

2.9 DOMESTIC WATER PIPING, WITHIN BUILDING, BURIED

- A. Copper Tubing: ASTM B88, Type K, soft annealed.
 - 1. No joints allowed buried, run tubing continuous.
 - 2. Provide AWWA C209 cold-applied, integrated primer type, elastomeric adhesive, laminate polymeric tape coating, minimum 35 mil nominal thickness, in accordance with manufacturer's installation guidelines, for all piping buried or in contact with concrete, to a minimum of 6" above finished floor. Chase Construction Products Tapecoat H35 or approved equivalent.
 - 3. Applies to installations including services to island sinks and trap primer lines.
 - 4. Also provide protection from concrete for copper piping at penetrations through elevated decks.

2.10 DOMESTIC WATER PIPING, WITHIN BUILDING, NOT BURIED

- A. Copper Tubing: ASTM B88, Type L, hard drawn.
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22 wrought copper alloy solder joint pressure fittings.
 - 2. Joints between copper pipe and fittings shall be made in accordance with ASTM B828 using ASTM B32 Alloy HB lead-free solder.
 - 3. Fittings and joints for pipe sizes 1/2" through 4" may be mechanical press-connect system joints with ASME B16.51 lead-free copper bodied fittings with integral ethylene-propylene diene monomer rubber (EPDM) sealing gaskets. All fittings, couplings, and adapters shall be the product of a single system manufacturer and only that manufacturer's approved press tools, kits, and jaws shall be used.
 - a. EPDM o-rings shall be pre-installed and lubricated with NSF 61 listed lubricant.
 - b. All installers of copper press-connect fittings shall be trained by the fitting manufacturer's appointed representative and carry such credentials for the duration of the project.
 - c. The fitting manufacturer's representative shall conduct periodic inspections of the installation and shall provide written reports of such inspections to the Contractor and Engineer, including any observed deviations from the manufacturer's recommended installation practices.
 - d. Acceptable system manufacturers: Viega Pro-Press only.
 - 4. Rolled groove type fittings and joints shall be acceptable for copper pipe sizes 2-1/2 inch and larger, with all tools, couplings, adapters, fittings, and gaskets the product of a single system manufacturer.
 - a. Fittings shall be cast bronze using lead-free alloys per ASTM B584 or copper wrought copper constructed to ASTM B75/B75M, compliant with NSF 61 for potable water service applications, and meet ASTM F1548.
 - b. Couplings shall be epoxy/enamel (rust-inhibiting) coated ductile iron housings conforming to ASTM A536.
 - c. Gaskets shall be EPDM for potable water, meeting ASTM F1476, and NSF 61 / NSF 372 certified for potable water service from 30 degrees to 180 degrees F.
 - d. Acceptable system manufacturers: Victaulic, Shurjoint, Anvil Gruvlok.
- B. CPVC Pipe: ASTM D1784 minimum cell classification 23447 for chlorinated polyvinyl chloride compounds, NSF 61 schedule 80 system, the product of a single manufacturer per ASTM F441/F441M.
 - 1. Fittings: ASTM F439 schedule 80 CPVC.
 - 2. Joints: solvent cement in accordance with manufacturer's recommendations using ASTM F493 cement, in conjunction with ASTM F656 primer when recommended or when required by code.

3. Compliance: Pipe material shall be tested to ASTM E84 and listed as having flame spread/smoke developed values not to exceed 25/50 and be approved by the local AHJ as acceptable for use in return air plenums.
 4. Acceptable system manufacturers:
 - a. Spears Manufacturing Company EverTUFF
 - b. Georg Fischer Harvel, LLC
 5. Where CPVC is specified for use in conjunction with copper piping, transitions to copper branch lines shall be provided as follows:
 - a. A schedule 80 CPVC threaded bushing shall be provided at the CPVC fitting where the branch line/transition begins.
 - b. A type L copper or brass threaded nipple shall be joined to the starting end of the copper branch line.
 - c. The metallic threaded nipple shall be completely joined to the CPVC bushing.
 - d. This shall apply to both vertical to horizontal and horizontal to horizontal transitions.
- C. Stainless Steel Pipe: ASTM A312/A312M, schedule 10S, welded or seamless pipe, Type 304/L.
1. Fittings: ASTM A403/A403M, wrought stainless steel butt-welding fittings of same Type and wall thickness as piping. Manufactured to the dimensional requirements of ASME B16.9. Chemical composition of the filler metal shall comply with AWS A5.9/A5.9M based on the alloy content of the piping.
 2. Alternatively, rolled grooving with grooved NSF approved stainless steel fittings of the same Type and wall thickness as the piping, complete with the couplings and gaskets of a single approved system manufacturer may be provided throughout.
 - a. Such mechanical joints shall comply with ASTM F1476 and ASTM F1548.
 - b. Acceptable system manufacturers: Victaulic, Anvil Gruvlok, Shurjoint.
 3. Joints between pipe and fittings and transition joints to other materials shall be made in accordance with the manufacturer's installation instructions and using fittings, etc. designed for the specific transition.
 4. All pipe, fittings, and installation shall be compliant with NFPA 20, NSF 372, and shall be in accordance with the requirements of NSF 61.

2.11 ADAPTERS, TRANSITIONS, UNIONS, COUPLINGS, FLANGES, CONNECTORS

- A. (Non-Acid Waste) Drainage Applications:
1. Provide approved listed adapter and transition fittings appropriate to the specific pipe transition and in accordance with code requirements.
 2. **Not buried:** For dissimilar piping not buried, provide stainless steel shielded, molded elastomeric couplings and adapters meeting ASTM C564 and ASTM C1460. Applies to installations including cast iron to PVC transitions immediately adjacent to the building floor where piping below is buried.
 - a. Husky 4200 or Cremco
 - b. Fernco Proflex
 3. **Buried, but NOT below building slab:** For dissimilar buried piping beyond the limits of building or readily accessible buried piping transitions in backwater valve pits, etc. Provide shear resistant .012" thick 300 series stainless steel shielded, **PVC gasketed** flexible couplings and adapters meeting ASTM D5926 and ASTM C1173. For direct-bury applications, provide AWWA C209 cold-applied, integrated primer type, elastomeric adhesive, laminate polymeric tape coating, minimum 35 mil nominal thickness, in accordance with manufacturer's installation guidelines, to completely wrap the shield, banding, and screws. Chase Construction Products Tapecoat H35 or approved equivalent.

