
    a. Remotely manage the serial server and the connected serial device
    b. Off-site troubleshooting
10. The serial server shall be provided with a monitor port for use by any PC on the LAN/WAN to actively view and troubleshoot the communications status.
    a. Shows when there is a client connection to the server.
    b. Shows client IP address.
    c. Serial transmit and receive byte counter.
    d. Displays RTS/DTR - DCD/DSR/CTS status.

2.13 POWER DISTRIBUTION PANELS

A. Power Supplies for field hardware shall be designed specifically for the system equipment installed. These power supplies shall be regulated, isolated versions for the system controller, I/O modules, card readers, peripheral alarm detection equipment, and electrified lock hardware. Each version shall be available in UPS with battery back-up and non-UPS models. All power supplies shall be housed in locked enclosures that also allow mounting space for the system controllers, I/O Modules, single card reader modules, dual interface modules, and power distribution modules. Each power supply enclosure shall be equipped with a tamper switch that is monitored by a system controller.
    1. Furnish separate power supplies for the Division 08 electrified lock hardware. Power supplies used to supply power to the electrified lock hardware shall not be used to serve power to the system controllers or expansion control modules.

B. 12VDC/24VDC power limited with individual selectable outputs
    1. UL listed for use with the card access control system.
    2. Minimum 6amp continuous output at 12VDC.
    3. Minimum 6amp continuous output at 24VDC.
    4. 120VAC input.
    5. Metal enclosure with cam lock.
    6. Provide low battery and battery presence monitoring to the card access control system.
    7. Provide AC power loss monitoring to the card access control system.
    8. Provide and install the necessary primary power transformer.
    9. "Plug In" style transformers shall not be permissible.
    10. Provide tamper switch for each stand alone enclosure and monitor by the card access control system.
    11. Provide power distribution module(s) with each power supply.
    12. UL listed for use with the power supply.
    13. Each version shall contain a UPS with battery back-up.
        a. Refer to section 28 05 00.1.4.C. for requirements of the UPS

C. Power Distribution Module
    1. Eight individually PTC style short circuit protection outputs.
    2. Minimum individual PTC rating of 2.5 amp.
    3. Power output LED indicator for each output
    4. All power distribution modules shall have a fire alarm system interface
    5. Provide separate power distribution modules for:
        a. Fail safe electric locks.
        b. Fail secure electric locks.

c. Intrusion detection devices.
d. Card Access Control System modules

2.14 INTRUSION DETECTION DEVICES

A. Recessed Balanced Magnetic Door Position Switches:
1. Balanced magnetic switch, comprised two high reliability Rhodium plated reed switches of different sensitivity.
2. Each contact and magnet shall ¾” in diameter.
3. All contacts and magnets shall be potted in polyurethane in their respective housings.
4. The contacts shall have an actuating gap distance (make) of up to 0.4" (1 .031 cm).
5. Operating temperature range: -55° F to 212° F.
6. Furnish the intrusion detection circuits in a Closed-loop configuration.

2.15 REQUEST TO EXIT DEVICES

A. Request to Exit Motion Sensor.
1. 12 or 24VAC or VDC
2. Two (2) form C relay contacts, 1A @ 30VDC resistive load.
3. Passive Infrared (PIR) and microwave dual technology sensor.
4. Adjustable latch time up to 60 seconds
5. Selectable trigger mode for reset when the time expires or to remain until motion stops.
6. Selectable fail safe/fail secure mode.
7. External LED indication
8. Coverage 8feet by 10feet (2.4m by 3m)

2.16 FIRE ALARM INTERFACE

A. Provide and install a seamlessly integrated fire alarm interface where required by the local authority having jurisdiction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Security System Integrator shall be required to coordinate all work with Owner’s Designated Personnel prior to the commencement of the scope of work as specified herein.

B. The Security System Integrator shall make application for and obtain any and all permits required by federal, state, county, city, or other authority having jurisdiction over the work.

C. The Security System Integrator shall be responsible for the installation of all the equipment specified herein.

D. The Security System Integrator shall be responsible for supplying and installing all necessary wire/cable required under this specification section for a complete and operational system.

E. The Security System Integrator shall be responsible for installing and terminating all security circuits to the gate operator/controller equipment supplied and installed by others.
1. The Security System Integrator shall be responsible for coordinating with all other contractors for the installation and termination of all cabling and security devices.

F. The Security System Integrator shall be responsible for coordinating the conduit/raceway installation with the Electrical contractor.
1. Any conduit to be supplied and installed beyond what is shown on the Telecom/Security Series project drawings shall be the responsibility of the Security System Integrator.

G. Use methods and lubricating compounds on cables and wires to prevent damage to cables and wires during pulling-in. Provide compounds that are not injurious to the cable and wire jackets and do not harden or become adhesive.

H. Install equipment and devices in accordance with manufacturer's specifications.

I. Provide tamper-resistant installation and "torx with peg" fastening devices.

J. Coordinate the complete system configuration requirements with the owner.
   1. To ensure that the owner's system operational requirements are met and the system is fully functional, the installer/contractor shall be responsible for testing ANL's configuration/programming of the system controllers installed under this scope of work.

3.2 DEMONSTRATION AND TRAINING

A. Furnish the necessary trained personnel to perform the demonstration, training and instructions and arrange to have the manufacturer's representatives present to assist with the demonstrations.
   1. Allow a minimum 2 days time for performing the prescribed demonstrations and training.

B. Arrange with the Owner's designated representative the date and times for performing the demonstrations and training.
   1. The Owner will select date and time for demonstration and training.

C. Comply with requirements of the General Provisions of the Contract Systems Demonstrations, Section 28 05 00, 3.3.

END OF SECTION

SECTION 28 31 00

FIRE ALARM/MASS NOTIFICATION SYSTEM (Revised AD-4)

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. The fire alarm system (FAS) shall be a software programmable, microprocessor-based fire alarm system using addressable device technology to provide protective premises manual and automatic fire alarm service, sprinkler supervisory and waterflow alarm service and voice alarm service.

B. System shall interface with other building systems for the purpose of initiating fire safety functions including elevator recall, elevator shutdown, HVAC fan shutdown, smoke door closure, etc.

C. Digital alarm communicator transmitter (DACT) shall transmit alarm, supervisory and trouble conditions to a continuously manned location.

D. The system specified in this section shall be a combined Fire Alarm/Mass Notification System which will be based on the more stringent requirement of either of the system in terms of speaker/strobe coverage per NFPA-72.

1.2 RELATED DOCUMENTS

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

B. The work covered by this section is to be coordinated with related work as specified elsewhere in the specifications. Requirements of the following sections apply:
   1. Division 26: Electrical Systems.
   2. Division 23: HVAC Systems.

C. The System and all associated operations shall be in accordance with the following:
   1. NFPA 72, National Fire Alarm Code (latest edition).
   2. NFPA 70, National Electrical Code (latest edition).
   3. Underwriter Laboratories (UL).
   4. Factory Mutual (FM).
   5. ADA/ABA Accessibility Guidelines.

1.3 SYSTEM DESIGN REQUIREMENTS

A. The fire alarm control panel (FACP) shall provide panel space to accommodate future system expansion by 20 percent.

B. Initiating device circuits (IDC) shall be Style B.

C. Signal line circuits (SLC) for addressable devices shall be Style 4 and shall be sized and installed to accommodate a 50 percent future increase in number of devices attached to each circuit.

D. Notification appliance circuits (NAC) shall be Style Y. Audible appliance NAC's shall be sized and installed to accommodate a 100 percent future increase in the number of devices attached to a circuit with a maximum power loss of 50 percent (3 dB loss). Visual appliance NAC's shall be sized and installed to accommodate a 50 percent future increase in the number of devices attached to a circuit with a maximum voltage drop of 10 percent.

E. In high ambient noise areas, i.e. mechanical rooms, motor bell/strobe combination shall be used.

F. DC power supplies shall be sized to accommodate a 50 percent increase in connected load. Audio amplifiers shall be sized to accommodate a 100 percent increase in connected load.

G. The control unit shall receive 120 VAC power via a dedicated branch circuit with a disconnecting means, and shall be identified (in red marking) as “Fire Alarm Circuit”. The location of the circuit disconnecting means shall be permanently identified at the fire alarm control panel.

H. The system shall automatically transfer to battery standby upon failure of 120 VAC power. Loss of primary power shall sound a trouble signal at the FACP. The FACP shall indicate when the system is operating on an alternate power supply. The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal 120 VAC power in a normal supervisory mode for a period of 24 hours with 15 minutes of “all-call” alarm operation at the end of this period.

I. The system batteries shall be supervised so that a low battery or a depleted battery condition, or disconnection of the battery shall be indicated at the control unit and displayed for the specific fault type. The system shall support NAG Lockout feature to prevent subsequent activation of Notification Appliance Circuits after a Depleted Battery condition occurs in order to make use of battery reserve for front panel annunciation and control.

J. The system shall support 100 percent of addressable devices in alarm or operated at the same time, under both primary (AC) and secondary (battery) power conditions.

K. All circuits requiring system-operating power shall be 24 VDC and shall be individually fused at the control unit.

L. Remote Access:
   1. FACP shall have the capability to provide Remote Access through a Dial-Up Service Modem using the public switched telephone system of a private switched telephone system.
   2. A personal computer or technician’s laptop, configured with terminal emulation software shall have the ability to access the FACP for diagnostics.
   3. FACP shall have the capability to provide third party access through serial interface connections and be agency listed for specific interfaces and for the purpose.

M. The fire alarm annunciator and duplicate fire alarm control panel shall be mounted in a flush mounted enclosure. The duplicate fire alarm panel shall have all the same controls as the main panel, including microphone handset for fire alarm announcements, and mass notification annucements. The configuration of the annunciator shall be at a minimum, of that shown on Drawing FA-501.

N. Fire alarm contractor shall be responsible for verifying compliance with voice intelligibility requirements for all acoustically distinguished spaces (ADS) per NFPA-72.

1.4 SYSTEM OPERATION

A. Required Functions: The following are required system functions and operating features:
   1. Priority of Signals: Fire alarm events have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions. Priority Two, Supervisory and Trouble events have second-, third-, and fourth level priority, respectively. Signals of a higher-level priority condition occurred first. Annunciate all events regardless of priority or order received.
   2. Non Interfering: An event on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP located in the emergency electrical room, and the duplicate remote panel located in the corridor near the entrance vestibule, after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent addressable device activations.
   3. Transmission to Remote Central Station: Automatically route alarm, supervisory, and trouble signals to an ANL remote fire command center.
   4. Annunciation: Operation of alarm and supervisory initiating devices shall be annunciated at the FACP, indicating the location and type of device.

5. General Alarm: A system general alarm initiated by a manual fire alarm station, sprinkler waterflow alarm switch, spot type smoke detector, spot type heat detector or air-sampling smoke detector shall include:
   a. Indication of alarm condition at the FAC panels (and the annunciator).
   b. Identification of the device and zone that is the source of the alarm at the FAC panels and the annunciator.
   c. Operation of audible and visible notification devices throughout the building until silenced at FACP.
   d. Closing doors normally held open by magnetic door holders.
   e. Shutting down supply and return fans Dampers associated with each fan shall close when their associated fan stops.
   f. Notifying the ANL fire department.
6. In addition to the general alarm functions above:
   a. Operation of an elevator machine room smoke detector, elevator hoistway smoke detector or an elevator lobby smoke detector at any floor other than the first floor shall signal the associated elevator to return to the first floor per ASME A17.1.
   b. Operation of an elevator lobby smoke detector at the first floor shall signal the associated elevator to return to the designated alternate floor per ASME A17.1.
   c. Operation of an elevator hoistway smoke detector or elevator machine room smoke detector shall signal the associated elevator to flash the fireman's hat warning signal in the elevator cab.
   d. Operation of an elevator hoistway heat detector or elevator machine room heat detector shall signal the elevator shunt-trip disconnect switch to open and remove power from the affected elevator per ASME A17.1.
   e. Operation of an EAS manual alarm station shall cause the EAS audible and visual alarm notification appliances to operate and shall also cause an alarm signal to be sent to the ANL fire command center. Alarms shall operate until silenced at the FACP or the manual alarm stations are reset.
   f. Activation of any smoke detector located in the atrium area shown on drawings FA-101B, FA-102B, FA-103B, and corridor on Drawing FA-101C, shall sound the general fire alarm, open all motor operated smoke control window sashes, and activate the atrium smoke control system via the HVAC smoke control panel. Upon silencing the alarm and conditions reset to normal, the window sash motors shall reset the windows to the normal close position.
7. Supervisory Operations: Upon activation of a sprinkler system supervisory device such as fire pump controller relay, low air pressure switch, valve position supervisory switch or activation of a duct mounted smoke detector, the system shall operate as follows:
   a. Activate the system supervisory service audible signal and illuminate the LED at the control unit and the graphic annunciator.
   b. Pressing the Supervisory Acknowledge key will silence the supervisory audible signal while maintaining the Supervisory LED "on" indicating off-normal condition.
   c. Record the event in the FACP historical log.
   d. Transmission of supervisory signal to ANL fire department.
8. In addition to the supervisory operations above, operation of a duct mounted smoke detector shall shut down its associated fan. Dampers associated with the fan shall close when the fan stops running for any reason.
9. Restoring the condition shall cause the Supervisory LED restore system to normal.
10. Alarm Silencing: If the "Alarm Silence" button is pressed, all audible and visible alarm signals shall cease operation.
11. System Reset:
    a. The "System Reset" button shall be used to return the system to its normal state. Display messages shall provide operator assurance of the sequential steps as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-alarming the system.
    b. Should an alarm condition continue, the system will remain in an alarmed state.

B. Analog Smoke Sensors:
   1. Monitoring: FACP shall individually monitor sensors for calibration, sensitivity, and alarm condition, and shall individually adjust for sensitivity. The control unit shall determine the condition of each sensor by comparing the sensor value to the stored values.
   2. Environmental Compensation: The FACP shall maintain a moving average of the sensor's smoke chamber value to automatically compensate for dust, dirt, and other conditions that could affect detection operations.
   3. Programmable Sensitivity: Photoelectric Smoke Sensors shall have 7 selectable sensitivity levels ranging from 0.2 percent to 3.7 percent, programmed and monitored from the FACP.
   4. Sensitivity Testing Reports: The FACP shall provide sensor reports that meet NFPA 72 calibrated test method requirements. The reports shall be viewed on a CRT Display or printed for annual recording and logging of the calibration maintenance schedule.
   5. The FACP shall automatically indicate when an individual sensor needs cleaning.
   6. The FACP shall continuously perform an automatic self-test on each sensor which will check sensor electronics and ensure the accuracy of the values being transmitted. Any sensor that fails this test shall indicate a trouble condition.
   7. Magnet test activation of smoke sensors shall be indicated as an alarm but distinguished by its label and history log entry as being activated by a magnet.

C. Surge Protection:
   1. Install surge protection on normal AC power for the FACP and its accessories. Install on all system wiring external to the building housing and the FACP as recommended by the manufacturer, and per Article 800 of the National Electric Code.

1.5 SUBMITTALS

A. General: Submit the following according to Conditions of Contract and Division 1 Specification Sections:
   1. Product data sheets for system components highlighted to indicate the specific products, features, or functions required to meet this specification. Alternate or as-equal products submitted under this contract must provide a detailed line-by-line comparison of how the submitted product meets, exceeds, or does not comply with this specification.
   2. Wiring diagrams from manufacturer.
   3. Shop drawings showing system details including location of FACP, all devices, riser diagram, conduit runs, circuiting and details of graphic annunciator. Prepared by NICET Level III designer and approved by a registered Fire Protection Engineer.
   4. System power and battery charts with performance graphs and voltage drop calculations to assure that the system will operate per the prescribed backup time periods and under all voltage conditions per UL and NFPA standards.
   5. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. A list of all input and output points in the system shall be provided with a label indicating location of use of IDC, NAC, relay, sensor, and auxiliary control circuits.
   6. Submit scaled and dimensioned isometric drawings of the air sampling network piping showing all bends, tees and sampling ports. Submit a printout of the manufacturer's calculation program for determining the size of sampling ports and verifying that smoke transport times are shorter than noted in manufacturer's instructions. Submit full size detail drawings of sampling ports for approval by the Architect.
   7. Operating instructions for FACP.
   8. Operation and maintenance data for inclusion in Operating and Maintenance Manual. Include data for each type product, including all features and operating sequences, both automatic and manual. Provide the names, addresses, and telephone numbers of service organizations.
   9. Product certification signed by the manufacturer of the fire alarm system components certifying that their products comply with indicated requirements.
   10. Record of field tests of system.
   11. Record of Completion (supplied by ANL) based on NFPA 72 (paragraph 1c).

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A factory authorized installer is to perform the work of this section.

B. Each and all items of the Fire Alarm System shall be listed as a product of a single fire alarm manufacturer under the appropriate category by Underwriters Laboratories, Inc. (UL) and shall bear the "UL" label and/or FM listed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The manufacturer shall be a nationally recognized company specializing in fire alarm and detection systems. This organization shall employ factory trained and NICET certified technicians.