- a. Cremco
 - b. Mission Rubber Company, LLC
 - c. Fernco, Inc. Strong Back RC 1000 Series
- 4. Adapters, couplings, bushings for copper DWV pipe shall be cast bronze or wrought copper, ASME B16.23 / ASME B16.29.
- B. Domestic Water Applications:
 - 1. Provide joints between various materials with approved adapter and transition fittings appropriate to the specific pipe transition and in accordance with code requirements and the manufacturer's instructions.
 - 2. For copper tube and pipe: adapters, bushings, plugs, caps, and couplings shall be wrought copper or cast bronze; flanges (minimum class 150) and unions shall be cast bronze. Provide with solder or threaded connections as necessary and as produced to applicable standards ASME B16.15, ASME B16.18, ASME B16.22, ASME B16.24, ASME B16.50 ASME B16.50, ASME B1.20.1. All such appurtenances shall be for use in above ground potable water systems.
 - 3. Buried to not buried transitions for water service entries:
 - a. 100% fusion bonded epoxy coated ASTM A536 cast ductile iron construction coupling with acrylonitrile butadiene rubber (NBR) gaskets and EPDM insulating boot for water service. 5/8 inch high strength stainless steel bolts and nuts. Coupling shall meet AWWA C219. Romac Industries, Inc. IC501 or pre-approved equivalent.
 - b. 100% fusion bonded 14 mil epoxy coated coupling with ASTM A536 cast ductile iron rings. Complete with acrylonitrile butadiene rubber (NBR) gaskets and type 304 stainless steel bridge, spacers, nuts, and bolts. Coupling shall meet AWWA C219, NSF 61, and NSF 372. Krausz USA Hymax Grip Coupling Restraint or pre-approved equivalent.
 - 4. Dielectric connections:
 - a. For pipe sizes 2 inch and smaller, provide lead-free dielectric unions, rated to 180 F at 250 psi and compliant to ASSE 1079.
 - b. For pipe sizes larger than 2 inches, provide lead-free dielectric flanged pipe fittings, rated to 180 F at 175 psi and meeting ASME B16.1.
 - c. For grooved copper joining systems, provide grooved end dielectric transition fitting from system manufacturer, with virgin polypropylene internal lining, meeting NSF 61.
- C. General:
 - 1. Unions for ferrous pipe shall be ASME B16.39 galvanized malleable iron, threaded, minimum pressure class 150.
 - 2. Plugs and bushings for ferrous pipe shall be ASME B16.14 galvanized malleable iron, threaded.
 - 3. Nipples for ferrous pipe shall be schedule 40, galvanized, ASTM A53/A53M welded steel pipe nipples, threaded, meeting ASTM A733.
 - 4. Couplings for ferrous pipe shall be galvanized steel, threaded, manufactured in accordance with ASTM A865/A865M.
 - 5. Flanges for ferrous pipe shall be galvanized forged steel construction, either socket weld or slip-on weld type, minimum pressure class 150, manufactured to ASME B16.5.
 - 6. Bolts, nuts, and gaskets for flanged connections shall be appropriate to the pipe material, fluid type, temperature, and pressure. 1/16" thick pre-formed neoprene, typical.

7. Provide flexible stainless steel connectors at pumps and other such equipment, in accordance with manufacturer's recommendations. Connectors shall have corrugated hose and braided 300 series stainless steel jacketing. Carbon steel flanged or grooved ends as appropriate. NSF 372 lead-free for all potable water applications. Metraflex Company or pre-approved equivalent.

2.12 GATE VALVES (IRON)

- A. ASTM A126 cast iron bodied, class 125 gate valve with bolted bonnet, non-rising ASTM B16/B16M brass stem and packing gland, solid wedge, cast iron hand-wheel. Bronze wedge for sizes up through 6" and cast iron wedge with bronze bushing and wedge face rings for sizes 8" and larger.
- B. Basis of design:
 1. NIBCO T-619 (threaded) for sizes 2" through 4".
 2. NIBCO F-619 (flanged) for sizes 6" and larger.
- C. Acceptable alternate manufacturers:
 1. Apollo
 2. Milwaukee
- D. Applies only to limited installations such as services from submersible pumps and ejectors. Not to be used for domestic water systems.

2.13 GATE VALVES (DUCTILE IRON)

- A. Fusion bonded epoxy coated ASTM A536 ductile iron bodied, class 125 gate valve with bolted bonnet, non-rising Type 304 stainless steel stem, resilient wedge. End connections as suited for adjacent piping. Provide with square operating nut for extended handle operation or with hand-wheel as appropriate for depth of burial and access. Certified lead-free to NSF 61 / NSF 372 and AWWA C509 & AWWA C515 compliant (3" and larger).
- B. Basis of design:
 1. NIBCO 619 series for sizes 2" through 12".
- C. Applies to outdoor, buried domestic water main installations beyond 5 feet from the building edge. Not to be used inside of buildings.

2.14 BALL VALVES

- A. All bronze cast construction two-piece 600 psi body, blow-out proof stem, Teflon seated, lead-free, with stainless steel trim (including ball, stem, and valve handle). Threaded connections. Certified lead-free to NSF 61 / NSF 372 and suited to 180 degrees F.
- B. Basis of design (bronze valves):
 1. NIBCO T-585-66-LF (full port) for all sizes up through 2".
 2. NIBCO T-580-66-LF (conventional port) for sizes 2-1/2" and 3".
- C. Valves 4" and larger shall be split body stainless steel construction, 275 psi cold working pressure, blow-out proof stem, PTFE seated, type 316 stainless steel trimmed, class 150, full port design with manual gear operator. NIBCO F-515-S6-F-66-FS.
- D. Acceptable alternate manufacturers:
 1. Apollo 77 CLF-A series (full port) for all sizes up through 2".
 2. Milwaukee UPBA-400S (full port) for all sizes up through 2".
 3. Apollo 77 CLF-A series (full port) for size 2-1/2" and Apollo 70LF-140 series (standard port) for 3".
 4. Milwaukee UPBA-100S (standard port) for sizes 2-1/2" and 3".
- E. Applies to domestic water system installations.

- F. Provide valves complete with extended lever handles as required to accommodate insulation and full valve operation.
- G. Provide valves complete with memory stop kit where used for balancing applications.

2.15 BUTTERFLY VALVES

- A. ASTM A536 ductile iron bodied, (minimum) 200 psi lug type wafer style butterfly valve with ASTM A564 Type 316 series stainless steel stem, ASTM A743 stainless steel disc, and EPDM rubber seat/lining. Extended neck. Certified lead-free to NSF 61/NSF 372 and suited to 180 degrees F.
- B. Basis of design:
 - 1. NIBCO LD-2000-3 (lever handle operated) for sizes 2-1/2" through 4".
 - 2. NIBCO LD-2000-5 (manual gear operated) for sizes 6" and larger.
 - 3. Install between standard ASME (minimum) class 125 flanges in accordance with manufacturer's recommendations.
- C. Acceptable alternate manufacturers:
 - 1. Apollo
 - 2. Milwaukee ML234E (lever handle operated) and ML334E (manual gear operated).
- D. Applies to domestic water system installations.

2.16 BUTTERFLY VALVES (GROOVED)

- A. Grooved end, lead-free, copper alloy bodied, 300 psi butterfly valve with EPDM encapsulated ductile iron or aluminum bronze disc, EPDM seat/seal, stainless steel stem and trim, and extended neck. ANSI/NSF 61 certified for potable water systems. Lever handle operated for sizes 2-1/2" through 4" and manual gear operated with handwheel for sizes 6" and larger.
- B. Acceptable manufacturers:
 - 1. Victaulic 608N (cast brass body with aluminum bronze construction disc).
 - 2. Shurjoint SJ-C300 (ASTM B584 bronze bodied).
 - 3. Anvil Gruvlok Series 6700 CTS (ASTM B584 bronze bodied).
- C. Applies only to domestic water system installations employing grooved copper joining systems, as specified elsewhere in this section. Manufacturers shall only be acceptable where their grooved systems are provided.

2.17 CHECK VALVES (BRONZE)

- A. ASTM B62 / ASTM B584 bronze body and disc, minimum 200 psi (cold working pressure) Y-pattern horizontal swing type check valve with removable bronze bonnet, Type 300 series stainless steel nuts and hinge pin, and PTFE disc seat. Threaded connections. Certified lead-free to NSF 61 / NSF 372 and suited to 180 degrees F.
- B. ASTM A126 cast iron bodied, (minimum) class 125 globe style spring loaded (silent) check valve with ASTM B584 bronze disc and seat. Flanged connections. Certified lead-free to NSF 61 / NSF 372 and suited to 200 degrees F.
- C. Basis of design:
 - 1. NIBCO T-413-Y-LF (Y-pattern swing type) for sizes up through 2".
 - 2. NIBCO F-910-B-LF (globe style spring loaded type) for sizes 2-1/2" and larger.
- D. Acceptable alternate manufacturers:
 - 1. Apollo (for sizes up through 2")
- E. Applies to domestic water system installations including associated pump discharge lines. Valves shall be suited for installation in both horizontal lines and vertical lines with upward flow, in accordance with manufacturer's recommendations.

2.18 CHECK VALVES (IRON)

- A. ASTM A126 cast iron bodied, (minimum) class 125 conventional horizontal swing type check valve with bronze, cast or ductile iron disc. 200 psi cold working pressure. Threaded or flanged connections.
- B. Basis of design:
 - 1. NIBCO T-918-B (threaded connections) for sizes 2" through 4".
 - 2. NIBCO F-918-B (flanged connections) for sizes 6" and larger.
- C. Acceptable alternate manufacturers:
 - 1. Apollo (flanged in all sizes)
 - 2. Milwaukee F-2974A (flanged in all sizes)
- D. Applies only to limited installations such as services from submersible pumps and ejectors. Not to be used for domestic water systems.

2.19 PRESSURE REGULATING VALVES (PRV'S)

- A. ASTM B62 / ASTM B584 bronze bodied direct acting, ASSE 1003 single diaphragm type pressure regulating valve with removable bronze bonnet, in-line stainless steel strainer and spring, and FDA approved EPDM seat disc and Buna-N diaphragm. Threaded connections. Certified lead-free to NSF 61 / NSF 372 and suited to 180 degrees F.
- B. NSF 61 epoxy coated ductile iron bodied pilot-operated globe style pressure regulating valve assembly. Complete with low-flow bypass and stainless steel, bronze, and copper trim and fittings. NSF 61 EPDM seat disc and diaphragm. Threaded or flanged connections. Suited to 180 degrees F.
- C. Basis of design:
 - 1. Apollo PRH-LF (36HLF series) for direct acting valves, sizes up through 3". Provide with y-strainer. Provide threaded up through 2" and flanged for larger sizes.
 - 2. Apollo A127-LF series for pilot operated valves, sizes 1-1/4" through 4".
- D. Acceptable alternate manufacturers:
 - 1. Cla-Val
 - 2. Victaulic (pilot-operated valves)
 - 3. MGI Controls (direct acting valves)
- E. PRV's shall automatically reduce inlet pressure to a steady lower downstream pressure, regardless of changing flow rate. Provide complete with inlet strainer, inlet and outlet pressure gauges, isolation valves, and unions. Provide bypass line around assembly with normally closed valve.
- F. Point of use PRV's serving individual equipment items shall not be required to have a bypass.

2.20 BALANCING VALVES

- A. Self-contained, fully automatic thermally actuated balancing valve shall continuously adjust flow to maintain the desired domestic hot water temperature within the branch line, regardless of system operating pressure. Valve shall modulate between open and closed position within a 10 degrees F range. The valve set-point (closing temperature) shall be the hot water system supply temperature. Valve body and all internal components shall be constructed of stainless steel with major components constructed of Type 303 stainless. Rated for 200 psi maximum working pressure and no less than 250 degrees F maximum working temperature. Lead-free NSF 372 and NSF 61 compliant. Threaded connections.
- B. Basis of design:
 - 1. ThermOmegaTech Circuit Solver, sizes 1/2" through 2". Provide a union and ball type shutoff valve on both sides of the balancing valve.