B. Preferred Honeywell XLS-140 System or approved equal which is compatible with ANL's existing FA system.

C. Optional: (Need to be compatible with existing campus FA system)
   1. Siemens.
   2. Simplex.

2.2 MATERIALS

A. Fire Alarm Control Panel: (No approved equal):
   1. The fire alarm system control panel (s) shall be Honeywell XLS-140 or approved equal which is compatible with ANL's existing FA system and comply with UL 864, "Control Units for Fire-Protective Signaling Systems".
   2. The following FACP hardware shall be provided:
      a. Power limited base panel with 120 VAC input power.
      b. Provide battery voltage and ammeter readouts from the LCD display.
      c. Signal card circuits to match project requirements with 20 percent spare.
      d. Class B zone modules to match project requirements with 20 percent spare.
      e. (1) auxiliary electronically resetable fused 2A @ 24 VDC output, programmable disconnect operation for 4-wire detector reset door release auxiliary use.
      f. (1) auxiliary relay, SPDT 2A @32 VDC, programmable as a trouble relay either as normally energized or de-energized or as an auxiliary control.
      g. (1) 4-point relay module-10 amp.
      h. Minimum (4) Form "C" auxiliary relay circuits (Form C contacts rated 2A, 24 VDC, resistive), operation is programmable for trouble alarm, supervisory of other fire response functions. Relays shall be capable of switching up 1/2 A @ 120 VAC inductive.
      i. Remote Unit Interface: Supervised serial communication channel for control and monitoring of remotely located annunciators and I/O panels.
      j. Common event DACT or Point Reporting DACT.
      k. Service Port Modem for dial in passcode access to all fire control panel information.
      l. (2) 12 VDC batteries. Capable of maintaining system in normal supervisory mode for 48 hours plus 15 minutes of alarm operation.
   3. Cabinet: Lockable with "B" key steel enclosure. Arrange unit so all operations required for testing or for normal care and maintenance of the system are performed from the front of the enclosure. If more than a single unit is required to form a complete control unit, provided exactly matching modular unit enclosures.
   4. Alphanumeric Display and System Controls: Panel shall include a minimum of 80 character LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.

5. Software: The fire alarm system shall allow for loading and editing instructions and operating sequences as necessary. Capability of storing and downloading while the system is in operation, and a backup system, shall be included. On-site programming to accommodate system expansion is required. All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory.
6. History Logs: Provide a means to recall alarms and trouble conditions in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided.
7. Recording of Events: Record all alarm, supervisory, and trouble events by means of a system printer. Include the type of signal (alarm, supervisory, or trouble), the device identification, date and time of the occurrence. Differentiate alarm signals from all other printed indications.

B. Addressable Manual Pull Stations:
1. Shall be Addressable Single action type, red Lexan or metal, and finished in red with molded, raised-letter operating instructions of contrasting color. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units.
2. Protective Shield (if required) shall be tamperproof, clean Lexan shield and red frame that easily fit over manual pull stations.

C. Addressable Spot-Type Photoelectric Only Smoke Sensors: (Do not use ionization type):
1. Shall comply with UL 268, “Smoke Detectors for Fire Protective Signaling Systems”, including the following features:
   a. Operating Voltage: 24 VDC, nominal.
   b. Self-Restoring: Detectors do not required resetting or readjustment after actuation to resort normal operation.
   c. Plug-In Arrangement: Sensor and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. Base shall provide break off plastic tab that can be removed to engage the head/base locking mechanism. No special tools shall be required to remove head once it has been locked. Removal of the detector head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit.
   d. Each detector assembly shall contain a magnetically actuated test switch to provide for easy alarm testing at the sensor location.
   e. Ease sensor base shall contain LED that will flash each time it is scanned by the Control Unit (once every 4 seconds). In alarm condition, the detector head LED shall be on steady.
   f. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a “wrong device”, the control unit shall operate with the installed device at the default alarm settings for that sensor; 2.5 percent obscuration for photoelectric sensor, 135˚F and 15˚F rate-of-rise for the heat sensor, but shall indicate a “Wrong Device” trouble condition.
   g. The sensor’s electronics shall be immune from false alarms caused by EMI and RFI. Removal of the sensor head for cleaning shall not require the setting of the addresses.

D. Addressable Duct-Mounted Photoelectric Smoke Detector:
1. Shall be photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied and shall incorporate the following features:
   a. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single “Form C” contact rated at 7 A @ 28 VDC or 10 A @ 120 VDC.
   b. Duct Housing shall provide a relay control indicator Yellow LED.
   c. Compact Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.

d. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke detector.
e. Duct Housing shall provide a magnetic test area and red sensor status LED.
f. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.
g. Each duct detector shall have a Remote Test Station with an alarm LED and test switch where required by ANL.

E. Addressable Heat Sensors:
1. Shall be combination fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp: 135˚F fixed-temperature setting except as indicated.

F. Fire Alarm-Notification Appliances: Wall mount all audible/visual devices:
1. Fire alarm audible /visible device shall be speaker/strobes that match fire alarm panel make and model with field selectable wattage ranges from 1/8 watt to 8 watts. The standard notification appliance shall be Cooper/Wheelock EMNA series or equivalent with clear strobe for fire and amber for MNS. For outdoor use, use waterproof speaker. Use Wheelock motor bell/strobe in high noise areas in place of speaker/strobe.
2. Fire alarm notification appliance circuit provided synchronization of strobes at a rate of 1 Hz and operates horns with a Temporal Code Pattern operation. The circuit shall provide the capability to silence the audible signals, while the strobes continue to flash over a single pair of wires. The capability to synchronize multiple notification appliance circuits shall be provided.

G. Addressable Circuit Interface Modules:
1. There shall be two types of modules:
a. Type 1: Monitor Circuit Interface Module:
1) For conventional 2-wire smoke detector and/or contact device monitoring with Class B or Class A wiring supervision. The supervision of the zone wiring will be Class B. This module will communicate status (normal, alarm, trouble) to the FACP.
2) For conventional 4-wire smoke detector with Class B wiring supervision. The module will provide detector reset capability and over-current power protection for the 4-wire detector. This module will communicate status (normal, alarm, trouble) to the FACP.
b. Type 2: Line Powered Monitor Circuit Interface Module:
1) This type of module is an individually addressable module that has both its power and its communications supplied by the two wire multiplexing signaling line circuit. It provided location specific addressability to an initiating device by monitoring normally open dry contacts. This module shall communicate four zone status conditions (normal, alarm, current limited, trouble) to the FACP.
2) All Circuit Interface Module shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions. Modules shall have an onboard LED to provide an indication that the module is powered and communicating with the FACP. The LED shall provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

H. Air Sampling Smoke Detectors: Fenwal Analaser II. There is no approved equal.

I. Non-Addressable Manual Pull Stations:
1. Fire alarm stations shall be single-action dry-contact type, weatherproof construction, and finished in red with molded, operating instructions and the label “FIRE” in white raised-letters. Station will mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units.

2. Emergency alarm stations shall be single-action, dry-contact type and finished in yellow with molded, operating instructions and the label "EMERGENCY" in white raised letters. Station shall latch until manually reset. Provide stations with weatherproof construction where noted.

2.3 WIRING

A. Fire alarm wiring to be solid only.

B. Jacket color to be Red.

C. Fire alarm wiring shall be 16 AWG minimum, 2 pair twisted shielded FPLR or FPLP (where required) for fire alarm devices.

D. Audio/visual circuits shall use 2 pair twisted shielded #12 AWG FPLR or FPLP for bell/strobe combination. For speaker/strobe combination: Speaker (1) pair #16 AWG (min.) twisted, shielded. Strobe: (1) pair #14 AWG (min.) unshielded.

E. Provide at least two spare cables for each type of circuit (signaling line, audible notification appliance, visual notification appliance, auxiliary power, etc.) from the FACP to each floor terminal cabinet. Label each cable at both ends to identify the cable and its intended use.

2.4 SPARE PARTS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents:
   1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but not less than 1 unit.
   2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but not less than 1 unit.
   3. Smoke, Fire, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but not less than 1 unit of each type.
   4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but not less than 1 unit of each type.
   5. Keys and Tools: One extra set for access to locked and temperproofed components.
   6. Audible and Visual Notification Appliances: One of each type installed.
   7. Fuses: Two of each type installed in the system.
   8. Additional amplifiers for speaker system if back-up amplification is not installed.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation General:

AD-4: Section 28 31 00: Revise paragraph 3.1.A.1.

   1. Install the Fire Alarm Cabling in minimum 3/4 inch conduits in all areas.
   2. Install system components and all associated devices in accordance with applicable NFPA standards and manufacturer's recommendations.
   3. Installation personnel shall be supervised by persons who are qualified and experienced in the installation, inspection, and testing of fire alarm systems. Examples of qualified personnel shall include, but not be limited to, the following:
      a. Factory trained and certified personnel.

B. Furnish all materials, labor, equipment and accessories, including but not limited to, fire alarm systems, initiating devices, notification appliances, controls, supervisory devices and accessories:
   1. The Fire Alarm System shall consist of all necessary hardware equipment and software programming to perform the following functions:
      a. Fire alarm and detection operations.

b. Control and monitoring of elevators, smoke control equipment, door hold-open devices, fire suppression systems, emergency power systems, and other equipment as indicated in the drawings and specifications.

2. Notify an ANL representative two (2) days in advance of any necessary interruption of the fire alarm system required to complete the scope of this Contract. All final connections and terminations to the existing system or interruption of service to existing equipment will be performed by ANL personnel. Obtain from the ANL representative standard ANL "Out of Service" signs to be installed on all new fire alarm stations and/or fire alarm stations rendered temporarily inoperable during the scope of this Contract. Cover all "Out of Service" fire alarm stations with cardboard enclosures until activated. Remove and return signs to ANL representative after stations are activated. Paint fire alarm junction boxes "BLUE" and mark with adhesive labels furnished by ANL.
3. Record of Completion:
   a. See NFPA 72 4.5.1.3: Requirements for Certificate of Completion. Contractor to comply with NFPA 72 and all ANL standards. Issue to ANL a "Record of Completion" after completing operational acceptance tests. (Record of Completion form shall be supplied to the Contractor by ANL).
   b. Every system shall include the following documentation, which shall be delivered to ANL upon final acceptance of the system. Final payment will be dependant on all items below being submitted to ANL:
      1) A manufacturer's operations and maintenance manual and installation instructions covering all systems and system equipment.
      2) As-built drawings.
      3) Acceptance Tests: Upon completion of an installation of alterations, all functions of the system shall be tested, including operation of the system in various alarm and trouble modes for which it is designed (e.g., open circuit, grounded circuit, power outage, etc.). Satisfactory tests of the entire system shall be made in the presence of ANL Construction Inspector and ANL's authority having jurisdiction.
      4) Provide training to cognizant ANL personnel on installation, testing and maintenance of the system installed or altered.
      5) Record of Completion form issued by ANL-Completed.

END OF SECTION

SECTION 31 13 16
PRUNING AND REPAIRING EXISTING TREES

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Arborist qualifications: Experienced arborist or tree surgeon.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Tree coating: Asphaltic varnish containing antiseptic.

PART 3 - EXECUTION

3.1 PRUNING

A. Remove dead or dying limbs, and limbs that interfere with pedestrian or vehicular traffic on proposed walks and roads.
   1. To prevent stripping bark, stub cut branches that are too large to be supported by hand.
   2. On branch cuts over 1 IN in diameter provide coating.

B. Where existing trees interfere with construction, prune conflicting limbs back flush to main trunk.

C. Provide 7 FT vertical clearance where evergreens overhang new sidewalks.

D. Provide 10 FT vertical clearance where existing trees overhang vehicular roads.

3.2 REPAIR

A. Repair bark wounds:
   1. Remove injured bark.
   2. Shape wound to elongated ellipse.
   3. Disinfect and apply coating.

B. Repair rotten areas.

3.3 CLEANUP

A. Remove tree debris from Laboratory's property.

END OF SECTION

SECTION 31 23 00
BUILDING EXCAVATION, FILLING, AND BACKFILLING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. Unsuitable material: 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: As determined using ASTM-D1557 (Modified Proctor).
   3. Geotech: Geotechnical Engineer or Representative of Foundation Consultant employed by Owner to inspect foundation work.

1.2 EXTRA WORK

A. Removal and replacement of unsuitable material will be paid as extra work.
   1. Notify (Laboratory'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.

1.3 QUALITY ASSURANCE

A. Subsurface soils investigations have been made at project site.
   1. Soils information was obtained 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. Laboratory 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 Laboratory.
   3. If initial test fails, Contractor pays for retesting.

C. Tolerances of subgrade:
   1. 0.10 FT plus/minus 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. Contractor is responsible for:
   1. Determining safe slopes of excavations for the earth materials encountered.
   2. Shoring and bracing excavations as required to protect personnel, utilities, existing construction and new work.
   3. Removing bracing when safe.
   4. 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.

5. Complying with rules and regulations governing earthwork and respective utilities.
6. Providing adequate barricades and warning lights as required to protect persons and property and to satisfy applicable regulations.
7. 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. 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 analysis verifying conformance with the following.
      a. Granular fill below footings - IDOT CA-6.
      b. Granular fill around drain tile, and against basement walls and retaining walls – Less than 3 percent passing No. 200 sieve or IDOT CA-7.

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.
   1. Excavation may be filled with lean concrete (2500 psi) or IDOT CA-6 compacted to 95% per ASTM 1557. If CA-6 is used excavation shall extend one foot beyond the footing limits for each foot of depth.

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 percent 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 and pile caps.

B. Obtain Geotech's approval of footing subgrade before placing concrete.

C. Do not carry excavations lower than indicated, except when directed by Geotech.

D. If excavations are made below indicated level, fill with lean concrete (2500 psi) or IDOT CA-6 compacted to 95% per ASTM 1557, at no extra cost. If CA-6 is used excavation shall extend one foot beyond the footing limits for each foot of depth.

E. When excavations become soft and wet, remove soft material and replace with lean concrete (2500 psi) or IDOT CA-6 compacted to 95% per ASTM 1557, at no extra cost. If CA-6 is used excavation shall extend one foot beyond the footing limits for each foot of depth.

F. When freezing temperatures are expected, do not excavate to full depth unless footings or pile caps 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.

C. Scarify top 8 IN of excavation surface or subgrade and compact to 95 percent of maximum density.

D. Place fill material in 9 IN lifts and compact each lift to 95 percent maximum density.

E. Maintain moisture content of fill material during compaction as follows.
   1. Granular soils – +/- 2% of optimum.
   2. Clay soils - +/- 3% of optimum.

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. Provide granular backfill at foundation walls and retaining walls in accordance with the recommendation in the soils report.

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.

B. Place minimum of 200 mm, 8 IN granular fill around underslab drain tile.

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 48 00
UNDERPINNING

PART 1 - GENERAL

1.1 DESCRIPTION

A. General:
   1. Furnish labor, materials, tools, equipment and services for underpinning as indicated, in accord with provisions of Contract Documents.
   2. Completely coordinate with work of other trades, including site utilities and other foundation construction.
   3. Although such work is not specifically indicated, provide supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure and complete installation.
   4. See Division 01 for General Requirements.

B. Related Work Specified Elsewhere:
   1. Excavation and backfilling: Section 31 23 00.
   2. Forming, reinforcing, mixing, placing, curing, and testing concrete: Division 03.
   3. Earth Retention System: Section 31 50 00.
   4. Demolition: Section 02 41 00.

C. Definitions.
   1. Underpinning is a permanent supporting structure beneath existing foundations designed to transmit foundation loads to a lower bearing level. Underpinning includes temporary support necessary to safely perform underpinning work and the restoration of the structure upon completion of the work.
   2. Temporary support is the construction required to support existing structures during underpinning installation.
   3. Restoration means the correction by repair or replacement of the structure underpinned. Restoration shall be to the equivalent condition existing prior to the start of the contract work unless otherwise indicated.
   4. Geotech: Geotechnical Engineer employed by Laboratory, empowered to conduct inspections and make approvals.

1.2 QUALITY ASSURANCE

A. Assume complete responsibility for design, installation, maintenance, as well as damage resulting from installation and performance of underpinning.

B. Carefully examine site and verify elevations of existing footings and underground utility lines.

C. Design criteria:
   1. Provide underpinning such that indicated footing loads will be directly transferred to the desired bearing level limiting settlement to a maximum of 1/4 IN.
   2. Consider temporary lateral forces on the underpinning that may be present during construction operations. Underpinning may also be required to act as an earth retention system. Refer to Section 31 50 00 for requirements of earth retention system.
   3. Bearing area of existing footings shall be maintained unless use of higher bearing strengths are justified by Laboratory's Geotech.
   4. Do not use driven piling or sheet piling.

D. Qualifications:
   1. Designer: Underpinning must be designed registered Engineer, licensed to practice Structural Engineering in the Illinois.

2. Design engineer must be knowledgeable in underpinning with minimum 5 years' experience in design of systems such as that proposed.
3. Contractor: Underpinning must be installed by a contractor who specializes in installation of underpinning systems.
4. Contractor: Minimum of 5 years' experience in area of underpinning systems.

E. Inspection:
1. Designer shall observe work in progress to see that design is being followed and that design criteria are being met.
2. Obtain required permits. Inform local authorities as necessary and facilitate inspections required by regulatory agency having jurisdiction over underpinning work.

1.3 SUBMITTALS

A. Project Information:
1. Provide computations and details for construction of underpinning and temporary support of structures. Include descriptions of the methods and staging of the work to be performed.
2. The conditions of existing structures shown shall have been verified by field investigations.
3. Drawings and computations shall be signed and sealed by a registered Engineer (licensed to practice Structural Engineering in the state where project is located).
4. Submit evidence of design engineers and contractors qualifications.
5. Condition assessment and crack survey of structure to be underpinned.

1.4 JOB CONDITIONS

A. Carefully maintain bench marks, monuments, and other reference points.

B. Replace if disturbed or destroyed.

C. Protect active utilities from damage.

D. Provide protective barriers around excavations as required by governing agencies.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Concrete: Except as otherwise specified herein, concrete work shall meet the requirements of Division 03.