2. ThermOmegaTech Circuit Solver with integrated union (CSU) assembly, sizes 1/2" and 3/4". Balancing valve assembly shall come complete with union body and ball type shutoff valves on both sides.
 3. Provide complete with an integral check valve from the manufacturer, positioned after the balancing valve. For balancing valves not available with an integral check valve as part of the manufacturer's assembly, ensure to provide a lead-free swing type check valve on the downstream side of the balancing valve component.
- C. Applies to circulated domestic hot water system installations including multi-branch parallel piping circuits and single-loop piping circuits.
1. Provide balancing valve at end of each domestic hot water supply line (after last fixture served) just prior to the hot water return line, as indicated on Drawings and in accordance with manufacturer's installation recommendations.
 2. (For Basis of Design product) Provide a pipe tee or elbow with bushing as appropriate, 3/4" threaded thermowell, and bi-metal adjustable angle 3 inch dial thermometer downstream of each balancing valve. Thermowell stem length and thermometer temperature probe length to be suited for pipe size, insulation thickness, and to ensure clearance for maintenance access and easy viewing of thermometer. Trerice bimetal/sensor, threaded-stepped shank thermowell (style 76) of lead-free brass (PBF) material. Trerice Model B836 thermometer with 300 stainless steel case and stem, hermetically sealed, double strength glass windowed, aluminum white-faced dial, complete with external reset and 0 to 200 degrees F range. Thermowell and thermometer face to be oriented upright for readability.
- D. Acceptable Alternate Manufacturer (with field-adjustable temperature setting): Caleffi Thermosetter automatically modulating thermal balancing valve, Series 116A for sizes up to and including 1-1/4". Low lead de-zincification resistant (DZR) brass construction with threaded ends, complete with copper and stainless steel constructed adjustable cartridge with ABS adjustment knob, outlet check valve, outlet temperature gauge, union isolation valves, capped port for bypass cartridge. NSF 61 and NSF 372 compliant, suited for 230 psi maximum working pressure, and a maximum inlet temperature of 195 degrees F.

PART 3 - EXECUTION

3.1 EXCAVATION, BEDDING AND BACKFILL

- A. This section shall apply for the excavation, bedding, and backfill of all buried piping unless specifically noted otherwise. All work shall be coordinated with any job site subsurface drainage/dewatering and adjusted accordingly.
- B. Establish elevations of buried piping outside the building to ensure the following:
1. Not less than 2 feet of cover, or not less than maximum depth of frost penetration, whichever is the greater.
 2. For water lines intended for fire protection service, the depth of cover shall be:
 - a. Not less than 2'-6" in those locations where frost is not a factor.
 - b. Not less than 1'-0" below the frost line for the locality.
 - c. Not less than 3'-0" for piping under driveways.
 - d. Not less than 1'-0" below the bottom of the building foundation/footers.
 - e. In full compliance with the requirements of NFPA 13 and NFPA 24.
- C. Excavation:
1. Excavate trenches for underground piping to the required depths.
 2. The bottom of the trench or excavation shall be cut to a uniform grade.

3. Should rock be encountered, excavate 6 inches below grade, fill with bedding material and tamp to existing density.
 4. Coordinate alignment of pipe trenches to avoid obstructions. Ensure that proposed routing of pipe will not interfere with building foundation before any trenching has begun. Should conflicts occur, contact Architect/Engineer before proceeding.
 5. Should any sleeving of the building foundation be required, this shall be provided as directed by the structural engineer of record AND in accordance with the prevailing code, but in no case shall the sleeve be any less than two (2) pipe sizes larger than the pipe it serves.
- D. Bedding and Backfill:
1. Backfill shall not be placed until the piping has been inspected, tested and approved. Complete backfill to the surface of natural ground or to the lines and grades indicated on Drawings.
 - a. Provide 6 inch stabilized sand bed with 4 inch stabilized sand cover around each pipe.
 - b. Provide select fill up to finished surface or grade, unless indicated otherwise by project geotechnical report or specified otherwise in Division 02.
 - c. In lieu of cement stabilized sand, pea gravel may be used for the bedding and cover described above. Pea gravel shall be clean, well graded, fine gravel (per ASTM D2487) with an approximate top size of 3/8".
 2. Compacting Backfill: Place material in uniform layers of 8 inches maximum, loose measure and compact to not less than 95% of maximum soil density as determined by ASTM D698 Standard Proctor.
 3. Restoration: Compact backfill, where trenching or excavation is required in improved areas such as pavements, walks and similar areas, to a condition equal to the adjacent undisturbed earth and restore surface of the area to the condition existing prior to trenching or excavating operation.
 4. A clay fill "trench plug" extending 3 feet inside the building line and 5 feet outside the building line shall be placed to completely surround utility lines passing beneath the foundation and grade beam. The materials shall consist of on-site soils with a plasticity index (PI) between 30 and 40 percent compacted to at least 95 percent of the Standard Proctor and maximum dry density as determined by ASTM D698.
- E. Cement Stabilized Sand:
1. Materials:
 - a. Cement shall be Type I Portland cement conforming to ASTM C150/C150M.
 - b. Sand shall be clean, durable sand meeting grading requirements for fine aggregates of ASTM C33/C33M and free of organic matter and deleterious substances.
 - c. Water shall be potable and free of oils, acids, alkalis, organic matter, or other deleterious substances, meeting requirements of ASTM C94/C94M.
 2. Mixture:
 - a. Product shall consist of not less than 1.5 sacks of Portland cement per ton of dry sand.
 - b. Mixture shall contain sufficient water to hydrate the cement and be thoroughly mixed in a pugmill type mixer.
- F. For water lines (including In-Building Risers) intended for fire protection service, provide joint restraints by way of concrete thrust blocks in accordance with the requirements of NFPA 13 and NFPA 24.
- G. Aggressive Soil Conditions: Soil shall be considered aggressive and protection of buried metallic piping shall be provided as specified if any of the following situations exist:

1. Conditions are identified as such by the project geotechnical report or project geotechnical engineer.
2. The soil environment is a landfill area, swamp, marsh, polluted river bottom, cinder bed, or has alkaline soils.
3. A score of ten or higher is tallied when applying the soil assessment tool detailed in Appendix A of AWWA C105/A21.5. An excerpt of this evaluation procedure is provided below for reference but is not intended as a substitute for the complete and latest Standard:

NUMERICAL CORROSIVITY SCALE	
Soil Parameter	Assigned Points
Resistivity (ohm-cm)	
< 700	10
700 - 1,000	8
1,000 - 1,200	5
1,200 - 1,500	2
1,500 - 2,000	1
> 2,000	0
pH	
0 - 2	5
2 - 4	3
4 - 6.5	0
6.5 - 7.5	0
7.5 - 8.5	0
> 8.5	3
Redox Potential (mV)	
> 100	0
50 - 100	3.5
0 - 50	4
< 0	5
Sulfides	
Positive	3.5
Trace	2
Negative	0
Moisture	
Poor drainage continuously wet	2
Fair drainage generally moist	1
Good drainage generally dry	0

H. Building Sub-Surface Drainage System Installation:

1. The following general installation provisions are intended to complement, not conflict with, the recommendations of the project geotechnical report. In the event of a conflict with or more stringent requirements in this report, it shall govern the installation of this system.
2. Such pipe shall be bedded and surrounded by filter material of suitable gradation. Refer to the recommendations of the project geotechnical report.