PART 3 - EXECUTION

3.1 PREPARATION

A. Permits: Obtain, in the name of the Contractor, agreements, permits, rights, and consents necessary to effect the underpinning work which have not otherwise been provided.

B. Coordination with Structure owners.
1. Prior to starting work on any structure, confer with the structure owner or structure owner's authorized representative and obtain concurrence with the underpinning procedures and sequences of operations, including:
   a. The means of access to the construction area;
   b. The permitted areas of operations;
   c. Time restrictions for the performance of work which may be disturbing to the occupants of the structures; or
   d. The scheduling of the time and durations of any outages of utility and other services to the premises and of the operation of systems within the premises.
2. Give 3 days notice to the Architect of intended conferences with the Laboratory.

3. Review with the Laboratory the existing crack conditions and other current conditions of the structures before beginning work.
4. Locate, protect, support, and maintain without interruption utility facilities and services to the structures. Restore affected existing properties to original or better condition upon completion of underpinning work.

C. Movement Detection
1. Provide and maintain monitoring equipment to detect horizontal and vertical movement of structures which might be affected by the work.
2. Inscribe or firmly affix on each column, pile cap, or wall to be underpinned or supported, and at additional locations directed by the Contractor's engineer, visual methods of determining movements. The method used is optional but shall be capable of being read to an accuracy of 0.005 FT.
3. Movement readings should be referenced to a benchmark at least 100 FT from the site, so as not to be affected by any movement resulting from excavation operations.
4. Take readings daily or more often, if necessary, during the progress of underpinning operations, and at least weekly for a period of not less than 4 weeks after completion of such operations. Keep records of readings.

3.2 PERFORMANCE

A. Perform the work in accord with applicable regulations and other requirements of authorities having jurisdiction and in a manner to protect persons and property.

B. Perform underpinning with qualified personnel under the supervision of a registered professional engineer experienced in this type of work.

3.3 EXCAVATION AND SUPPORT

A. Excavate approach pits in panels under portions of the existing structures not to exceed 4 FT in length or by other suitable method. Alternate and stage excavations with the concrete work. Excavate for piers to rock or soil of suitable bearing capacity to support the loads. Where suitable bearing capacity is not encountered at given elevations, additional excavation shall be directed by the Geotech. Provide additional excavation support for the deepened underpinning as required by computations.

B. Excavation for underpinning shall be unclassified, conforming to the requirements for excavations specified under Section 31 23 00.

C. Support the sides of excavations in accord with applicable regulations and in a manner to prevent injury to persons and damage to properties.

D. Maintain a temporary slope not steeper than 2 horizontal to 1 vertical above the excavation or sheeting.

E. Dewater the excavations for underpinning. Provide pumps, equipment, and labor necessary for the underpinning operations.

F. Perform needling, shoring, cribbing, and posting as necessary to ensure the safety of the structure prior to and during underpinning.

3.4 UNDERPINNING

A. Perform underpinning to the minimum extent shown on the structural drawings.

B. Form for the staggered piers, place reinforcing, and place and cure concrete in accord with the requirements of Division 03. Repair defects that would affect concrete strength before continuing the excavations.

C. Where existing structures are to be supported on new concrete underpinning, pack solid the entire space between existing work and top of new concrete with dry-packed grout – a mix consisting of not more than 2 parts sand to one part cement, with only enough water added to obtain a moldable, not flowable state. Ram "dry-pack" tight and solid to insure full bearing between existing and new construction.
   1. If full bearing cannot be insured by this procedure, provide a non gas-forming non-shrink grout, such as Embeco 636 by Master Builders Company, Cleveland Ohio, or approved equal. Water added shall be the minimum that will provide a flowable mixture and completely fill the space to be grouted without segregation, bleeding or reduction in strength.

D. Patch openings remaining in or under existing construction.

E. Place earth backfill in accord with requirements for backfill in Section 31 23 00.

3.5 RESTORATION

A. Restore the grounds of adjacent properties disturbed by underpinning to their original condition which prevailed at the start of construction.

B. Remove temporary protective installations upon completion of the work.

C. Properly repair damage to structures caused by underpinning and restore surfaces to their original condition which existed at the start of construction, or better.

3.6 CLEANING

A. Remove debris and excess earth resulting from operations as they accumulate. Do not store debris on site or permit debris to be scattered over site.

B. Upon completion, remove construction materials, tools and apparatus and leave premises clean, neat, and orderly.

END OF SECTION

SECTION 31 50 00
EARTH RETENTION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Subsurface soils investigations have been made at project site.
   1. Soils information was obtained for use in preparing foundation design.
   2. Location of soils report is included in specifications.
   3. Examine site and soils report and determine character of materials to be encountered.

B. Definitions:
   1. Geotech: Soils Engineer or Representative of Foundation Consultant employed by Laboratory, empowered to conduct inspections and make approvals.
   2. Temporary earth retention system: System required to function only during construction period, up until which time excavation can safely be backfilled and retention system is no longer required.
   3. Permanent earth retention system: System required to function throughout service life of structure.

1.2 QUALITY ASSURANCE

A. Assume complete responsibility for design, installation, maintenance as well as damage resulting from installation or performance of the earth retention system.

B. Carefully examine site and verify elevations of existing footings of adjacent buildings and invert elevations of underground utility lines.

C. Standards:
   1. Post Tensioning Institute (PTI):
      a. Guide specification for post tensioning materials.
      b. Recommendations for prestressed rock and soil anchors.
   2. American Institute of Steel Construction (AISC):
      a. Specifications for design, fabrication and erection of structural steel for buildings.
      b. Code of standard practice for steel buildings.
   3. American Welding Society (AWS):
      a. AWS D1.1, structural welding code - steel.
   4. American Society for Testing Materials Standards (ASTM): Standards indicated.
   5. Structural Steel Painting Council (SSPC): Standards indicated.
   6. American Wood Preservers Association (AWPA).

D. Design criteria:
   1. Provide earth retention system which will safely withstand earth pressures and limit settlement of surrounding structures to maximum 1/4 IN vertically and laterally.
   2. Earth retention system shall utilize effectively prestressed tie backs or earth anchors to minimize lateral earth deflection.
   3. Earth pressures used for the design of the earth retention system shall be determined by recognized principles of soils mechanics and shall be acceptable to the Laboratory's Geotech.
   4. Design, installation and grouting of earth retention system to follow recommendations of Post Tensioning Institute's "Recommendations for Prestressed Rock and Soil Anchors".
   5. Consider long term effects, including creep and relaxation in anchor design such that lateral movement of finished wall is less than 1/4 IN during service life of structure.
   6. Do not use driven piles or sheet piling.

E. Qualifications:
   1. Designer: Earth retention system must be designed by a Structural Engineer registered in the State of Illinois.
   2. Design Engineer must be knowledgeable in area of earth retention systems with minimum 5 years experience in design of systems such as that proposed.
   3. Contractor: Earth retention system must be installed by Contractor who specializes in installation of earth retention systems such as that proposed.
   4. Contractor: Minimum of 5 years' experience in area of earth retention system installation.

F. Testing:
   1. Proof test tie-back anchors in accordance with Post Tensioning Institute's "Recommendations for Prestressed Rock and Soil Anchors" to verify their load carrying capabilities.
   2. Ten percent of permanent anchors shall be "performance tested" to at least 1.5 times design working load; and 10 percent of temporary anchors to at least 1.35 times design working load in accordance with referenced PTI standard.

G. Monitoring:
   1. The Laboratory shall employ a qualified geotechnical consultant familiar with the soil conditions at the site who shall install 3-dimensional survey monitoring instrumentation as required to observe the movement of the earth retention system and adjacent structures.
   2. The geotechnical consultant shall report the measured movements of the earth retention system and adjacent structures to the contractor and Laboratory on a weekly basis until such time that the earth retention system is no longer necessary as deemed acceptable by the Geotech.
   3. If movements are recorded that are larger than anticipated or projected, provide necessary support as to reduce the movements to the acceptable level .

H. Inspection:
   1. Structural Engineer responsible for design shall observe work in progress to see that design is being followed and design criteria are being met.
   2. After construction of earth retention system is complete Structural Engineer responsible shall verify correctness of installation and inform Architect.

1.3 SUBMITTALS

A. Project information:
   1. Include following:
      a. Description of system proposed including plans and details for stage of construction.
      b. Anchor (tiebacks).
         1) Type.
         2) Corrosion protection.
         3) Stressing procedure.
         4) Grout and grouting method.
      c. Crack survey of existing structures protected by earth retention system.
      d. Tie-back proof test results.
      e. Design calculations signed by a Structural Engineer licensed in State of Illinois.

B. LEED Information:
   1. MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. MR 5.1and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.4 JOB CONDITIONS

A. Carefully maintain bench marks, monuments, and other reference points.

B. Replace if disturbed or destroyed.

C. Protect active utilities from damage.

D. Provide protective barriers around excavation as required by governing agencies.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Anchor materials:
   1. Either single or multiple elements of wires conforming to ASTM-A421; or strands conforming to ASTM-A416; or steel bars conforming to ASTM-A722.
   2. Minimum protective coating (except over bond length): Double corrosion protection system consisting of a plastic sheathing and grease over tendon in addition to grouting.
   3. Take extra care to ensure complete and uninterrupted continuity of protective coating.

B. Structural steel:
   1. New rolled shapes or plates of structural grade steel conforming to ASTM-A36 or ASTM-A992, Grade-50.
   2. Deformations, imperfections, camber and sweep of piles not more than allowed by ASTM-A6.
   3. Pile lengths necessary to reach required depths shall be determined by Contractor.
   4. Soldier pile: Coated with coal tar epoxy, with predrilled holes to prevent damage to corrosion protection system.

C. Protective coatings:
   1. Corrosion protection material which is not detrimental to prestressing steel, with following properties:
      a. Free from cracks and not brittle or fluid over entire anticipated range of temperatures.
      b. Chemically stable for life of tendon.
      c. Nonreactive with surrounding materials such as concrete, tendons or sheathing.
      d. Corrosion inhibiting.
      e. Impervious to moisture.
   2. Coal tar epoxy: Tnemec Tneme-Tar 46-413, minimum 8 mils.
   3. Grease: Specially compounded for post tensioning.

D. Timber lagging: Of sufficient size and strength to support loads imposed on it; pressure treated in accordance with AWPA standards to preserve capacity of element for service life of structure.

PART 3 - EXECUTION

3.1 PREPARATION

A. Do not start work nor purchase materials required until description and calculations for proposed earth retention system and details have been examined for compliance with the specifications.

3.2 EXCAVATION

A. Install earth retention system to dimensions and elevations indicated, allowing additional space as required for construction operations and inspection of foundations.

B. Excavate and remove existing concrete encountered.

C. Do not perform blasting.

D. Remove old foundations, building construction, and other materials concealed beneath present grade, as required to execute work, and as indicated.

E. Properly level off bottoms of excavations.

F. Control grading around building.

G. Pitch earth to prevent water from running into excavated areas or damaging structure.

H. Provide pumping required to keep excavated spaces clear of water.

I. When springs or running water are encountered, notify Architect and Engineer, provide free discharge of water by trenches or pumps, and drain to appropriate point of disposal as directed.

J. Maintain earth retention system from time of installation until completion of backfilling around building.

END OF SECTION

SECTION 32 40 13
SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, appurtenances, tools, equipment, and services for site furnishings, as indicated, and in accordance with Contract Documents.

B. Completely coordinate with work of other trades.

C. Section includes:
   1. Bicycle racks.
   2. Snuffers.
   3. Benches.
   4. Tables.

1.2 QUALITY ASSURANCE

A. Source Limitations: Obtain site furnishing through one source from single manufacturer when practicable.

1.3 SUBMITTALS

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

B. Samples:

C. Project Information:
   1. Site Furnishings Schedule: For site furnishings use same designations indicated on Drawings when preparing Schedule.

D. Closeout Submittals.
   1. Maintenance Data for Site Furnishings.

E. LEED Information:
   1. LEED Credit MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. LEED Credit MR 5.1and 5.2, Local/Regional Materials: Manufacturer's certification indicating final point of assembly for products and materials located within 500 miles of Project site. Include manufacturer's name, address and phone number.

1.4 WARRANTY

A. Manufacturer's 1 year warranty covering repair or replacement resulting from defects in material or workmanship.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Bicycle Racks:
   1. Base:
      a. Saris Cycling Group (800-783-7257)
   2. Optional:

a. Madrax.
b. Graber.

B. Snuffers:
1. Base:
a. Wausau Tile (800-388-8728)
2. Optional:
a. Quick Crete Products Corp. (866-703-3434)
b. Doty & Sons Concrete, Inc. (800-233-3907)

C. Benches:
1. Base:
a. Wausau Tile (800-388-8728).
2. Optional:
a. Quick Crete Products Corp. (866-703-3434)
b. Doty & Sons Concrete, Inc. (800-233-3907)

D. Tables:
1. Base:
a. Wausau Tile (800-388-8728).
2. Optional:
a. Quick Crete Products Corp. (866-703-3434)
b. Doty & Sons Concrete, Inc. (800-233-3907)

E. Other manufacturers desiring approval comply with Section 00 26 00.

2.2 MATERIALS

A. Anchors, Fasteners, Fittings, and Hardware:
1. Manufacturer's standard, corrosion-resistant, coated or noncorrodible materials, commercial quality.
2. Angle Anchors: For inconspicuously bolting legs of site furnishings to on or below grade substrate; one per leg.

B. Grout:
1. Nonshrink, nonmetallic, premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM-C1107.
2. Grout shall be for exterior applications.

C. Erosion Resistant Anchoring Cement:
1. Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement.
a. Formulation manufactured for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound.
b. Resistant to erosion from water exposure without needing protection by sealer or waterproof coating.
2. Anchoring cement shall be for exterior applications.

2.3 BICYCLE RACKS

A. Base Product:
1. (2) Wave Racks for (12) bike storages:
a. Model: (1) 2163 5 Bikes and (1) 2165 7 Bike, as manufactured by Saris Cycling Group.
2. Size: 36 IN high x 38.38 IN wide for 5 bike unit and 36 IN high x 62.38 IN wide for 7 bike unit.
3. Fabrication
a. Bicycle racks shall not be welded in sections.
1) Only base plate shall be welded to steel pipe with two 1/8 IN vent holes. Provide one hole on inside of each upright where pipe is welded to baseplate.

b. Finish: Coat bicycle rack after fabrication with Thermoplastic, polyethylene copolymer based powder coating.
   1) Color: Silver.
   2) Racks shall have welded, flanged base plates, minimum 6 IN diameter x 1/4 IN thick with minimum (4) 5/8 IN diameter mounting holed on each base plate.

2.4 SNUFFERS

A. Base Product:
   1. Model: WS150 Smokeless Reinforced Concrete Snuffers as manufactured by Wausau Tile.
   2. Size: 12 x 36 IN height.
   3. Color: B-31 Weatherstone White.
   4. Free Standing.

2.5 BENCHES

A. Base Product:
   1. Model: TF5117 Reinforced Concrete Benches as manufactured by Wausau Tile.
   2. Size: 48 x 18 x 18 IN height.
   3. Color: B-31 Weatherstone White.
   4. Free Standing.

2.6 TABLES

A. Base Product:
   1. Model: TF5119 Reinforced Concrete Tables as manufactured by Wausau Tile.
   2. Size: 36 x 36 x 18 IN height.
   3. Color: B-31 Weatherstone White.
   4. Free Standing.

2.7 FABRICATION

A. Metal Components:
   1. Form to required shapes and sizes with true, consistent curves, lines, and angles.
   2. Separate dissimilar metal materials to prevent electrolytic action.

B. Welded Connections:
   1. Weld connections continuously.
   2. Weld solid members with full-length, full-penetration welds.
   3. Weld hollow members with full-circumference welds.
   4. At exposed connections, finish surfaces smooth and blended so no roughness or unevenness shows after finishing.
   5. Welded surfaces shall match contours of adjoining surfaces.

C. Pipes and Tubes:
   1. Form simple and compound curves by bending members in jigs.
   2. Produce uniform curvature for each repetitive configuration required.
   3. Maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of railing components.

D. Exposed Surfaces:
   1. Polished, sanded, or otherwise finished.
   2. Surfaces shall be smooth, free of burrs, barbs, splinters, and sharpness.
   3. Edges and ends shall be rolled, rounded, or capped.

E. Factory Assembly:
   1. Assemble components in factory to greatest extent possible to minimize field assembly.
   2. Clearly mark units required for assembly infield.

2.8 FINISHES - GENERAL

A. Comply with NAAMM "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Appearance of Finished Work:
   1. Variations in appearance of abutting or adjacent pieces are acceptable only if they are within range of approved samples.
   2. Noticeable variations in same piece are not acceptable.
   3. Variations in appearance of other components are acceptable if they are within the range of approved samples.
   4. Assemble or install to minimize contrast.

2.9 STEEL AND GALVANIZED STEEL FINISHES

A. Baked Enamel, Powder Coat Finish: Manufacturer's standard, baked, 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.
   1. Comply with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.10 STAINLESS-STEEL FINISHES

A. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

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

3.2 INSTALLATION, GENERAL

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 positioned at locations indicated on Drawings.

3.3 CLEANING

A. After completing site furnishing installation, inspect components.

B. Remove spots, dirt, and debris.

C. Repair damaged finishes to match original finish or replace component.

END OF SECTION

SECTION 32 92 19
SEEDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Location of work:
   1. Establish grass on areas within limits of grading, as indicated, which are not occupied by other planting or construction.
   2. Seed disturbed areas outside limits of construction.