3. Drainage system shall be provided directly behind and at the bottom of buried walls, within granular drainage medium as specified and in accordance with the latest project geotechnical report.
- I. Crawlspace Installations
 1. Where piping will be installed in such spaces, its installation shall be fully coordinated with the building slab/floor construction and/or existing conditions.
 2. Routing and installation shall be coordinated so that all piping is provided within the available clear space above the crawlspace "floor", with uniform slope as required per code and/or as indicated on the Drawings.
 3. Rods, hangers, inserts/anchors and hardware shall be provided to properly support the piping to prevent sagging, misalignment, stress on joints or fittings, and any deviation in required slope. Refer to other paragraphs in this Section for additional requirements for suspended pipe installation.
 4. All rods, hangers, and hardware in crawlspaces shall be provided hot-dipped galvanized or stainless steel. Refer to Section 22 05 29 for additional information on Hanger and Supports.
 5. All waste piping p-traps and all water piping located in such environments shall be insulated. Refer to Section 22 07 19 for additional information on Pipe Insulation.
 6. **Unless specifically noted otherwise, reference the Articles above addressing piping "NOT BURIED" for the pipe material to be provided within crawlspaces, for each plumbing system.**
- J. Void Form/Cartron Form/Void Box Installations
 1. Where piping will be installed in a such a setting, steps shall be taken to isolate and protect the piping from expansive soil conditions. This work shall be fully coordinated with the building slab/floor construction, the project geotechnical report, and the structural Drawings and specifications. The most stringent conditions/recommendations shall govern.
 2. All piping below slab shall be supported by an approved suspended system.
 3. System structure:
 - a. Shall provide a dimensionally stable underground void space that is independent from the overhead structural slab. The subterranean system shall support the weight of suspended lateral pipes and fittings, including all imposed loads, throughout the construction process.
 - b. The system shall be designed to have the ability to temporarily position and suspend the lateral pipes and fittings to the required height/depth and slope until permanently anchored to the overhead structural slab via the securing hanger system. The open, underground system will then remain independent from the securing hangers.
 - c. The open space of the system beneath the structural slab shall be designed to receive the infill of vertical expansion from the underlying soils. If vertical pressure is applied to the edges of the system in contact with the soil, the uplifting soil pressure will become separate and allow the lateral pipes and fittings to be totally independent from the system.
 4. System components:
 - a. The system shall have waterproof components related to its intended performance.
 - b. The system must maintain its structural integrity in all humid environments.
 - c. The system must have industry-proven performance in any and all inclement conditions.
 - d. The system shall be able to perform if and when submerged in water.

- e. All independent components not included in the system shall comply with the project specifications in order to achieve the intended results of the designed system.
- f. All vertical all-thread rod must have a component secured toward the top end and be permanently affixed into the concrete slab in order to maintain the required elevations.
- g. All system components, excluding all-thread rod, nuts/washers, shall be furnished by the designed, system manufacturer.
- h. Galvanized steel all thread-rod and hardware shall be provided and these materials shall be coordinated with the system manufacturer's related components.
- i. The system shall be installed per the manufacturer's requirements and recommendations.
- 5. Submittals: The exact system to be provided, complete with dimensioned detailed drawings and material specifications, shall be submitted for review by the Architect, MEP engineer, structural engineer, and project geo-technical engineer.
- 6. Acceptable System Manufacturers:
 - a. SuperVoid Systems, LLC
 - b. Void Form Products, Inc.
 - c. Other pre-approved system providers.
- 7. Manufacturer Training: The system manufacturer shall provide on-site training, support, and guidance to the Contractor regarding the recommended installation of their products.
- K. Pipe Penetrations of Buried Exterior Walls or Foundations
 - 1. Unless specifically indicated otherwise on the Drawings, each pipe penetration shall be provided with a schedule 40 galvanized steel pipe sleeve no less than two (2) pipe sizes larger than pipe itself.
 - 2. At each penetration provide GPT Industries ("Thunderline") Link Seal Modular Seal LS series. The exact model shall be as required for the pipe material, pipe size, and sleeve length for the penetration. Provide complete with EPDM sealing element and model "C" zinc coated carbon steel hardware.

3.2 INSTALLATION

- A. General requirements for piping:
 - 1. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
 - 2. Remove any scale, oil and dirt, on inside and outside, before assembly.
 - 3. Prepare piping connections to equipment with flanges or unions.
 - 4. Confirm pipe placement, depth/elevation, and flow lines prior to any installation.
 - 5. For gravity drainage applications, double combination wye and eighth bend fittings shall not be installed in a horizontal to horizontal orientation.
- B. General requirements for valves:
 - 1. Install valves with stems upright or horizontal, not inverted.
 - 2. All valves which serve check, balancing, or isolation/shut-off functions shall be line-sized unless specifically noted otherwise.
 - 3. Pressure reducing valves shall be sized in accordance with the manufacturer's recommendations to ensure the required downstream pressure across the full range of expected flows.
 - 4. Provide clearance for installation of insulation and access to valves and operable fittings. Valves installed beyond reasonable reach shall be provided with a chain operator.

5. Provide access doors where valves and operable fittings are not otherwise accessible. Access doors shall be of approved types set in locations pre-approved by submittal to the Architect.
6. Gate valves installed buried shall be covered with an adjustable cast iron roadway box extended to grade. Cover shall be cast iron with 'water' cast on top of cover and shall be set flush to finished paving or 2" above finished earthen grade. Box shall be supported from undisturbed soil or concrete base and shall not introduce any stress to piping under all traffic conditions.
- C. Install all materials in accordance with the manufacturer's published instructions.
- D. Unburied piping inside the building shall be installed concealed, out of public view wherever possible (above ceilings, inside walls and chases, within casework, etc.). This requirement shall not apply to fixture supplies & stops and chrome plated tubular brass drainage piping.
- E. All exposed sewer and water pipe in toilet rooms or other finished areas of the building shall be chrome plated.
- F. Provide non-conducting dielectric connections wherever joining dissimilar metals.
- G. Route piping in an orderly manner, parallel and perpendicular to building column grid lines, unless indicated otherwise on drawings, and maintain gradients.
- H. Install piping to conserve building space and not conflict with other trades or interfere with intended use of space.
- I. Group piping whenever practical at common elevations.
- J. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- L. Provide encasement for and support for utility meters in accordance with the requirements of utility companies.
- M. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting.
- N. Maintain uniformity in the installation of piping materials and joining methods. Do not mix material types.
- O. Where connecting new underground sanitary, storm, or vent piping to existing piping of dissimilar material, provide suitable mechanical transition fittings complete with corrosion protection for metallic elements. Chase Construction Products Tapecoat H35 or approved equivalent and a final coat of coal tar to completely cover the transition.
- P. Solder joints shall be wiped clean at each joint, remove excess metal while molten and flux residue when cooled.
- Q. Waste nipple from wall to tapped tee shall be schedule 40 threaded galvanized steel pipe or brass or copper with threaded adapter.
- R. General requirements for cast iron piping installation:
 1. Install all pipe and fittings in accordance with published recommendations from the manufacturer and the Cast Iron Soil Pipe Institute (CISPI). Specific items referenced below are not intended as a substitute for the complete and latest recommendations.
 2. Install bell and spigot type pipe with bell end upstream.
 3. Above ground horizontal pipe (suspended) shall:
 - a. Be supported at no less than at every joint, and within 18" of the hub or coupling.
 - b. Be maintained in alignment. Sagging or grade reversal shall be unacceptable.
 - c. Be supported at terminal ends of all runs or branches and at each change of direction or alignment.