1.2 QUALITY ASSURANCE

A. Minimum standards: U.S. Department of Agriculture (USDA), Federal Seed Act (53 Stat.1275) Rules and Regulations, as amended to date.

1.3 SUBMITTALS

A. Project information:
   1. Prior to delivery of materials, submit certificates certifying that materials meet requirements specified.
   2. Submit certified copies of reports for following materials:
      a. Seed indicating mixture percentage, botanical and common name(s), percentage by weight, and percentages of purity, germination and weed seed.
      b. Seed labeled in accordance with Federal Seed Act and equaling or exceeding specification requirements.
      c. Fertilizer indicating chemical analysis.
   3. Copies of invoices for fertilizer, indicating grade furnished, to determine total quantity applied.

B. Contract closeout information:
   1. Warranty.
   2. Maintenance data.

C. LEED Information:
   1. MR 5.1and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accord with US Department of Agriculture Rules and Regulations under Federal Seed Act.

B. Deliver fertilizer to site in original, unopened containers labeled with manufacturer's chemical analysis.

1.5 JOB CONDITIONS

A. Perform seeding when conditions and planting season are suitable for successful results.

B. Actual dates for seeding will vary depending on construction schedule and pending weather conditions. Notify Architect of anticipated dates for doing work at least 30 days in advance.

1.6 WARRANTY

A. Warrant seeded areas for 1 year from Substantial Completion.

B. Replacement materials and methods identical to original.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Establish a smooth, healthy, uniform, close stand of grass from specified seed.

B. Grass seed:
   1. Fresh, clean, new crop seed.
   2. Species, proportions and minimum percentages of purity, germination, and maximum percentage of weed seed, as specified.
   3. Grass seed mixture:

Common and Botanical Name	Percent by Weight	Minimum percent Germ	Minimum percent Purity
Kentucky Blue Grass (Poa pratensis)	30 percent	80	90.0
Creeping Red Fescue (Festuca Hector)	15 percent	80	98.0
Hard Fescue (Festuca Aurora E/Sun & Shade Mixture)	10 percent	90	98.0
Little Blue Stem (Schizachyrium scoparium)	15 percent	80	90.0
Annual Rye Grass (Lolium multiflorum)	15 percent	85	97.0
Perennial Rye Grass (Lolium perenne)	15 percent	80	90.0

C. Mulch:
   1. Clean, weed free, threshed straw of oats, wheat, barley, rye, beans, peanuts, rice or other locally available mulch material.
   2. Do not use mulch containing a quantity of matured noxious weed seeds or other species that will be detrimental to seeding, or provide a menace to surrounding land.
   3. Do not use mulch material which is fresh or excessively brittle, or which is decomposed and will smother or retard growth of grass.
   4. Anchor mulch to soil by disking.

D. Fertilizer:
   1. Commercial fertilizer of 18-46-0 analysis, meeting applicable requirements of State and Federal Law.
   2. Do not use cyanamic compounds or hydrated lime.

E. Water for planting purposes:
   1. Supplied by Laboratory.
   2. Provide equipment necessary to transport water from source to required locations.
   3. Do not waste water.

PART 3 - EXECUTION

3.1 SOIL PREPARATION

A. Limit preparation to areas which will be planted soon after preparation.

B. Prior to applying fertilizer, loosen areas to be seeded to minimum depth of 4 IN with double disc or other suitable device if soil has become hard or compacted.

C. Remove stones over 1 IN in any dimension, sticks, roots, rubbish and other extraneous matter.

D. Correct surface irregularities in order to prevent pocket or low areas which will allow water to stand.

E. Spread lime uniformly over designated areas at rate of 50 LB/1000 SF.

F. After application of lime, prior to applying fertilizer, loosen areas to be seeded if soil has become hard or compacted.

G. Grade areas to be seeded to smooth, even surface with loose, uniformly fine texture.
   1. Roll and rake, remove ridges and fill depressions, as required to meet finished grades.
   2. Fine grade just prior to planting.

H. Distribute fertilizer uniformly over areas to be seeded at rate of 8.3 LB/1000 SF.
   1. Use suitable distributor.
   2. Incorporate fertilizer into soil to depth of at least 2 IN.

I. Restore areas to be seeded to specified condition if eroded or otherwise disturbed between finished grading and planting.

J. If fertilizer application rate is determined, by invoices submitted, to be less than that specified, apply additional fertilizer.

3.2 SEEDING BY DRILLING OR BROADCAST

A. Do not use seed which is wet, moldy or otherwise damaged.

B. Use approved mechanical power driven drills or seeders, or mechanical hand seeders, or other approved equipment.

C. Distribute seed evenly over entire area at not less than 4 LB/1000 SF, 50 percent sown in one direction, remainder at right angles to first sowing.

D. Stop seeding when work extends beyond most favorable planting season or when satisfactory results cannot be obtained because of drought, high winds excessive moisture, or other factors.
   1. Resume work only when favorable condition develops.

E. Lightly rake seed into soil to depth of 1/4 IN followed by light rolling or cultipacking.

F. Immediately protect seeded areas against erosion by mulching.
   1. Spread mulch in a continuous blanket using 1-1/2 TON/ACRE to depth of 4 or 5 straws.
   2. Disk anchoring:
      a. Anchor mulch by punching it into soil to depth of 2 to 3 IN by using a disk, clodbuster, or other approved equipment.

3.3 MAINTENANCE

A. Maintain seeded areas for 90 days after seeding.
   1. Water, fertilize, weed, mow, trim, roll, regrade, reseed as required.
   2. Establish a smooth, healthy, uniform, close stand, free of eroded or bare areas, weeds and surface irregularities.

B. Provide and maintain temporary piping, hoses and watering equipment as required to keep seeded areas uniformly moist for proper growth.

1. Lay out temporary watering system and arrange watering schedule to avoid walking over muddy and newly seeded areas.
2. Prevent puddling and water erosion and displacement of seed and/or mulch.

C. Mow seeded areas as soon as there is enough top growth to cut with mower set at recommended height for principal species and before height exceeds 3 IN.
   1. Repeat mowing as required to maintain height.
   2. Do not delay mowing until grass blades bend over and become matted.
   3. Do not mow when grass is wet.
   4. Time initial and subsequent mowings as required to maintain height of 1-1/2 to 2 IN.
   5. Do not mow lower than 1-1/2 IN.
   6. Remove no more than one-half grass leaf surface at any time.

D. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose.

E. Anchor as required to prevent displacement.

F. Replant bare areas using same materials specified.

END OF SECTION

SECTION 32 92 21
NATIVE GRASS SEEDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Location of work: Establish native grasses on areas indicated as "native grass seeding," which are not occupied by other planting or construction.

1.2 SUBMITTALS

A. Project information:
   1. Certificates for grass seed mixture, stating botanical and common name, place of origin, strain, and percentages of purity and germination, and amount of pure live seed (PLS).
   2. Certify that each container of seed delivered is fully labeled in accordance with Federal Seed Act and equals or exceeds specification requirements.
   3. If planting is scheduled for fall: Type of cover crop and planting procedures.

B. Contract closeout information:
   1. Warranty.
   2. Maintenance data.

C. LEED Information:
   1. MR 5.1and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.3 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accordance with US Department of Agriculture Rules and Regulations under Federal Seed Act.

B. Deliver fertilizer in original containers, labeled with content analysis.

1.4 JOB CONDITIONS

A. Perform seeding between November 1 and June 30 when ground is not frozen and when no excessive rain storms is expected.

B. May 1 to June 30 is preferred.

C. Preferred planting time for cover crop: June 1 through July 15.

1.5 WARRANTY

A. Warrant seeded areas for 1 year from Substantial Completion.

B. Reseed as required to establish full cover.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Seed:
   1. Certified seed of locally adapted strains as specified.

2. Place of origin: Not more than 200 miles east, south, or west; and 50 miles north from where it will be planted.
3. Provide mixture as follows:
   a. Wet Native Plant Seed Mix – Apply at 10 PLS (pure live seed) pounds per acre.
      1) Grasses:

Common and Botanical Name	Proportion by Weight (Percent)
Fowl Manna Grass (Glyceria striata)	7.5
Virginia Wild Rye (Elymus virginicus)	7.5
Switch Grass (Panicum virginicus)	7.5
Prairie Cord Grass (Spartina pectinata)	7.5
TOTAL PROPORTION BY WEIGHT	30 PERCENT

      2) Temporary Cover Corp:

Common and Botanical Name	Proportion by Weight (Percent)
Annual Rye Grass (Lolium multiflorum)	20
Perennial Rye Grass (Lolium perenne)	20
TOTAL PROPORTION BY WEIGHT	40 PERCENT

      3) Forbes:

Common and Botanical Name	Proportion by Weight (Percent)
Swamp Milkweed (Asclepias incarnata)	3.0
New England Aster (Aster novae-angliae)	3.0
Spotted Joe-Pye Weed (Eupatorium maculatum)	3.0
Sneezeweed (Helenium autumnale)	3.0
Path Rush (Juncus tenuis)	3.0
Common Mountain Mint (Pycnanthemum virginianum)	3.0
Riddell's Goldenrod (Solidago riddellii)	3.0
Germander (Teucrium canadense)	3.0

Blue Vervain (Verbena hastata)	3.0
Common Ironweed (Vernonia fasciculata)	3.0
TOTAL PROPORTION BY WEIGHT	30 PERCENT

b. Dry Native Plant Seed Mix – Apply at 10 PLS (pure live seed) pounds per acre.

1) Grasses:

Common and Botanical Name	OZ/ACRE PLS
Side-Oats Grama (Bouteloua curtipendula)	3.0
Canada Wild Rye (Elymus canadensis)	3.0
Virginia Wild Rye (Elymus virginicus)	4.5
Purple Love Grass (Eragrostis spectabilis)	4.5
Switch Grass (Panicum virgatum)	4.5
Little Bluestem (Schizachyrium scoparium)	6.0
Prairie Drop Seed (Sporobolus heterolepis)	4.5
TOTAL PROPORTION BY WEIGHT	30 PERCENT

2) Temporary Cover Corp:

Common and Botanical Name	Proportion by Weight (Percent)
Annual Rye Grass (Lolium multiflorum)	20
Perennial Rye Grass (Lolium perenne)	20
TOTAL PROPORTION BY WEIGHT	40 PERCENT

3) Forbes:

Common and Botanical Name	OZ/ACRE PLS
Sky Blue Aster (Aster azureus)	3.0
Shooting Star (Dodecatheon meadia)	3.0
Purple Prairie Clover (Dalea purpurea)	3.0
Shooting Star	

(Dodecatheon meadia)	3.0
Purple Coneflower (Echinacea purpurea)	3.0
Michigan Lily (Lilium michiganense)	3.0
Pale Spiked Lobelia (Lobelia spicata)	3.0
Foxglove Beard Tongue (Penstemon digitalis)	3.0
Black-Eyed Susan (Rudbeckia hirta)	3.0
Early Goldenrod (Solidago juncea)	3.0
Stiff Goldenrod (Solidago rigida)	3.0
TOTAL PROPORTION BY WEIGHT	30 PERCENT

B. Mulch:
   1. Weed free hay (not brome or bluegrass hay); prairie grass, Bermuda grass or other hay.
   2. Straw mulch of oat, wheat, or rice straw.
   3. Mulch to be free of noxious weeds and foreign materials, and kept in a dry condition, not molding or rotten.

C. Fertilizer: Commercial fertilizer of 16-20-0 analysis, meeting applicable requirements of Illinois State law.

D. Herbicide: 2, 4-D (ester form).

E. Cover crop: Sorghum, soybeans, milo, millet or sudangrass, etc.

F. Tacking agent: As per State specifications.

G. Water: Provide clean, fresh water free from impurities injurious to vegetation.

PART 3 - EXECUTION

3.1 SOIL PREPARATION

A. Seeding with cover crop:
   1. Plant cover crop 4 - 8 LB/ACRE, in rows not exceeding 42 IN wide over areas to be seeded.
   2. Allow cover crop to mature.
   3. Harvest completely leaving stubble at least 18 IN in field.

B. Leave seedbed weed-free and firm.

3.2 SEEDING

A. Seed with grass drill.
   1. Drill following contour lines as closely as practical.
   2. Nisbet grass drill has been proven to be successful in this operation.

3. Areas of one acre or less may be sown by hand broadcasting; mix seed with generous amount of damp sand to insure even distribution.
4. Minimum seeding rate is 20 PLS/SF.

B. Harrow or rake seed into ground following seeding.
1. Seed depth: Between 1/4 and 1/2 IN.

C. Immediately after seeding, protect slopes of 3:1 or greater from erosion by mulching.
1. Spread mulch in continuous blanket using 1 to 2 TON/ACRE.
2. Anchor mulch to ground with disc mulch tiller.

3.3 MAINTENANCE

A. Maintain seeded areas for one full growing season.

B. Do not mow native grass.

C. When weeds are shading out native grass seedlings, shred weeds back to height of seedlings with rotary shredder.
1. Before August of growing season, shred weeds at least 2 times.

D. Herbicide may be used to control weed growth in first year.
1. Do not apply until weeds are 40 percent broadleaf and seedlings are at least 1 IN high and at 2-4 leaf stage.
2. If herbicide is used, apply twice.
3. Use 1/2 to 1 LB active ingredient/Acre.

END OF SECTION

SECTION 32 93 13
PLANTS AND PLANTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. In event of conflict between quantities of plants indicated on drawings and in plant list, plant list will govern.

1.2 QUALITY ASSURANCE

A. Nursery stock standard: "American Standard for Nursery Stock," ANSI-Z60.1.

B. Work performed by qualified nurseryman or landscape contractor.

C. Qualifications of pruners: Experienced plantsmen.

1.3 SUBMITTALS

A. Product Data:
   1. Manufacturer's specifications for all materials.

B. Samples:
   1. Inert Mulch:
      a. Small sample(s) for color selection.
      b. 2 LBS of each type and color selected for final approval.
   2. Organic Mulch: 1/2 LBS of each type.

C. Project Information:
   1. Notify Architect of plant material delivery schedule in advance so that plant material may be inspected on-site prior to installation.

D. Contract Closeout Information:
   1. Warranty.
   2. Maintenance data.

E. LEED Information:
   1. MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. MR 5.1and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Handle plants at all times so that roots or balls are adequately protected from breakage of balls, from sun and drying winds.

B. Plants with dried out tops or roots will be rejected.

1.5 JOB CONDITIONS

A. Protect existing improvements and trees.
   1. Repair or replace damaged items.

B. Protect completed work.

C. Verify location and existence of underground utilities.
   1. Protect existing utilities from damage due to construction activity.
   2. Repair damage to utility items.

D. If plant locations conflict with existing improvements or rock, Architect will select other locations.
   1. Make changes at no extra cost.
   2. Do not change location of plants without permission of Architect.
   3. Where tree locations fall under existing overhead wires, or crowd existing trees, adjust locations as directed by Architect.

E. Planting times:
   1. Trees and shrubs: Any time ground is suitable between November 1 and May 1. Seedlings shall be planted in Spring.
   2. Groundcovers: Between March 15 and May 1.
   3. Do not plant when ground is frozen or temperature is below 32 degF.

1.6 WARRANTY

A. Remove and replace new plants supplied, which are impaired, dead or dying during 1 year from initial acceptance.

B. Replacement materials and methods identical to original.

C. Plants replaced under warranty will not have a second warranty, except as stated in paragraph D below.

D. If fall planted material is dead or dying in the spring, replace material during that spring season. If said plants fail again during growing season, replace again in the fall. Every plant must leaf out and be in a healthy condition at beginning of growing season.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Plant materials:
   1. Species and ize indicated.
      a. No substitutions without written approval of Architect.
   2. Sound, healthy, vigorous, with normal top and root systems.
   3. Free from diseases, insect pests or their eggs.
   4. Nursery grown stock, freshly dug.
   5. No heeled-in, cold storage or collected stock.
   6. Grown in same or colder climatic zone as project.

B. Trees:
   1. Single leader, straight trunk (unless otherwise indicated in plant list).
   2. Well branched, free of branches up to 5 FT high (unless otherwise indicated in plant list).
   3. Symmetrical growth.

C. Balled and burlapped plants (B & B): Firm, natural balls of soil wrapped with burlap or strong cloth and tied.

D. Container grown plants (CG):
   1. Roots well established in soil, but not root bound.
   2. Grown in container for at least one growing season.

E. Bare root plants (BR): Intact root system cleaned of earth, wrapped immediately in wet straw, moss or other suitable material.

F. Planting soil:
   1. All top soil will be provided by Owner.

2. Modify soil, if needed, with sand and/or peat moss.

G. Organic Mulch: Shredded pine bark or hardwood chips of approved commercial grade.

H. Inert Mulch:
1. Decomposed granite
2. Color(s): As selected by Landscape Architect.

I. Peat moss: Finely shredded sphagnum or fibrous peat moss of an approved commercial grade; free from woody substances.

J. Sand: Clean and free of toxic materials, ASTM-C33.

K. Herbicide: Pre-emergent/Post-emergent: Commercial grade conforming to State and Federal regulations.

L. Weed barrier: Non-woven, geotextile fabric.

M. Metal edging:
1. Steel edging:
a. 1/8 x 4 IN.
b. 16 IN tapered steel stakes.
c. Painted black.

N. Tree wrap:
1. 2 ply asphalt laminated Kraft crepe paper in strips, or burlap in strips.
2. Secure to tree with good quality 6 ply cotton twine or binder twine.