- d. Have all closet bends, traps, trap arms, and similar branches firmly secured.
 - e. Be braced to prevent movement or joint separation.
 - f. Be provided with suitable sway bracing (such as clamps, rods, and hardware) where pipe and fittings are suspended in excess of 18" by means of non-rigid hangers.
- 4. Above ground vertical pipe shall:
 - a. Be secured at each stack base.
 - b. Be secured at each floor and riser clamps shall be provided on no greater than 15'-0" intervals.
 - c. Be adequately supported to keep the system (pipe and contents) in alignment.
- 5. Provide seismic restraints in seismically active areas, whether specifically required by the prevailing code or not.
- S. For all buried non-metallic piping outside the building, provide minimum 14 AWG solid copper tracer wire (ASTM B1, ASTM B3) with high molecular weight polyethylene insulation (HMWPE) per ASTM D1248. Wire shall be suited for direct bury applications to facilitate the detection and tracing of underground piping systems. THHN wire and other such nylon jacketing shall not be allowed. Insulation color shall be provided per the particular utility, in accordance with the American Public Works Association (APWA) uniform color code. Provide corrosion proof wire connectors with twist locking design and protective dielectric sealant. Copperhead Industries, LLC Snakebite or pre-approved equivalent. Tracer wire shall be placed in the same orientation as the installed pipe and laid six inches directly above the piping. One end of the tracer wire shall be brought aboveground at a building wall or riser for easy identification.
- T. PVC pipe, fittings, or similar un-rated material shall not be installed in a return air plenum unless the entire length of all such piping is encased within a minimum two (2) hour fire rated enclosure.
- U. Installations of buried thermoplastic piping systems shall be in strict conformity with the manufacturer's published instructions and the requirements of ASTM D2321 (gravity pipe) and ASTM D2774 (pressure pipe).
- V. Installation of thermoplastic piping systems which are not buried shall be in accordance with the manufacturer's recommendations. The specific items indicated below are not intended as a substitute for the complete and latest manufacturer's recommendations.
 - 1. Hangers and supports shall not compress, distort, cut, or abrade the piping. Nor shall they force the pipe and fittings into position.
 - 2. Piping shall be supported at intervals sufficiently close to maintain pipe alignment and to prevent any sagging or grade reversal. System maximum operating temperature will determine support spacing.
 - 3. Piping shall be supported at all branch ends and at all changes of direction, as close as practical to the fitting to avoid introducing excessive torsional stresses into the system.
 - 4. Directly support (or if need be, immediately adjacent to) concentrated loads in the system, such as valves and other appurtenances.
 - 5. Allowances must be made for thermal expansion and contraction of the piping system where temperature fluctuations can reasonably be expected to produce such movement. Provide and place hangers accordingly so as not to restrict.
 - 6. Plastic piping systems shall not be placed alongside steam or other high temperature pipe lines or other high temperature objects.
 - 7. Drainage piping shall be supported at trap arms as close as possible to the trap and all closet bends shall be supported and braced.

- W. Installation of solvent cement joints for PVC and CPVC piping shall be in strict conformity with the requirements of ASTM D2855 and manufacturer's published instructions.
- X. Provide approved heavy duty transition coupling at each transition from cast iron pipe not buried to buried PVC pipe as specified elsewhere in this section. Transition shall be made as close as possible to the floor for sanitary DWV piping systems and at test tee "minimum 12 inches A.F.F." for storm drainage piping. Support vertical cast iron pipe from floor anchors using riser clamp and galvanized all thread rod as specified in Section 22 05 29.
- Y. All grooved system tools and components (couplings, adapters, fittings, gaskets, and specialties) shall be the product of a single domestic system manufacturer.
- Z. Grooved pipe system manufacturer shall provide on-site training for contractor's field personnel by a factory trained representative in the proper use of grooving tools, application of groove, and product installation. Factory trained representative shall periodically visit the job site and inspect installation. Contractor shall remove and replace any improperly installed products at no additional cost to the owner.

3.3 APPLICATION

- A. Provide union downstream of all valves at equipment or apparatus connections.
- B. Provide unions downstream of all threaded isolation valves in the domestic water system to facilitate any future valve replacement.
- C. Provide male adapters each side of threaded valves in copper piped system. Sweat solder adapters to tube prior to make-up of threaded connections.
- D. Provide approved isolation valves for shut-off and to isolate all equipment items and distinct parts of systems. Isolation valves shall be provided for both hot and cold water in locations including, but not necessarily limited to, the following:
 - 1. At the domestic water service entry.
 - 2. At each wing of the building.
 - 3. At each floor for each domestic water tap branching off from a vertical riser.
 - 4. At each domestic water branch line capped for future use.
 - 5. At each restroom or restroom group.
 - 6. At each hose bibb, wall hydrant, roof hydrant, hose reel, and trap primer device (except for flush valve or tailpiece type trap primer devices).
 - 7. At each domestic water branch line within 24" of the corresponding main.
 - 8. At each plumbing fixture not otherwise served by a localized fixture group isolation valve.
 - 9. At each kitchen or similar food service space.
- E. Each plumbing water rough-in stub out shall be fitted with a supply stop.
- F. Valves installed in insulated piping shall be fitted with extended lever operators of sufficient length to raise handle above the insulation jacket material. Where valve is used for throttling service, the valve handle shall be equipped with adjustable memory stop device.
- G. Provide non-slam type check valves on discharge lines from all water pumps. Install at a minimum length of 5 times the pipe diameter from the pump and in accordance with manufacturer's installation recommendations.

3.4 ERECTION TOLERANCES

- A. All gravity drainage piping shall be provided at a uniform and continuous slope in accordance with the prevailing plumbing code and as described below. If any of the criteria below conflicts with the prevailing code then the code requirements shall govern:

1. Gravity piping 3" and smaller shall be provided at no less than 1/4" per foot slope.
 2. Gravity piping 4" and larger shall be provided at no less than 1/8" per foot slope.
 3. Where the code allows for a shallower slope than indicated above, this shall be allowed if required per project conditions.
 4. Where the code requires a steeper slope than indicated above (such as for grease waste piping) than such requirements shall control.
- B. All vent and branch vent pipes shall be graded and connected as to drip back by gravity to the drainage pipe it serves. A slope of 1 inch per 40 feet will suffice for this requirement, subject to the approval of the local Authority Having Jurisdiction.
- C. Slope all horizontal water piping with uniform pitch of 1/8 inch per 10 feet to low points to allow for complete system drainage. For long runs, where constant pitch cannot be maintained, provide intermediate low points and rise up again from such locations. Slope horizontal branches back to mains or risers. Provide clearly identified supplementary drain valves where hose bibbs, hydrants, or sill cocks will not suffice for this requirement.

3.5 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Prior to starting work, all domestic water systems shall be complete, thoroughly flushed clean and free of all foreign matter or erection residue.
- B. Ensure PH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- C. On building side of the main shut off valve, provide a 3/4" connection through which chlorine can be introduced into the water piping
- D. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, in sufficient quantity to obtain 50 to 80 mg/L residual free chlorine solution throughout the entire domestic water piping systems.
- E. Bleed water from outlets as required to ensure complete distribution and test for disinfectant residual at a minimum 15 percent of total outlets.
- F. Maintain disinfectant in system for 24 hours.
- G. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- H. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- I. Take samples no sooner than 24 hours after flushing, from 5 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.6 SERVICE CONNECTIONS

- A. Provide new sanitary and storm sewer services connecting to existing building services or utility lines as shown on the drawings.
- B. Before commencing work, field verify invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover as required.
- C. Provide new domestic water service connecting to existing building services or utility lines as shown on plans. Assure connections are in compliance with requirements of the jurisdiction having authority.
- D. Extension of services to the building shall be fabricated from the same materials as the utility service lines or those materials specified herein.
- E. Should points of connection vary from those indicated on the drawings contractor shall properly allow for this in the actual connections field fabricated.

3.7 RODDING SEWERS

- A. All sanitary soil and waste lines, both in the building and out, shall be rodded out after completion of the installation.
- B. This Work shall be done, as part of the contract, to make certain that all lines are clear, and any obstruction that may be discovered shall be removed immediately. Rodding shall be accomplished by utilizing a rotary cutter, which shall be full size of pipe being cleaned.

3.8 VIDEO INSPECTION AND DOCUMENTATION

- A. It shall be the responsibility of the plumbing contractor to retain the services of a qualified, independent company (other than the installing plumbing contractor) with no less than ten (10) years of experience in digital video camera inspection/investigation of plumbing drainage waste and vent lines for commercial/institutional building projects.
- B. The independent company shall perform a complete video camera inspection of all waste piping buried inside the building. This shall include sanitary waste and any specialty waste (grease waste, oily waste, etc.) systems and shall extend from the building all the way to any associated outdoor traps/interceptors.
- C. The independent company shall create a permanent digital video record of their inspection with accompanying definitive identification (audio or visual) to indicate different systems and different areas of the systems inspected.
- D. The independent company shall prepare a comprehensive written report including, but not necessarily limited to, the following:
 - 1. Complete company contact information.
 - 2. Project name and address.
 - 3. Date(s), time(s), and conditions during the inspection(s).
 - 4. Name(s) of the operator(s) performing the inspection(s).
 - 5. A general summary of the inspection results.
 - 6. A written description of any and all material and/or installation deficiencies or irregularities found, with accompanying pictorial documentation. This shall include conditions such as:
 - a. Deformed or damaged piping
 - b. Full or partial blockage of piping
 - c. Deleterious material or debris within the piping
 - d. Slope deficiencies (inadequate, inconsistent, or absent slope)
 - e. Valleys or "dips" in the piping
 - f. Improper fittings in the piping including reductions in pipe size in the direction of flow
- E. The written report shall be submitted under this Section but separately from other submittals of this Section. This shall occur immediately prior to substantial completion.
- F. The written report and the digital video record (DVD or USB flash drive) shall also be submitted as part of the Project Record Documents.

3.9 TESTING OF PLUMBING PIPING SYSTEMS

- A. During the progress of the work and upon completion, tests shall be made as specified herein and as required by Authorities Having Jurisdiction, including Inspectors, Owner or Architect. The Architect or duly authorized Construction Inspector shall be notified in writing at least 2 working days prior to each test or other Specification requirement which requires action on the part of the Construction Inspector.