O. Tree stakes:
1. 2 x 4 x 30 IN wood stakes.

P. Staking wire: 12 GA galvanized.

Q. Reinforced rubber hose: 5/8 or 3/4 IN diameter.

R. Water for planting purposes:
1. Supplied by Laboratory.
2. Provide equipment necessary to transport water from source to required locations.
3. Do not waste water.

2.2 PLANT LIST

A. See drawings for plant list.

PART 3 - EXECUTION

3.1 PREPARATION

A. Immediately heel-in or plant bare root material.

3.2 PLANTING PROCEDURE

A. Layout: Stake all plant material locations and layout bedlines prior to beginning installation. Architect may approve layout or make adjustments to plant material locations to meet field conditions.

B. Excavate materials without additional cost.

C. Loosen bottom of pits prior to planting.

D. Tree and shrub pits:
1. Circular, with vertical sides.
2. At least 12 IN greater in diameter than ball diameter.
3. Sufficient depth to provide 6 IN of planting soil under ball when set to natural grade.

E. Massed planting and groundcover beds:
   1. Remove sod if required.
   2. Shrubs: Plant in individual holes of required size.
   3. Groundcover beds: Rototill existing topsoil to depth of 6 IN.
   4. Modify soil with sand and/or peat moss if needed, to insure proper plant growth.

F. Set plants straight or plumb, at such level that after settlement they bear same relationship to finished grade as they did in their former setting.
   1. Remove burlap, rope, wires, etc., from top of balls.
   2. Do not remove burlap from sides and bottom of balls.

G. Backfill plants with planting soil.
   1. Tamp under and around balls to eliminate voids.
   2. Tamp to one-half depth of pit and thoroughly water and puddle before backfilling to proper grade.
   3. After planting has been completed, flood pit again so that backfill is thoroughly saturated and settled.

H. After planting is complete, form saucer 3 IN high around each plant extending to limit of plant pit using existing soil.

I. Mulching:
   1. Mulch tree planting pit after saucer has been shaped to depth of 3 IN with organic mulch.
   2. In massed plantings, mulch entire area uniformly to depth of 2 IN with organic mulch.
   3. Mulch uniformly over groundcover beds to depth of 2 IN with organic mulch.
   4. If mulching is delayed and soil has dried out, water plants thoroughly before spreading mulch.

J. Staking:
   1. Stake trees immediately after planting.
   2. Set stakes securely at an angle.
   3. For deciduous trees 3 IN and smaller : Two stakes spaced opposite sides of tree.
   4. Provide rubber hose around trunk; one for each wire.
   5. Attach wire from stake to hose and secure.

K. Tree wrap:
   1. Wrap trees 2 IN caliper or larger by neatly overlapping wrapping material between ground line and second branch.
   2. Place ties at top and bottom of wrapping material and not more than 12 IN OC between top and bottom ties.

L. Pruning:
   1. Remove dead or damaged branches.
   2. Thin trees to about two-thirds of initial branching.
   3. Remove only dead or damaged branches from conifers.

M. Metal edging: Install edging in accordance with manufacturer's recommendations and as indicated on drawings.
   1. Keep top of edging flush with grass, walks, or curbs.

3.3 INERT MULCH AREAS

A. In areas to receive inert mulch, apply herbicide in accord with manufacturer's recommendations.

B. Cover areas with weed barrier.

C. Overlap edges minimum 6 IN.

D. Install (2) lifts of 2 IN uniform layer of inert mulch.
   1. Recess area so that top of rock is flush with grass, walks or curbs.

E. If plants are installed during same time that inert mulch is installed, delay herbicide application 3 to 4 weeks.
   1. Apply herbicide later over surfaces.

3.4 CLEAN-UP

A. Remove debris and waste materials, and excess earth materials.

B. Resod any damaged turf areas.

3.5 REVIEW FOR INITIAL ACCEPTANCE

A. At end of each planting season, Architect will review and record acceptability of plant material.

B. Payment for completed work will be based only on acceptable plant materials and workmanship.

3.6 MAINTENANCE

A. Maintain new and transplanted materials for one year from initial acceptance.
   1. Water when necessary.
   2. Remove dead or dying branches, and sprouts.
   3. Tighten, repair or replace tree stakes and wrapping.
   4. Maintain mulch depth.
   5. Weed plant beds and pits.

END OF SECTION

Section 33 47 19
BIORETENTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Definitions:
   1. A bioswale (, rain garden or infiltration basin) is a shallow depression in the landscape designed to collect stormwater runoff, maximize infiltration, filter suspended solids, and channel water slowly to the nearest outlet.
   2. An infiltration cell is the amended soil bed area of the bioswale.

B. Location of Work:
   1. Areas as designated on Construction Drawings

C. Coordinate work with other trades and subcontractors.

1.2 QUALITY ASSURANCE

A. General contractor to coordinate a pre-construction conference with grading and landscape sub-contractors, Landscape Architect, and Owner.

B. Finished grading tolerance:
   1. 30 mm 0.1 FT plus/minus from design elevations.

C. Layout work by Landscape Architect registered in the State of Illinois.

D. Owner will hire an independent soils laboratory to verify soil mixture.

E. Tolerances of subgrade:
   1. Plus/minus 60 mm 0.20 FT from required elevations.

F. ASTM-D4833: Standard Test Method for Index Resistance of Geotextiles, Geomembranes, and Related Products.

G. ASTM-D4751: Standard Test Method for Determining Apparent Opening Size of Geotextile.

H. ASTM-D4491: Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

1.3 SUBMITTALS

A. Submit in accordance with Division 1 in sufficient detail to show full compliance.

B. Submit manufacturer's product description, criteria, limitations, applications and technical data.

C. Prior to installation, submit test results of final soil mix for fertility, pH, micronutrient analysis, organic content; include statement indicating costs for each product having recycled content.

D. LEED Information:
   1. MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. MR 5.1and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
   3. LEED Credit MR 6.0, Rapidly Renewable Materials: Manufacturers' product data for products manufactured from rapidly renewable material; indicate type of rapidly renewable material.

1.4 JOB CONDITIONS

A. Protect existing facilities, utilities (overhead and underground), sidewalks, pavement, and existing landscaping.
   1. Repair damaged items.
   2. Cost of repair to items not indicated paid by Owner.
   3. Notify Owner and Construction Manager and make emergency repair as directed.

B. Protect Graded areas against erosion.
   1. Re-establish graded areas against erosion.

C. Protect engineered soil of Bioswale from sediment infiltration during construction.
   1. Bioswale soil contaminated by sediment wash off to be excavated and replaced.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fill materials:
   1. Soil Media
      a. 30% compost, 50% sand and 20% native top soil, measured by volume.
      b. Soil is to be evenly and thoroughly mixed onsite, using a tumbler, to avoid separation of soil components during backfilling operations.
      c. Topsoil (provided by Owner) shall have a maximum clay content of 5%. If existing soils have a clay content exceeding 5%, appropriate amendments shall be utilized to dilute the clay content to allow tolerances.

B. Geotextile Fabric
   1. Non-woven, needle punched, geotextile fabric
      a. GeoTex 351 or equivalent.
      b. Flow rate: 150 GPM/SQ FT
      c. Tensile strength: 95 LBS according to ASTM D-4632
      d. UV Resistance (% retained at 500 hrs.): 70%
      e. Hydraulic opening size: 50 US Std. Sieve

C. Under drains
   1. Underdrains
      a. See construction drawing for locations and details

D. Organic Mulch
   1. Double shredded hardwood mulch.

E. Compost
   1. Locally obtained and well rotted compost.
   2. Compost shall have an organic matter content of 35%-65% per ASTM D-2974.
   3. Compost shall have a carbon to nitrogen ratio between 20:1 and 35:1.

F. Sand
   1. The sand shall consist of sound durable particles reasonably free from an excess of soft and unsound particles and of other objectionable deleterious material.
   2. The gradation shall meet IDOT FA-2 classification.

G. Aggregate
   1. Open graded course aggregate.
   2. The gradation shall meet IDOT CA-7 classification.

PART 3 - EXECUTION

3.1 EXCAVATION, BACKFILL, AND COMPACTION

A. Stake bioretention and under drain system layout perimeter. Layout to be inspected by Landscape Architect.
   1. Notify Landscape Architect one week prior to staking inspection.

B. Excavate infiltration cell as indicated in the construction drawings.
   1. Start at the middle of the garden and excavate to edges using light weight equipment. Limit equipment movement to minimize compaction of cell area.
   2. Remove excavated soil from infiltration cell.
   3. Do not use excavated soil in infiltration cell or side slopes.

C. Protect Bioretention Garden from erosion during construction with approved control devices.

D. Excavate trenches for underdrain system, providing a 1% slope MIN.
   1. Lay geotextile fabric on subgrade.
   2. Place 6 IN of aggregate material below underdrain pipe.
   3. Underdrain pipes to be backfilled with an additional 12 IN of filter aggregate.
   4. All perforated pipe shall be wrapped in geotextile fabric.
      a. Perforated pipe should only be used in infiltration cell. All other pipe to be solid.
      b. Provide one cleanout port in each infiltration cell.
      c. Ensure that all outlets and inlets are unobstructed.

E. After completion of sub-drain installation, fill infiltration cells in 6 IN lifts. Lightly compact each lift.

F. Thoroughly water infiltration cell after soil placement and wait 24 hours MIN. Confirm finished grade. Add necessary soil, in 6 IN lifts MAX, as necessary to meet finished grade of entire cell.

G. Provide surveyed confirmation of finished grades of cell sub-grade and finished grade.

3.2 PREPARATION OF SIDE SLOPES AND RETENTION BASE

A. Rototill entire area of garden side slopes and perimeter berm edge to a depth of 6 IN.

B. Do not fertilize soil, as this can encourage weed growth.

C. Install protection mat on side slopes for erosion control.

D. Install ½ depth of mulch on bottom of retention basin.

3.3 PLANT PLACEMENT

A. Use planks to stand on while installing plants to minimize compaction by foot traffic.
   1. Install plants as shown on construction drawings and plant schedule.
   2. Keep roots moist at all times.
   3. Thoroughly water in after compacting backfill of planting holes.
   4. Apply final ½ depth of mulch.

3.4 MAINTENANCE

A. Provide maintenance to be performed by a nursery or land management professional on a monthly basis for the first growing season (1 year), to include repairs to eroded areas, replacement of dead or dying material, and weeding.

B. Complete the first annual inspection of the BMP in the fall with the Landscape Architect, Owner, and Maintenance Contractor.

C. Cut perennials and ornamental grass to a height of 3 IN to 6 IN in early spring.

END OF SECTION

SECTION 33 60 01
VALVES, PIPING, AND EQUIPMENT IN VALVE MANHOLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Valves, piping and equipment in valve manholes for underground site distribution systems for steam, condensate and chilled water.

B. Related Sections include but are not necessarily limited to the following:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Division 2 - Existing Conditions.
   4. Section 03 05 00 - Concrete.
   5. Section 20 05 00 - General Mechanical Requirements.
   6. Section 20 05 19 - Piping Specialties.
   7. Section 20 05 23 - Manual Valves.
   8. Section 20 11 00 - Pipe and Fittings.
   9. Section 23 21 13 - Hydronic Piping Systems.
   10. Section 23 22 00 - Steam Distribution Systems.
   11. Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems.
   12. Section 31 23 33 - Trenching, Backfilling and Compacting for Utilities.
   13. Section 33 61 13 - High Pressure Steam and Condensate Systems (30 to 150 PSIG).

1.2 SYSTEM DESCRIPTION

A. Provide vaults, underground anchor blocks and accessories including drainage, manhole covers, ladders, etc. for complete and functional underground structures as required to support underground chilled water, steam and condensate piping.

1.3 QUALITY ASSURANCE

A. See Section 20 05 00.

B. Referenced Standards:
   1. ASME International (ASME):
      a. B1.20.1, (1983; R 2006) Pipe Threads, General Purpose (Inch).
      b. B16.11, (2009) Forged Fittings, Socket-Welding and Threaded.
      c. B16.34, (2009) Valves - Flanged, Threaded and Welding End.
      d. B16.9, (2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings.
      e. B31.1, (2007; Addenda a 2008; Addenda b 2009) Power Piping.
      f. B40.100, (2005) Pressure Gauges and Gauge Attachments.
      g. BPVC SEC IX, (2010) BPVC Section IX-Welding and Brazing Qualifications.
   2. ASTM International (ASTM):
      a. A106, (2008) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
      b. A123, (2009) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      c. A234, (2010) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
      d. A53, (2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
      e. A733, (2003; R 2009e1) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples.

f. B209, (2007) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
g. C449, (2007) Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
h. C533, (2009) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
i. C547, (2007e1) Standard Specification for Mineral Fiber Pipe Insulation.
j. C552, (2007) Standard Specification for Cellular Glass Thermal Insulation.
k. E84, (2010) Standard Test Method for Surface Burning Characteristics of Building Materials.
l. F1139, (1988; R 2010) Steam Traps and Drains.

3. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):
   a. SP-110, (2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
   b. SP-25, (2008) Standard Marking System for Valves, Fittings, Flanges and Unions.
   c. SP-45, (2003; R 2008) Bypass and Drain Connections.
   d. SP-58, (2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation.
   e. SP-69, (2003) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard).
   f. SP-72, (2010) Ball Valves with Flanged or Butt-Welding Ends for General Service.
   g. SP-80, (2008) Bronze Gate, Globe, Angle and Check Valves.
   h. SP-83, (2006) Class 3000 Steel Pipe Unions Socket Welding and Threaded.
4. National Fire Protection Association (NFPA):
   a. 70, (2011) National Electrical Code.
5. The Society for Protective Coatings (SSPC):
   a. Paint 16, (2006) Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint.
   b. SP 10/NACE No. 2, (2007) Near-White Blast Cleaning.
6. Underwriters Laboratories (UL):
   a. 723, (2008) Test for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

A. Shop Drawings:
1. See Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data including:
   a. Component details.
   b. Location of miscellaneous fittings including anchors and seals.
   c. Piping and Fittings.
   d. Valves.
   e. Insulation.
   f. Sump Pumps and Drainers.
   g. Expansion Joints.
3. Detailed structural, piping and penetration drawings.
   a. Minimum scale 1/2 IN equal 1 FT.

B. Operation and Maintenance Manuals:
1. See Section 01 33 00 for requirements for:
   a. The mechanics and administration of the submittal process.
   b. The content of Operation and Maintenance Manuals.
2. Operation and Maintenance data including:
   a. Step-by-step procedures for equipment start-up, installation, operation and shutdown.
   b. Approved shop drawings.
   c. Routine maintenance procedures.
   d. Trouble shooting guide.
   e. Wiring and control diagrams.

C. LEED Information:
1. MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.

2. MR 5.1and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect all materials and equipment delivered and placed in storage from the weather, excessive humidity, and excessive temperature variation; dirt, dust, or other contaminants.

PART 2 - PRODUCTS

2.1 STANDARD PRODUCTS

A. Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2 NAMEPLATES

A. Each major item of equipment such as sump pump, motor, steam trap, and pressure reducing valve shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.3 ASBESTOS PROHIBITION

A. Asbestos and asbestos-containing products will not be allowed.

2.4 ELECTRICAL WORK

A. Motors, manual or automatic motor control equipment, and protective or signal devices required for the operation specified shall be provided under this section in accordance with NFPA 70 and Section 26 05 43.

2.5 PIPING AND FITTINGS

A. General Requirements:
   1. Piping, fittings and piping accessories inside the valve manholes shall conform to the requirements of ASME B31.1 and shall be suitable for the working pressure and temperature requirements of the system.
   2. To the greatest extent possible, the piping and fittings inside the valve manholes shall match the piping and fittings located on the outside of the valve manhole.
   3. All piping in valve manholes shall be steel with joints welded except that joints 3/4 IN and smaller may be threaded.
   4. No supports, anchors, or stays shall be attached to any piping system in places where either the installation of or the movement of the pipe and its contents will cause damage to the construction.

B. Steel Pipe:
   1. Pipe shall be black steel, seamless or electric-resistance welded, conforming to the requirements of ASTM A53, Grade B or ASTM A106, Grade B. Pipe shall be Schedule 40.
   2. Gauge piping , condensate piping and piping 3/4 IN DIA and smaller shall be Schedule 80.
   3. Nipples:
      a. Nipples shall conform to ASTM A733 as required to match adjacent piping.
   4. Pipe Threads:
      a. Pipe threads shall conform to ASME B1.20.1. Pipe threads may be used only on pipe 3/4 IN or smaller. All pipe which is to be threaded shall be Schedule 80.

C. Fittings:
   1. All fittings, valves, flanges and unions shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2. Welded Fittings:
   a. Welded fittings shall conform to ASTM A234, buttwelded or socket welded, as required to match connecting piping. Buttwelded fittings shall conform to ASME B16.9, and socket welded fittings shall conform to ASME B16.11.
3. Unions:
   a. Unions shall conform to MSS SP-83 as required to match adjacent piping.
4. Ball Valves:
   a. Ball valves shall conform to MSS SP-72 for flanged or buttwelded valves or MSS SP-110 for threaded ball valves.

2.6 VALVES

A. General:
   1. Unless otherwise specified, valves shall comply with the material, fabrication, and operating requirements of ASME B31.1.
   2. Valves shall be suitable for the temperature and pressure requirements of the system on which used.
      a. Valves for steam shall conform to ASME B31.1Class 300, as suitable for the application.
      b. Valves for condensate services shall conform to ASME B31.1 Class 150.
      c. Valves 3/4 IN and smaller may be bronze where seal welding is not required.
      d. Valves 6 IN and larger shall have a 1 IN minimum gate or globe bypass valve sized in conformance with MSS SP-45.

B. Steel Valves:
   1. Steel globe, gate, angle, and check valves shall conform to the requirements of ASME B16.34 and ASME B31.1 for the temperature and pressure requirements of the system.
   2. Gate valves 2-1/2 IN and smaller shall be rising stem.
   3. Gate valves 3 IN and larger shall be outside screw and yoke.

C. Bronze Valves:
   1. Globe, Gate, and Angle Valves:
      a. Bronze globe, gate, and angle valves shall conform to requirements of MSS SP-80, union bonnet type.
   2. Check Valves:
      a. Bronze check valves shall conform to the requirements of MSS SP-80.

D. Packing:
   1. Packing used with valves shall not contain asbestos.
   2. Valve stem packing shall be die-formed, ring type specifically designated as suitable for the temperature and pressure of the service and compatible with the fluid in the system.
   3. Packing shall be polytetrafluoroethylene with minimum 50 percent graphite filament.
   4. Valves 1-1/2 IN and smaller shall have four or five packing rings and valves 2 IN and larger shall have at least six packing rings.
   5. Spiral or continuous packing will not be acceptable.
   6. A metal insert shall be provided having proper clearance around the valve stem at the bottom of the stuffing box and acting as a base for the packing material.
   7. Packing glands shall be furnished with a liner of noncorrosive material and shall be of one piece construction with provisions for not less than two bolts for packing adjustment.

2.7 STEAM TRAPS

A. General:
   1. Class of trap bodies shall be suitable for a working pressure of not less than 1.5 times the steam supply pressure, but not less than 200 psi, and traps shall be capable of operation under a steam-supply pressure as indicated.
   2. Traps shall have capacities as shown when operating under the specified working conditions.
   3. Traps shall fail open.

B. Bucket Traps:

1. Bucket traps shall be inverted-bucket type with automatic air discharge and conform to ASTM F1139.

C. Thermostatic Traps:
1. Traps shall be thermostatic type; bimetallic element with automatic air discharge and conform to ASTM F1139.

2.8 STRAINERS

A. Strainers shall be basket or y-type with connections the same size as the pipe lines in which the connections are installed.

B. The strainer bodies for steam systems shall be heavy and durable, of cast steel, with bottoms drilled and plugged.

C. The strainers shall be suitable for the temperature and pressure requirements of the system on which they are installed.

D. The bodies shall have arrows clearly cast on the sides to indicate the direction of flow.

E. Each strainer shall be equipped with an easily removable cover and sediment basket.

F. The body or bottom opening shall be equipped with nipple and gate valve for blowdown.

G. The basket for steam systems shall be not less than 0.025 IN thick stainless steel, Monel or sheet brass, with small perforations of sufficient number to provide a net free area through the basket of at least 2.5 times that of the entering pipe.

H. The flow shall be into the basket and out through the perforations.

2.9 PRESSURE GAUGES

A. Gauges shall conform to ASME B40.100, and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Minimum dial size shall be 4-1/4 IN.

2.10 INSULATION AND JACKETING

A. 2General Provisions:
1. All piping, fittings, valves, etc., in the valve manholes shall be insulated. Insulation shall be premolded, precut or job fabricated to fit and shall be removable and reusable. Thickness of insulation shall be in accordance with Tables 1 and 2. Insulation jackets shall be provided for all pipe and fitting insulation.

B. Insulation:
1. Insulation for all piping, fittings, and valves shall be molded calcium silicate conforming to ASTM C533, Type I, or molded mineral fiber insulation conforming to ASTM C547, Class 2, or cellular glass insulation conforming to ASTM C552.
2. All insulation shall be asbestos free. Laminated construction shall not be used unless the thickness exceeds 4 IN.
3. Insulations and the manufacturers approved for use are:
   a. Delta, available from Rockwool in Leeds, Alabama.
   b. MPT-PC and MPT-PF, available from Mineral Products of Texas in Houston, TX.
   c. Thermo-12, Super Caltemp, available from Johns Manville in Denver, Colorado.
   d. Foamglass (cellular glass), available from Pittsburgh Corning Corporation.

C. Aluminum Jackets:
1. Aluminum jackets shall be smooth sheet, 0.016 IN nominal thickness and conform to the requirements of ASTM B209, Type 3003, 3105, or 5005.
2. Aluminum jackets for chilled water shall be supplied with a factory installed moisture barrier. This moisture barrier shall consist of at least 40 LB kraft paper coated on one side with a 1 mil thick polyethylene film. The moisture barrier shall be adhered to the aluminum jacket over the entire area of the aluminum jacket insulation-side surface.

D. Bands:
   1. Bands for aluminum jacket shall be 3/8 IN wide and 32 GA thickness made of aluminum or annealed stainless steel. Bands for insulation shall be 1/2 IN wide and 32 GA thickness made of annealed stainless steel.

E. Insulation for Flanges, Unions, Valves, and Fittings:
   1. Flanges, unions, valves, and fittings shall be insulated with premolded prefabricated, or field fabricated segments of insulation of the same material and thickness as the manhole pipe insulation.
   2. Insulation shall be removable and reusable and shall have essentially the same thermal characteristics and thickness as the adjoining piping.

F. Finishing Cement:
   1. Mineral fiber hydraulic-setting thermal insulating cement in accordance with ASTM C449.

G. Glass Tape:
   1. Glass tape shall meet the requirements of UL 723 and ASTM E84.

2.11 SUMP PUMPS AND DRAINERS

A. Sump Pumps:
   1. Sump pumps with the capacities indicated shall be installed in the valve manholes as shown.
   2. The sump pumps furnished shall be a manufacturer's standard commercial product.
   3. Sump pumps shall be electrically driven and submersible, capable of operating while completely submerged.
   4. The pumps and motors shall be capable of continuously pumping liquids at a temperature of 200 DegF.
   5. The pumps and motors shall be capable of running without damage when not submerged.
   6. Sump pumps shall have permanently lubricated bearings, monel shafts, bronze impellers, screened inlets and housings of bronze.
   7. Each sump pump shall be capable of passing a 3/8 IN sphere.
   8. The motors shall have the horsepower indicated and shall have overload protection.
   9. The discharge piping shall be schedule 80 or shall be protected from corrosion.
   10. The pumps shall be automatically controlled by a submersible switch assembly with pump wiring and switch suitable for submersion in 200 DegF liquids.
   11. Motors shall be 120 V, 60 Hz, single phase.
   12. All controllers, water level switches, and electrical connections shall be suitable for service at 100 percent humidity, at 200 DegF temperature, and occasional water submersion.
   13. Another switch shall be provided to indicate high water level, and shall be connected to an emergency warning light mounted on or adjacent to the valve manhole as indicated.
      a. This high water level alarm shall be set at a level which is below the bottom of any pipe in the valve manhole.
   14. Auxiliary contacts in a separate junction box shall be provided to permit connection to an Energy Monitoring and Control System (EMCS) for monitoring the operation of each pump motor and the high water level alarm system.

2.12 CONCRETE VALVE MANHOLES AND ACCESSORIES

A. Valve Manhole Construction:
   1. Valve manhole dimensions shall be as indicated.
   2. Valve manholes shall be drained as shown.
   3. Concrete sections shall not be less than 6 IN thick.
   4. When concrete covers are used for direct buried conduit systems, the top of the concrete cover shall be designed to be a minimum of 6 IN above the surrounding grade.
   5. Concrete cover shall be designed to support anticipated loadings.
   6. 4 x 4 FT aluminum access door (Bilco model JD-2AL or equal with slip resistant finish) shall be provided in the concrete top.
   7. For direct buried systems, two (2), 6 IN goosenecks shall be used.
      a. One shall extend below the top.

b. The other shall be similar but shall extend to within 2 FT of the manhole floor to provide natural air movement.

8. Valve manhole sides shall be constructed by one monolithic pour and shall extend not less than 6 IN above grade unless otherwise stated. Valve manholes shall be waterproofed in accordance with Division 3.
9. All steel components shall be protected from corrosion.

B. Ladders:
1. Valve manhole ladders shall be steel, shall have nonslip surfaces, and shall consist of uprights with steps or rungs.
2. Ladders shall not be less than 16 IN in width, with 3/4 IN DIA rungs, spaced 12 IN apart.
3. The two stringers shall be a minimum 3/8 IN thick and 2-1/2 IN wide.
4. Ladders shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 FT apart vertically, and installed to provide at least 6 IN of space between the wall and rungs.
5. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A123.

C. Pipe Sleeves:
1. Pipe sleeves of sufficient length to pass through valve manhole or building walls shall be provided.
2. Pipe sleeves shall be zinc-coated steel pipe, conforming to the requirement of ASTM A53, Schedule 40 or standard weight.
3. The pipe sleeves shall be secured in the proper position and location during construction of the valve manhole.
4. The space between the sleeve and the pipe casing, and the caulking and sealing materials shall be selected so there shall be NO electrical continuity between the pipe sleeve and the pipe casing when finished.
5. Pipe Sleeves for Conduit Penetrations:
   a. A modular mechanical type sealing assembly will be used between the valve manhole pipe sleeve and the conduit casing or uninsulated chilled water pipe.
   b. The mechanical seal shall consist of interlocking elastomeric links shaped to continuously fill the annular space between the casing or uninsulated chilled water pipe and sleeve.
   c. The link material shall be a synthetic elastomeric capable of withstanding long term exposure at 400 DegF without deterioration. The links shall be attached to each other with corrosion resistant steel bolts, nuts and pressure plates.
   d. The link, bolts, nuts and pressure plates shall be the product of single manufacturer and shall be furnished as the product of single manufacturer and shall be furnished as a package or kit.
   e. The links shall be loosely assembled with bolts to form a continuous rubber belt around the casing or uninsulated chilled water pipe with a pressure plate under each bolt head and each nut.
   f. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the casing or the uninsulated chilled water pipe and the sleeve.
   g. The pipe sleeve diameter shall be sized so that no more than one half of the seal assembly's expansion capability is used to achieve a water seal.

D. Pipe Supports:
1. Pipe Supports shall be in accordance with MSS SP-58 and MSS SP-69, type as shown. All pipe supports, including structural cross support members, shall be galvanized in accordance with Section 05 50 10. Chains, straps, or single point supports shall not be used.

2.13 MISCELLANEOUS METAL

A. Miscellaneous metal not otherwise specified, shall conform to Section 05 50 10.

B. Miscellaneous metal bolted together, shop welded, or assembled in the field, and pipe supports, including structural cross support members and anchors, shall be hot-dip galvanized in accordance with Section 05 50 10.

PART 3 - EXECUTION

3.1 EXAMINATION

A. After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 SITE WORK

A. Excavation, Trenching, and Backfilling:
   1. Excavation, trenching, and backfilling of the valve manholes shall be as shown and in accordance with Division 33.

B. Electric Work:
   1. Any wiring required for the operation of the equipment specified, but not shown on the electrical drawings, shall be provided under this section in accordance with Section 26 05 43.

C. Painting:
   1. The heat affected zone of field welded galvanized surfaces and other galvanized surfaces damaged during installation shall be cleaned in compliance with SSPC SP 10/NACE No. 2, and painted in accordance with Section 09 91 13.
   2. Steel and iron appurtenances, piping, and supports shall be cleaned in compliance with SSPC SP 10/NACE No. 2, and painted in accordance with SSPC Paint 16, coal-tar epoxy-polyamide.

3.3 PIPING

A. General:
   1. All piping in valve manholes shall be steel and insulated. Insulation shall be protected with an aluminum jacket, except for chilled water lines where indicated not to be insulated.
   2. Pipe shall be accurately cut to measurements established at the site and shall be worked into place without springing or forcing.
   3. Pipe and insulation shall clear all openings and equipment.
   4. Excessive cutting or other weakening of structural members to facilitate piping installation will not be permitted.
   5. Burrs shall be removed from ends of pipe by reaming. Installation shall permit free expansion and contraction without damage to joints or hangers.
   6. Piping shall be installed in accordance with ASME B31.1. Joints for piping in valve manholes shall be welded, except joints at traps, strainers, and at valves and piping 3/4 IN and smaller which may be threaded.
   7. Supports, anchors, or stays shall not be attached where either expansion or the weight of the pipe will cause damage to permanent construction.
   8. The method of attaching supports shall not interfere with the operation of the cathodic protection system.

B. Welded Joints:
   1. Joints between sections of pipe, between sections of pipe and valves, and between sections of pipe and fittings shall be welded except where joints are allowed to be screwed for pipe sizes 3/4 IN and smaller. The welding shall conform to the requirements specified in paragraph WELDING.

C. Threaded Joints:
   1. Threaded Joints:
      a. Threaded joints shall have graphite or inert filler and oil, graphite compound, or polytetrafluoroethylene tape applied to the male threads only.
      b. Unions shall be provided at all screwed valves, strainers and connections to equipment 3/4 IN and smaller.
      c. Dielectric unions shall be used at connections of dissimilar metals in 3/4 IN and smaller piping.

D. Reducing Fittings:
   1. Eccentric reducers in horizontal runs shall be installed with the straight side down. Changes in horizontal piping sizes shall be made through eccentric reducing fittings.

E. Branch Connections:
   1. Branches from mains shall branch off top of mains as indicated or as approved. Connections shall ensure unrestricted circulation, elimination of air pockets, and shall permit the complete drainage of the system. Branch connections may be made with either welding tees or forged branch outlet fittings.
   2. Branch outlet fittings where used shall be forged and shall be no larger than two nominal pipe sizes smaller than the main run. Branch outlet fittings shall be reinforced to withstand external strains and designed to withstand full pipe bursting strength.

F. Pipe Supports in Valve Manholes:
   1. Horizontal and vertical runs of pipe in valve manholes shall be securely supported.

3.4 WELDING

A. Piping shall be welded in accordance with qualified procedures, using performance qualified welders and welding operators.

B. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX.

C. The Contracting Officer shall be notified 24 HRS in advance of tests and the tests shall be performed at the work site.

D. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record.

3.5 INSULATION

A. The insulation shall be installed so that it will not be damaged by pipe expansion or contraction.

B. Insulation shall not become wet before, during, or after installation.

C. Insulation installed over welds shall be grooved to assure a snug fit.

D. Insulation shall be held in place with stainless steel straps.

E. A minimum of 2 bands shall be installed on each individual length of insulation and maximum spacing shall not exceed 18 IN centers.

F. Installation:
   1. Material shall be installed in accordance with published installation instructions of the manufacturer.
   2. Insulation materials shall not be applied until piping tests are completed.
   3. Prior to application, surfaces shall be thoroughly cleaned of moisture, grease, dirt, rust, and scale, and painted where required.

G. Insulation on Pipes Passing Through Sleeves:
   1. Insulation shall be continuous, as required by paragraph Pipe Sleeves Through Valve Manhole Cover. Aluminum jackets shall be provided over the insulation. When penetrating valve manhole walls, aluminum jacket shall extend not less than 2 IN beyond the sleeve on each side of the wall and shall be secured with an aluminum band on each side of the wall. Where flashing is provided, the jacket shall be secured with not less than one band located not more than 1 IN from the end of the jacket. When penetrating valve manhole tops, pipe shall be insulated as required for valve manhole service as indicated.

H. Covering of Insulation in Valve Manholes:
   1. The insulation for pipe, flanges, valves, and fittings shall be covered with aluminum jackets.

I. Insulation of Piping Accessories in Valve Manholes:
   1. Flanges, couplings, unions, valves, fittings, and other pipe accessories, unless otherwise shown or approved, shall be insulated with removable and reusable factory premolded, prefabricated, or field fabricated insulation.

2. For accessories in valve manholes, aluminum sheet shall be applied over the insulation. Where accessories are designated not to be insulated, the adjoining insulation and jacket shall terminate neatly.
3. The terminations for the chilled water systems shall provide a complete vapor seal.

J. Insulation Thickness:

TABLE 1
Minimum Pipe Insulation Thickness (IN)
For Steam (16 to 408 psig)

NOMINAL PIPE DIAMETER (IN)	MPT-PC MPT-PF	DELTA	THERMO-12 SUPER CALTEMP	FOAMGLASS
1.0	2.0	2.5	4.0	4.5
1.5	2.0	2.5	4.0	4.5
2.0	2.5	3.5	4.5	5.0
2.5	2.5	3.5	4.5	5.0
3.0	3.0	4.0	5.0	6.0
4.0	3.0	4.0	5.0	6.0
5.0	3.0	4.0	5.0	6.0
6.0	3.5	4.5	5.5	6.0
8.0	3.5	4.5	5.5	6.0
10.0	4.0	5.0	6.0	6.5
12.0	4.0	5.0	6.0	6.5

TABLE 2
Minimum Pipe Insulation Thickness (IN)
For Condensate Return

NOMINAL PIPE DIAMETER (IN)	MPT-PC MPT-PF	DELTA	THERMO-12 SUPER CALTEMP	FOAMGLASS
1.0	1.5	2.0	3.0	3.0
1.5	1.5	2.0	3.0	3.0
2.0	1.5	2.0	3.0	3.0
2.5	1.5	2.0	3.0	3.0
3.0	2.0	2.5	3.5	3.5
4.0	2.0	2.5	3.5	3.5
5.0	2.0	2.5	3.5	3.5
6.0	2.5	3.0	4.5	4.5
8.0	2.5	3.0	4.5	4.5

3.6 VALVE MANHOLES AND ACCESSORIES

A. Piping and Equipment in Valve Manholes:
1. Piping and equipment in valve manholes shall be installed to provide easy access without stepping on piping or equipment, and to provide sufficient working room.

2. Piping and equipment in valve manholes shall be installed and supported as shown on the drawings. All globe, angle and gate valves shall be installed with the stems horizontal or above.

B. Sump Pumps Installation:
   1. Sump pumps shall be installed as indicated. All electrical connections shall be hard wired.
   2. Electrical circuits to the sump pumps shall be dedicated circuits.
   3. All circuit breakers and switches in the electrical power distribution to the sump pumps shall be capable of being locked in the "ON" position and will be signed as follows:
      a. THIS CIRCUIT SUPPLIES POWER TO THE ELECTRIC SUMP PUMPS IN THE UNDERGROUND DISTRIBUTION SYSTEM. THIS CIRCUIT MUST BE "ON" AT ALL TIMES; OTHERWISE EXTENSIVE DAMAGE WILL OCCUR TO THE UNDERGROUND HEAT DISTRIBUTION SYSTEM AND PREMATURE FAILURE WILL OCCUR.
      b. The words on the sign shall be stamped on a corrosion resistant metal plate with letters 3/8 IN high, and the plate shall be affixed permanently near the switch or circuit breaker.

3.7 TESTS

A. Tests of piping in the valve manholes will be performed as part of the testing of the direct buried conduit system. These tests shall include the piping in the valve manhole and performed in accordance with the system supplier's Approved Brochure or the contract specifications.

END OF SECTION

SECTION 33 61 13

PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM (Revised AD-4)

PART 1 - GENERAL

1.1 DEFINITIONS

A. The following definitions shall apply to the work:
   1. Heat Distribution System:
      a. A complete pre-engineered, underground heat distribution and condensate return system including all required components such as steam pipe, condensate return pipe, and fittings, anchors, pipe supports, insulation, and protective casing, for the system supplied. The pre-engineered system does not include valve manholes and the piping and equipment inside the valve manholes; Section 33 60 01 shall be used for pertinent requirements. The pre-engineered system shall include all piping and components to a point at least 6 IN inside the building and valve manhole walls. The UHDS shall not use any part of the building or valve manhole structure as an anchor point.
   2. Direct-Buried:
      a. A system which is buried, without the need for a field-fabricated protective enclosure such as a concrete trench or tunnel.
   3. UHDS Types:
      a. Drainable-Dryable-Testable (DDT) Direct-Buried:
         1) A factory-fabricated system including an outer RFP jacket, polyurethane insulation, air and water-tight inner steel protective casing, air space and an insulated carrier pipe. Drains and vents are provided at the end plates of the system (in manholes or buildings). The drains are normally capped but the caps can be removed to drain water which may leak into the air space if there is a failure in the casing or the carrier pipe. The vents allow water vapor to escape and provide a tell-tale sign of leakage.

B. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

AD-4:
   1. Thermacor (DUO-THERM 505), Thermocor Processes, LP, Fort Worth, TX
   2. Perma Pipe (Multi-Therm 500), Midwesco, Inc., Niles, IL.

1.2 SYSTEM DESCRIPTION

A. Scope:
   1. The work includes the design and fabrication; furnishing; installing, and testing of a direct buried underground insulated steam pipe and insulated steel condensate return pipe, consisting of piping as indicated, together with fittings and appurtenances necessary for a complete and operable system. Gland type end seals will not be permitted.

B. UHDS Design:
   1. The UHDS manufacturer shall be responsible for the complete design of the UHDS, the product to be supplied, fabrication, witnessing installation and testing of the system within the design parameters established by the contract drawings and specifications, and in compliance with the detailed design.
   2. The complete design of the UHDS shall be sealed by a Professional Engineer in the employ of the UHDS manufacturer.

C. Operating Characteristics:
   1. The steam supply system shall have an operating temperature of 350 DegF and an operating pressure of 125 psig and condensate return system shall have an operating temperature of 280 DegF and an operating pressure of 50 psig.

D. Rated Characteristics:
   1. Furnish thermal expansion calculations for the supply and return piping using the following design characteristics and installation temperature. The system design conditions for steam and condensate shall be a temperature of 450 DegF and a pressure of 665 psig.
   2. For calculation purposes, the installation temperature shall not be higher than the ambient temperature at the site: 40 DegF.

1.3 SUMMARY

A. Section Includes:
   1. Steam and condensate piping for direct buried underground application and all accessories and appurtenances for a complete working system.

B. Related Sections include but are not necessarily limited to the following:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Division 2 - Existing Conditions.
   4. Section 03 05 00 - Concrete.
   5. Section 20 05 00 - General Mechanical Requirements.
   6. Section 20 05 19 - Piping Specialties.
   7. Section 20 05 23 - Manual Valves.
   8. Section 20 11 00 - Pipe and Fittings.
   9. Section 23 21 13 - Hydronic Piping Systems
   10. Section 23 22 00 - Steam Distribution Systems.
   11. Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems.
   12. Section 31 23 33 - Trenching, Backfilling and Compacting for Utilities.
   13. Section 33 60 01 - Valves, Piping and Equipment in Valve Manholes.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See 01 33 00 for requirements for the mechanics and administration of the submittal process.
   2. See Section 20 05 00.
   3. Product technical data including:
      a. Complete system layout and details:
         1) Indicating amount of expansion.
         2) Indicating provisions for system expansion.
         3) Supporting calculations.
      b. Anchorage.
      c. Component details.
      d. Location of miscellaneous fittings including anchors and seals.
      e. Gland seals.
      f. Field closures.
      g. Location of field joints.
   4. Detailed piping and penetration drawings.
      a. Minimum scale 1/2 IN equal 1 FT.
      b. Details to be specific and to include:
         1) Flexible joint details.
         2) Floor and foundation elevations.
         3) Final grades.
         4) Anchors.
         5) Sleeves.
         6) Seals.
         7) Crossovers and related items.
   5. Provide anchor block sizes.
   6. Provide copy of stress analysis for proposed system in accordance with ASME B31.1.
   7. Factory test report.

8. Field hydrostatic test report.

B. Work Plan.

C. Quality Assurance Plan.

D. TestReports:
   1. Thermal performance testing.
   2. Operational testing.

E. Certificates:
   1. Statement of qualifications.
   2. Resume.

F. Operation and Maintenance Manuals:
   1. See Section 01 33 00 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.
   2. Operation and Maintenance data including:
      a. Step-by-step procedures for equipment start-up, installation, operation and shutdown.
      b. Approved shop drawings.
      c. Routine maintenance procedures.
      d. Trouble shooting guide.
      e. Wiring and control diagrams.

G. LEED Information:
   1. MR 4.1 and 4.2, Recycled Content: Product data indicating percentages by weight of post-consumer and post-industrial recycled content for products having recycled content; include statement indicating costs for each product having recycled content.
   2. MR 5.1and 5.2, Regional Materials: For products and materials required to comply with requirements for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

1.5 QUALITY ASSURANCE

A. Manufacturer:
   1. The UHDS manufacturer is the company responsible for the design and manufacture of the pre-engineered system. The manufacturer shall submit certification of past experience as specified in the submittals paragraph; the certificate shall indicate the location, type of system, size of system, point of contact (POC) including phone number, for information verification. This certificate of satisfactory operation shall be an original signed by a principal officer of the UHDS manufacturer. The UHDS manufacturer directs the installation of the system and has a representative on the jobsite. The manufacturer shall submit a Work Plan indicating when various items of work and tests are to be carried out and when its representative will be present at job site. The manufacturer shall submit a list of characteristics indicating what defects or damage will necessitate replacement. The manufacturer shall submit a Quality Assurance Plan for fabrication, delivery, storage, installation and testing of the system. The manufacturer shall submit data sheets for all coatings and indicating thicknesses of insulation for carrier pipes.

B. Manufacturer's Representative:
   1. The UHDS manufacturer's representative shall be a person who regularly performs the duties specified, is certified in writing by the UHDS manufacturer to be technically qualified and experienced in the installation of the system, and shall be authorized by the manufacturer to make and sign the daily reports specified. The UHDS manufacturer's representative shall be under the direct employ and supervision of the UHDS manufacturer.

C. Testing Firm:

1. The Testing Firm must be able to certify that: weld examination methods and procedures, and the interpretation of radiographic films will be performed in accordance with ASME B31.1; the firm intends to utilize the proper film exposure, techniques, and penetrameter to produce density and geometric sharpness in sufficient clarity to determine presence of defects; and that all radiographic films will be reviewed and interpreted, and reading reports signed, by not less than a Certified American Society for Nondestructive Testing Level III Radiographer.

D. Contract Drawings:
   1. The contract drawings accompanying this specification provide information on:
      a. The size of carrier pipes, approximate length, and site location of the system.
      b. The routing and elevation of the piping along the route.
      c. Location and design of manholes.
      d. The obstacles that must be avoided along the path.
      e. Location of piping anchors (anchors will be no closer than 3 FT or further than 5 FT from entrance to manholes or buildings) at manholes and/or buildings. The UHDS manufacturer shall incorporate anchors as needed for the system.
      f. Operating pressure and temperature of system.

E. Referenced Standards:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. M300, (2003; R 2007) Standard Specification for Inorganic Zinc-Rich Primer.
   2. ASME International (ASME):
      a. B16.11, (2009) Forged Fittings, Socket-Welding and Threaded.
      b. B16.9, (2007) Standard for Factory-Made Wrought Steel Buttwelding Fittings.
      c. B31.1, (2007; Addenda a 2008; Addenda b 2009) Power Piping.
      d. B40.100, (2005) Pressure Gauges and Gauge Attachments.
   3. ASTM International (ASTM):
      a. A106, (2008) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
      b. A134, (1996; R 2005) Standard Specification for Pipe, Steel, Electric-Fusion (Arc)-Welded (Sizes NPS 16 and Over).
      c. A135, (2009) Standard Specification for Electric-Resistance-Welded Steel Pipe.
      d. A139, (2004; R 2010) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over).
      e. A167, (1999; R 2009) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
      f. A234, (2010) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
      g. A36, (2008) Standard Specification for Carbon Structural Steel.
      h. A53, (2007) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Equipment and material placed on the job shall remain in the custody of the Contractor until final acceptance whether or not the Contractor has been reimbursed for the equipment and material by the Government. The Contractor is solely responsible for the protection of the equipment and material against damage from any source while stored or during installation. Protect materials against damage from UV light, and entry of water and mud, by installing watertight protection on open ends at all times. Immediately replace sections of the casing or carrier piping found to have been subjected to full or partial submergence in water (which would allow the insulation to become wet). Materials awaiting installation shall be covered to protect from UV degradation.

1.7 1.7 SITE CONDITIONS

A. Classification of the site conditions for the UHDS shall be based on ASTM D 2487 and the following criteria: Severe.

PART 2 - PRODUCTS

2.1 STANDARD PRODUCTS

A. Provide for this project a designed system and equipment which is of current production and that essentially duplicate systems that have been in satisfactory use for at least 5 years prior to bid opening at 3 locations. Provide systems that have been operated under pressure, temperature and site characteristics which are equal to or more severe than the operating conditions in this specification and that have distributed the same medium.

2.2 FACTORY FABRICATED, DIRECT-BURIED DDT SYSTEMS

A. DDT Steam Carrier Pipes:
   1. Requirements shall be in accordance with paragraph HEAT DISTRIBUTION PIPING.

B. DDT Condensate Carrier Pipes:
   1. Carrier piping for condensate return systems shall be steel, Schedule 80. Pipe requirements shall be in accordance with paragraph HEAT DISTRIBUTION PIPING.
   2. Condensate carrier pipes shall not be located in conduit casings which contain steam pipes or any other piping.

C. DDT Carrier Pipe Insulation:
   1. Carrier pipe insulation shall conform to minimum thicknesses and type listed in Tables 1 and 2 as required for temperature specified under paragraph Rated Characteristics.

D. Insulation Banding and Scrim:
   1. Stainless steel bands and clips, at least 1/2 IN wide, conforming to ASTM A167 (304 stainless steel), at a maximum spacing of 18 IN shall be used over the scrim to secure the insulation onto the carrier pipe; a minimum of 2 bands shall be used for each 4 FT section of insulation.
   2. Scrim shall be vinyl-coated fiberglass with 18 x 16 mesh (number of filaments per 1 IN) and made of 0.013 IN DIA vinyl-coated fibrous glass yarn.

E. Inner Casing:
   1. Casing shall be smooth-wall steel, electric resistance spiral welded, conforming to ASTM A134, ASTM A135, or ASTM A139 and the values tabulated below.
   2. Eccentric connectors shall be provided between casing sections as needed to provide drainage of casing section between manholes and between manholes and buildings.

CASING DIAMETER (IN)	MINIMUM THICKNESS
6 - 26	10 GA
27 - 36	6 GA
37 - 42	4 GA

F. Casing End Plates, Vents, and Drains:
   1. End plates shall be made of ASTM A36, minimum thickness 0.375 IN.
   2. A 1 IN ASTM A53, Schedule 40, galvanized vent riser pipe shall be provided on end plate vent opening.
   3. Vent pipe shall extend to top of manhole and terminate directly below grated manhole cover with a 180 degree bend.
   4. A 1 IN drain shall be provided at the bottom and vent at the top.
   5. Brass plugs and half coupling, constructed with welded steel and welded to the end plate, shall be furnished; drains shall be plugged; vents shall not be plugged.
   6. End plates and anchors shall be designed and factory fabricated by the DDT manufacturer to prevent the ingress of moisture into the DDT System.

7. All subassemblies shall be designed to allow for complete draining, drying and pressure testing of the system.

G. Air Space:
1. Continuous 1 IN minimum air space shall be provided between carrier pipe insulation and casing.

H. Outer Jacketing Assembly:

AD-4:
1. Out jacketing assembly insulation shall be spray applied polyurethane foam, applied directly to the Inner Conduit, having a nominal 2 LB/FT^3 density and a K-Factor of 0.16 with a closed cell content of 90 - 95 percent for all straight lengths and fittings. Insulation thickness shall be 1 IN. The outer conduit shall be shall be extruded, black, high density polyethylene (HDPE), having a minimum wall thickness of 125 mils for jacket sizes equal to or less than 12", 150 mils for jacket sizes greater than 12" to 20", and 175 mils for jacket sizes greater than 20". The inner surface of the HDPE jacket shall be oxidized by means of corona treatment, flame treatment (patent pending), or other approved methods.

I. Coating of End Plates and Conduit Extending into Manholes:
1. End plates and conduit extending into manholes shall be coated with a zinc-rich coating conforming to AASHTO M300 Type IA, except that volatile organic compounds shall not exceed 2.8 LBS/GAL.
2. The zinc-rich coating shall be applied in accordance with the coating manufacturer's requirements including surface preparation.
3. No additional top coat shall be applied.

J. Carrier Pipe Guides:
1. Carrier pipe guides shall be spaced 10 FT on centers maximum, no more than 5 FT from pipe ends, with a minimum of 3 guides per elbow section.
2. Guides shall be designed to allow thermal expansion without damage, to provide proper pipe guiding, and to allow horizontal movement in 2 directions as required at expansion loops and bends.
3. Design of supports shall permit flow of water through the support.
4. Pipe insulation shall extend through the pipe guides and be protected by steel sleeves. Design of guides shall negate metal-to-metal contact between the casing and the carrier pipe.
5. Insulation or non-metallic material used to ensure no metal-to-metal contact shall not be compressed by the weight of the carrier pipe when full of water.

K. Anchor Plates:
1. Anchor plate shall be ASTM A36 steel, welded to carrier pipe and casing, 1/2 IN minimum thickness, with passages for air flow and water drainage thru the annular air space in the system.
2. Exterior surface of the anchor plate shall be coated with the same coating material as the casing.

L. Field Connection of Casing Sections:
1. Field connection of casing shall be made using a compatible steel section, welded to casing sections, coated on all surfaces with UHDS manufacturer's coating field repair compound, and covered with a 0.05 IN minimum thickness polyethylene shrink sleeve designed for a service temperature exceeding 176 DegF.

M. Manufacturer's Identification:
1. Embossed brass or stainless steel tag, hung by brass or stainless steel chain at each end of each conduit or insulated piping in the manholes and buildings, shall be provided.
2. The tag shall identify UHDS manufacturer's name, date of installation, Government contract number, and manufacturer's project number.

2.3 PIPE INSULATION TYPE AND MINIMUM THICKNESS

A. Materials containing asbestos will not be permitted. The minimum thickness of insulation for the heat distribution system shall be in accordance with Tables 1 and 2 in which the insulations listed have passed the 96 hour boiling water test.

TABLE 1
Minimum Pipe Insulation Thickness (IN)
For Steam Supply

NOMINAL PIPE DIAMETER (IN)	DELTA	THERMO-12 SUPER CALTEMP	MPT-PC MPT-PF
6.0	4.5	5.5	3.5
8.0	4.5	5.5	3.5
10.0	5.0	6.0	4.0
12.0	5.0	6.0	4.0

NOTE:
1) Delta is available from Rockwool in Leeds, Alabama.
2) MPT is available from Mineral Products of Texas in Houston, TX
3) Thermo-12 and Super Caltemp are available from Johns Manville in Denver, Colorado.

TABLE 2
Minimum Pipe Insulation Thickness (IN)
Condensate Return

NOMINAL PIPE DIAMETER (IN)	DELTA	THERMO-12 SUPER CALTEMP	MPT-PC MPT-PF
2.0	2.0	3.0	1.5
2.5	2.0	3.0	1.5
3.0	2.5	3.5	2.0
4.0	2.5	3.5	2.0
5.0	2.5	3.5	2.0
6.0	3.0	4.5	2.5
8.0	3.0	4.5	2.5

NOTE:
1) Delta is available from Rockwool in Leeds, Alabama.
2) MPT is available from Mineral Products of Texas in Houston, TX
3) Thermo-12 and Super Caltemp are available from Johns Manville in Denver, Colorado.

2.4 HEAT DISTRIBUTION PIPING

A. Steam Pipe:
1. Pipe material shall be steel; seamless ASTM A53, Grade B or ASTM A106, Grade B; or electric resistance welded ASTM A53, Grade B; Schedule 40.
2. Standard weight will be permitted for pipe sizes 12 IN and above.
3. ASTM A53, Type F furnace butt welded pipe will not be allowed.

4. Joints will not be allowed in factory fabricated straight section of carrier pipes.
5. Factory fabricated piping sections, as part of an expansion loop or bend, shall have all welded joints 100 percent radiographically inspected in accordance with ASME B31.1.
6. Radiographs shall be reviewed and interpreted by a Certified American Society for Nondestructive Testing (ASNT) Level III radiographer, employed by the testing firm, who shall sign the reading report.

B. Condensate Pipe:
1. Pipe shall be steel; seamless ASTM A53, Grade B or ASTM A106, Grade B, schedule 80; electric resistance welded ASTM A53, Grade B; Schedule 80.
2. ASTM A53, Type F furnace butt welded pipe will not be allowed. Joints will not be allowed in the factory fabricated straight section of the carrier pipe.
3. Factory fabricated piping sections, as part of an expansion loop or bend shall have all welded joints 100 percent radiographically inspected in accordance with ASME B31.1.
4. Radiographs shall be reviewed and interpreted by an ASNT Certified Level III radiographer, employed by the testing firm, who shall sign the reading report.
5. Joints:
   a. Joints shall be butt-weld except socket-weld joints will be permitted for pipe sizes 2 IN and smaller.
   b. Dye penetrant may be used in place of 100 percent radiographic inspection for pipe sizes 2 IN and below. Location and elevation of all field joints shall be indicated on detailed design layout drawings.
   c. Split-ring welding rings may be used.

C. Fittings:
1. Welds in factory fittings shall be radiographically inspected. Radiographs shall be reviewed and interpreted by a Certified ASNT Level III radiographer, employed by the testing firm, who shall sign the reading report.
2. The Contracting Officer may review all inspection records, and if any welds inspected are found unacceptable in accordance with ASME B31.1, the fitting shall be removed, replaced, and radiographically reexamined at no cost to the Government.
3. Butt-Welded:
   a. Fittings shall be steel; ASTM A234, Grade B or ASME B16.9, same schedule as adjoining pipe.
   b. Elbows shall be long radius unless otherwise indicated.
   c. Tees shall be full size or reducing as required, having interior surfaces smoothly contoured. Split-ring welding rings may be used.
4. Socket-Welded:
   a. Fittings shall be forged steel ASME B16.11; 2000 LB class shall be used for pipe sizes 2 IN and below.
   b. Dye penetrant inspection may be used in lieu of radiographic inspection of welded fittings for pipe sizes 2 IN and below.

2.5 EXPANSION LOOPS AND BENDS

A. Stresses shall be less than the maximum allowable stress from the Power Piping Code (ASME B31.1). Detailed design layout drawings and stress and anchor force calculations shall be provided for all loops and bends. Locations of all anchors, guides and supports shall be shown. The calculations shall be based on design characteristics (pressures and temperatures) specified for both the supply and return lines.

PART 3 - EXECUTION

3.1 PREPARATION

A. Job Conditions:
1. Phasing of demolition and construction shall be as shown on contract drawings.

B. Interruption of Existing Service:
   1. Arrange, phase and perform work and provide temporary facilities, materials, equipment, and connections to utilities, to ensure adequate heat distribution service for existing installations at all times. Only necessary interruptions required for making connections will be permitted, and only at times when approval is obtained from the Contracting Officer. Set all interruptions to be as approved by the Contracting Officer.

C. Grading:
   1. Unless otherwise shown on the contract drawings or the detailed design layout drawings, steam/condensate and high temperature hot water supply/return lines shall be graded uniformly downward not less than 5.0 IN in 100 FT to the lower point of entry between manholes and/or building entries.

D. Connecting to Existing Work:
   1. Connect new work to existing work in a neat and workmanlike manner. Make connections only in manholes. Where an existing structure must be cut or existing utilities interfere, such obstructions shall be bypassed, removed, replaced or relocated, restored and repaired. Any changes required to the UHDS design as a result of interferences or conflicts shall be approved by the UHDS designer and the Contracting Officer. Work disturbed or damaged shall be replaced to its prior condition.

E. Coordination:
   1. The location of all items of equipment and work of all trades shall be coordinated.
   2. Operability and maintainability of the equipment and systems shall be maintained.

F. Variations:
   1. Any variations from the approved, detailed design layout drawings shall be submitted to the Contracting Officer for approval. Variations shall be signed and sealed by the UHDS manufacturers' professional engineer responsible for the complete design of the UHDS.

3.2 PIPE, PIPING JOINTS AND FITTINGS

A. Joint Preparation:
   1. Pipe and fittings shall be cleaned inside and outside before and after assembly.
   2. Dirt, scale, and other foreign matter shall be removed from inside the piping by use of a pipe swab or pipe pig before connecting pipe sections, valves, equipment or fittings.
   3. Eccentric connectors shall be used as needed between casing sections to provide drainage of casing section between manholes and between manholes and buildings.

B. Direction Changes:
   1. Changes in direction shall be made with factory-built reinforced fittings. Field-fabricated fittings and miters will not be permitted.

3.3 WELDING

A. The Contractor will be responsible for welding quality and shall:
   1. Conduct tests of the welding procedures used in the work, determine the suitability of the procedures used, determine that the welds made will meet the required tests, and determine that the welding operators have the ability to make sound welds under standard conditions.
   2. Comply with ASME B31.1.
   3. Perform all welding operations required for construction and installation of the heat distribution system.

B. Qualification of Welders:
   1. Rules of procedure for qualification of all welders and general requirements for fusion welding shall conform with the applicable portions of ASME B31.1, and as outlined below.

C. Examining Welders:
   1. Examine each welder to determine the ability of the welder to meet the required qualifications. Welders shall be tested for welds in all positions, including welds with the axis horizontal (not rolled) and with the axis vertical.

2. Each welder shall:
   a. Weld only in positions in which they have qualified.
   b. Identify welds with the specific code marking signifying name and number assigned.

D. Examination Results;
   1. Furnish a list of welder's names and corresponding code markings. Welders which fail to meet the prescribed welding qualifications shall be retested.
   2. Welders who fail the second test shall be disqualified for work on this project.

E. Beveling:
   1. Field and shop bevels shall be done by mechanical means or by flame cutting.
   2. Where beveling is done by flame cutting, surfaces shall be thoroughly cleaned of scale and oxidation just prior to welding.

F. Alignment:
   1. Split welding rings shall be used for field joints on carrier pipes above 2 IN to assure proper alignment, complete weld penetration, and prevention of weld spatter reaching the interior of the pipe.
   2. Field joints 2 IN and smaller shall be made with welding sockets.

G. Erection:
   1. Piping shall not be split, bent, flattened, or otherwise damaged before, during, or after installation.

H. Defective Welds:
   1. Defective welds shall be replaced and reinspected in accordance with ASME B31.1.
   2. Repairing defective welds by adding weld material over the defect or by peening will not be permitted.
   3. Welders responsible for defective welds shall be tested for qualification.

I. Electrodes:
   1. Electrodes shall be stored in a dry, heated area, and shall be kept free of moisture and dampness during fabrication operations.
   2. Electrodes that have lost part of their coating shall not be used.

J. Radiographic Testing:
   1. An approved independent testing firm regularly engaged in radiographic testing shall perform radiographic examination of 100 percent of the field welds in the carrier piping of direct-buried systems in accordance with ASME B31.1. The following shall be furnished: a set of films showing each weld inspected, a reading report evaluating the quality of each weld, and a location plan showing the physical location where each weld is to be found in the completed project, prior to installing casing field joints, backfilling and hydrostatic testing.
   2. All radiographs shall be reviewed and interpreted by a Certified American Society for Nondestructive Testing Level III radiographer, employed by the testing firm, who shall sign the reading report. The Contracting Officer may review all inspection records, and if any welds inspected are found unacceptable they shall be removed, rewelded, and radiographically reexamined at no cost to the Government.

3.4 HEAT DISTRIBUTION SYSTEM INSTALLATION

A. The UHDS manufacturer's representative shall oversee the delivery, storage, installation and testing of the system. Work shall be in accordance with the requirements specified and with the printed instructions of the manufacturer. These specifications shall take precedence over the printed instructions if conflicts arise. Printed instructions shall be submitted to the Contracting Officer prior to system installation.

B. Verification of Final Elevations:
   1. For the PIPI system, prior to covering the top of the pipe with PIPI, measure and record the elevation of the top of each pipe at each field joint, 1/3 points along each pipe section, and the top of each elbow. For the PIPI system, elevations of the top of each pipe shall be measured and recorded. Elevations shall be taken at every completed field joint, 1/3 points along each pipe section and top of elbows. These measurements shall be checked against the contract drawings and shall confirm that the conduit system has been installed to the elevations shown on the contract drawings. Slope shall be uniform to within 0.1 percent. These measurements shall be recorded by the Contractor, included in the UHDS manufacturer's representative daily report, and given to the Contracting Officer prior to covering the casing with backfill material.

C. Excavation, Trenching, and Backfilling:
   1. Pipe shall lay on a 12 IN minimum sand bed and shall be backfilled with sand on all sides to a minimum of 6 IN as measured from outside of casing. This sand bedding requirement does not apply to the PIPI system. Foundation for system shall be firm and stable. Foundation and backfill shall be free from rocks or substances which could damage the system coating. Concrete anchor and thrust blocks shall be installed in undisturbed earth. Backfilling shall not commence until system has been satisfactorily pressure tested (both hydrostatic test of carrier and air test of casing). Minimum depth of burial to the top of the casing shall be 39 IN. Maximum depth of burial to the top of the casing shall be 10 FT.

D. UHDS Manufacturer's Representative Responsibilities:
   1. The UHDS Manufacturer's representative shall be present at the job site and witness when the following types of work are being performed:
      a. Inspection and unloading.
      b. Inspection of trench prior to commencing installation of system.
      c. Inspection of concrete anchors and thrust blocks.
      d. Pneumatic and Hydrostatic testing.
      e. Field joint closure work.
      f. Air test of casing.
      g. Holiday test of conduit coating.
      h. Repair of any coating.
      i. Installation of cathodic protection system.
      j. Initial backfill up to 10 IN above the top of the casing.
      k. Verification of final elevations. Elevation readings shall be witnessed and recorded.
      l. Testing of cathodic protection system.
      m. Operational tests.
   2. The UHDS manufacturer's representative shall notify the Contractor immediately of any problems. The UHDS manufacturer's representative shall notify the Contracting Officer of problems requiring immediate action; otherwise, the daily reports shall note any problems encountered and indicate the corrective actions taken.

E. UHDS Manufacturer's Representative Reports:
   1. The UHDS manufacturer's representative shall: prepare and sign a written daily report; present the original daily report to the Contracting Officer no later than one working day after it is prepared; and forward 1 copy to the manufacturer's main office.
   2. The report shall state whether or not the condition and quality of the materials used and the delivery, storage, installation and testing of the system are in accordance with the drawings, specifications, and manufacturer's printed instructions and are satisfactory in all respects.
   3. When any work connected with the installation is unsatisfactory, the report shall state what corrective action has been taken or shall contain the UHDS manufacturer's recommendations for corrective action.
   4. The report shall identify any condition that could result in an unsatisfactory installation, including such items as open conduit ends left in the trench overnight and improper manhole entries.

5. The daily reports shall be reviewed, signed and sealed, on a weekly basis, by the registered engineer responsible for the system design. Signed and sealed copies of the daily reports shall be submitted with the payment request.
6. Requests for payment will be denied if the weekly review is not accomplished.
7. Upon completion of the work and before final acceptance, a notarized Certificate of Compliance, signed by a principal officer of both the manufacturing and the contracting firms, stating that the installation is satisfactory and in accordance with drawings, specifications, and manufacturer's instructions shall be delivered to the Contracting Officer.
8. The UHDS manufacturer shall retain a copy of all daily reports and the Certificate of Compliance for 5 years after final acceptance of the system by the Government.

F. Protection:
1. Casing coating shall be protected from damage during unloading, storage, rigging and installation. Casing and carrier pipe ends shall be protected from water intrusion during unloading, storage, rigging and installation. Piping and accessories shall be protected from damage due to exposure to UV light.

G. Defective Material:
1. The UHDS manufacturer's representative shall take prompt action to remove from the site all damaged or defective material, subject to rejection in accordance with the quality assurance provisions included in the manufacturer's submittals and printed instructions, and shall order prompt replacement of such material.

3.5 TESTS

A. General:
1. Leak-tightness of all piping systems shall be demonstrated by performing pressure tests (hydrostatic, pneumatic) and operational tests. Heat distribution system shall be pressure tested in conformance with specified requirements and printed instructions for the system supplied; tests shall include carrier piping and casing.
2. The carrier pipe shall be hydrostatically tested.
3. Casings of DDT systems shall be pneumatically tested.
4. Mercury shall not be used in thermometers required for the tests.

B. Pneumatic, Hydrostatic and Operational Tests:
1. Before conducting heat distribution system tests, lines shall be flushed with high pressure water until discharge shows no foreign matter.
2. Pneumatic Test:

a. The casing of DDT systems shall be pneumatically tested after welding and before field coating using air as the test medium. The test pressure shall be 5 psig. Persons not working on the test operations shall be kept out of the testing area while testing is proceeding. The test shall be made on the system as a whole or on sections that can be isolated. Joints in sections shall be tested prior to backfilling when trenches must be backfilled before the completion of other pipeline sections. The test shall continue for 24 HRS from the time of the initial readings to the final readings of pressure and temperature. The initial test readings of the instrument shall not be made for at least 1 hour after the casing has been subjected to the full test pressure, and neither the initial nor final readings shall be made at times of rapid changes in atmospheric conditions. There shall be no indication of reduction of pressure during the test after corrections have been made for changes in atmospheric conditions in conformity with the relationship T(1)P(2) = T(2)P(1), in which T and P denote absolute temperature and pressure, respectively, and the numbers denote initial (1) and final (2) readings. Pressure shall be measured with a pressure gauge conforming to ASME B40.100. A throttling type needle valve or a pulsation dampener and shutoff valve may be included. The diameter of the face shall be at least 4.5 IN with a measurable range of 0 to 15 psig and graduations of at least 0.5 psig. During the test, the entire system shall be completely isolated from all compressors and other sources of air pressure. Each joint shall be tested while under test pressure by means of soap and water or an equivalent nonflammable solution prior to backfilling or concealing any work. All labor, materials and equipment for conducting the tests shall be furnished by the Contractor and shall be subject to inspection at all times during the tests. Maintain proper safety precautions for air pressure testing at all times during the tests.

3. Hydrostatic Test:
   a. Carrier piping shall be tested hydrostatically before insulation is applied at field joints and shall be proved tight at a pressure 1.5 times the heat distribution supply pressure of 125 psig for 2 HRS. There shall be no indication of reduction of pressure during the test. Pressure shall be measured with a device calibrated to be read in increments not greater than 0.1 psi.
4. Operational Test:
   a. Prior to acceptance of the installation, subject system to operating tests simulating actual operating conditions to demonstrate satisfactory functional and operating efficiency. These operating tests shall cover a period of not less than 6 HRS for each portion of system tested. Submit for approval a schedule of the tests to be performed. Provide calibrated instruments, equipment, facilities and labor, at no additional cost to the Government. When failures occur, problems shall be repaired and test repeated.

C. Deficiencies:
   1. Deficiencies discovered shall be corrected at the Contractor's expense. Major deficiencies, or failure to correct deficiencies, may be considered cause for rejecting the entire installation.

3.6 VALVE MANHOLES

A. Valve manholes, piping, and equipment in valve manholes shall be in accordance with the contract drawings and Section 33 60 01.

3.7 BURIED UTILITY WARNING AND IDENTIFICATION

A. Plastic Marking Tape:
   1. Polyethylene plastic tape manufactured specifically for warning and identifying buried utility lines shall be supplied and installed.
   2. Tape shall be buried above the pipe during the trench backfilling operation and shall be buried approximately 12 IN below grade.
   3. Tape shall be polyethylene with a metallic core.
   4. The tape shall be manufactured with integral wires, foil backing or other means to enable detection by a metal detector when the tape is buried up to 3 FT deep.
   5. The metallic core of the tape shall be encased in a protective jacket or provided with other means to protect it from corrosion.

6. The tape shall be of a type specifically manufactured for marking and locating metallic underground utilities.
7. Tape shall be 6 IN wide and printed with a caution and identification of the piping system over the entire tape length. Tape shall be yellow with bold black letters.
8. Tape color and lettering shall be unaffected by moisture and other substances contained in the backfill material.

B. Markers for Underground Piping:
1. Markers for underground piping shall be located along the distribution and service lines.
2. Markers shall be placed as indicated approximately 2 FT to the right of the distribution system when facing in direction of flow in the supply line. The marker shall be concrete 6 IN square or round section 2 FT long.
3. The top edge of the marker shall have a minimum 1/2 IN chamfer all around. The letters STEAM and CONDENSATE shall be impressed or cast on the top, and on one side of the markers to indicate the type of system that is being identified.
4. Each letter shall be formed with a V-shaped groove and shall have a width of stroke at least 1/4 IN at the top and depth of 1/4 IN.
5. The top of the marker shall protrude not more than 1 IN above finished grade.

END OF SECTION