- B. Tests shall be conducted as part of this work and shall include all necessary instruments, equipment, apparatus, and service as required to perform the tests with qualified personnel. Submit proposed test procedures, recording forms, and test equipment for approval prior to the execution of testing.
- C. Tests shall be performed before piping of various systems have been covered or furred-in. For insulated piping systems testing shall be accomplished prior to the application of insulation.
- D. All piping systems shall be tested and proved absolutely tight for a period of not less than 24 hours. Tests shall be witnessed by the Architect or an authorized representative and pronounced satisfactory before pressure is removed or any water drawn off.
- E. Leaks, damage or defects discovered or resulting from test shall be repaired or replaced to a like new condition. Leaking pipe joints, or defective pipe, shall be removed and replaced with acceptable materials. Test shall be repeated after repairs are completed and shall continue until such time as the entire test period expires without the discovery of any leaks.
- F. Wherever conditions permit, each piping system shall thereafter be subjected to its normal operating pressure and temperature for a period of no less than five 5 days. During that period, it shall be kept under the most careful observation. The piping systems must demonstrate the propriety of their installation by remaining absolutely tight during this period.
- G. Domestic Water: Pressure test at one and one half times the normal working pressure or 125 psig, whichever is the greater, for 24 hours.
- H. Building Drainage, Waste and Vent (including all specialty waste systems) and building storm drain:
 - 1. After the rough-ins of buried drainage and vent lines (including branch laterals) have been set from the lowest level at point of connection to existing sewer (site utility) lines to above the floor line, all outlets shall be temporarily plugged or capped, except as are required for testing as described herein. Ground work shall not permit the backfill of trenches to cover any joints until the completion of testing. Backfill shall be limited to mid sections of full joints of piping only. For pipe in ground the piping shall be readied as described herein and filled with water to a verifiable and visible level to 10' above the lowest portions of the system being tested.
 - 2. On multi-level buildings only one floor level shall be tested at a time. Each floor shall be tested from a level below the structure of the floor, or the outlet of the building in the case of the lowest level, to a level of 12 inches above the floor immediately above the floor being tested, or the top of the highest vent in the case of the highest building level. The pipes for the level being tested shall be filled with water to a verifiable and visible level as described above and be allowed to remain so for 24 hours. If after 24 hours the level of the water has been lowered by leakage, the leaks must be found and stopped, and the water level shall again be raised to the level described, and the test repeated until, after a 24 hour retention period, there shall be no perceptible lowering of the water level in the system being tested.
 - 3. Should the completion of these tests leave any reasonable question or doubt of the integrity of the installation, additional tests including peppermint smoke, or other measures shall be performed to demonstrate the reliability of these systems to the complete satisfaction of the Owner's duly authorized representative. Such tests shall be conducted and completed before any joints in plumbing are concealed or made inaccessible.

3.10 COMPLETE FUNCTIONING OF WORK

- A. All work reasonably implied as essential to the complete functioning of the systems shown on the Drawings and Specification shall be completed as part of the work of this Division, unless specifically stated otherwise. It is the intention of the Drawings and Specification to establish the type and function of systems but not to set forth each item essential to the functioning of any system. In case of doubt as to the work intended or in the event of amplification or clarification thereof, the Contractor shall call upon the Architect for Supplementary Instructions and Drawings, etc.

END OF SECTION

SECTION 22 11 19
PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 22 02 00, are included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. The scope of the work shall include the furnishing and complete installation of the specialties covered by this Section, with all appurtenances, ready for the Owner's use.
- B. Include the following work in addition to items normally part of this Section:
 - 1. Hose Bibbs and Hydrants
 - 2. Backflow Preventers
 - 3. Water Hammer Arresters
 - 4. Strainers and Filters
 - 5. Thermostatic Mixing Valves
 - 6. Floor Drains and Floor Sinks
 - 7. Cleanouts
 - 8. Interceptors and Separators
 - 9. Roof Drains and Overflow Nozzles

1.3 RELATED WORK

- A. Section 22 05 29 - Hangers and Support for Plumbing Piping and Equipment
- B. Section 22 10 00 - Plumbing Piping
- C. Section 22 30 00 - Plumbing Equipment
- D. Section 22 40 00 - Plumbing Fixtures

1.4 REFERENCES

- A. ASME A112.6.3 - Floor Drains.
- B. ASME A112.6.4 - Roof, Deck, and Balcony Drains.
- C. ASME A112.1070 - Performance requirements for water temperature limiting devices.
- D. ASSE 1010 - Performance Requirements for Water Hammer Arresters.
- E. ASSE 1011 - Performance Requirements for Hose Connection Vacuum Breakers.
- F. ASSE 1012 - Performance Requirements for Backflow Preventers with an Intermediate Atmospheric Vent.
- G. ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies.
- H. ASSE 1015 - Performance Requirements for Double Check Backflow Prevention Assemblies.
- I. ASSE 1019 - Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance.
- J. ASSE 1052 - Performance Requirements for Hose Connection Backflow Preventers.
- K. ASSE 1060 - Performance Requirements for Outdoor Enclosures for Fluid Conveying Components.
- L. ASSE 1069 - Performance Requirements for Automatic Temperature Control Mixing Valves.
- M. ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices.

- N. ASSE 1071 - Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment.
- O. IAPMO (UPC) - Uniform Plumbing Code.
- P. ICC (IPC) - International Plumbing Code.
- Q. NSF 372 - Drinking Water System Components - Lead Content.
- R. PDI-WH 201 - Water Hammer Arresters.
- S. ASME A112.6.7 - Sanitary Floor Sinks
- T. ASSE 1057 - Performance Requirements for Freeze Resistant Sanitary Yard Hydrants with Backflow Protection
- U. ASSE 1069 - Performance Requirements for Automatic Temperature Control Mixing Valves
- V. AWWA C510 - Standard for Double Check Valve Backflow Prevention Assembly
- W. NSF 61 - Drinking Water System Components - Health Effects

1.5 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by the same manufacturer throughout.

1.6 SUBMITTALS

- A. Submit under provisions of Division One.
- B. Submit shop drawings and product data under provisions of Division One.
- C. Include component sizes, rough-in requirements, service sizes, and finishes.
- D. Manufacturer's Installation Instructions: Indicate assembly and support requirements.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division One.
- B. Record actual locations of equipment and backflow preventers.

1.8 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division One.
- B. Operation Data: Indicate frequency of treatment required for interceptors and separators.
- C. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. DELIVERY: Deliver clearly labeled specialties to; and store, protect and handle products on site in accordance with the provisions of Division One.
- B. TIMING AND COORDINATION: Arrange for delivery of materials to allow for minimum storage time at the project site. Coordinate with the scheduled time of installation.
- C. ACCEPTANCE: Accept specialties on site in original factory packaging. Inspect for damage. Damaged specialties shall not be acceptable.
- D. STORAGE: Store materials in a clean, dry location, protected from weather and damage.

1.10 EXTRA MATERIALS

- A. Furnish under provisions of Division One.
- B. Provide two loose keys for hose bibbs and hydrants and spare hose end vacuum breakers.

1.11 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes, and corrections.
 - 6. On site demonstration.

1.12 REGULATORY REQUIREMENTS

- A. Conform to applicable codes for the provision and installation of all required backflow prevention devices.
- B. Provide certificate of compliance from authority having jurisdiction indicating approval of installation of backflow prevention devices.
- C. Provide backflow prevention assembly test and maintenance report for all devices. A printed and signed form by the licensed tester that performed the work shall be provided both to the Owner and to the Public Water System in accordance with TCEQ (Texas Commission on Environmental Quality) requirements.

PART 2 - PRODUCTS

2.1 HOSE BIBBS/HYDRANTS

- A. General: Provide an operating handle for each loose keyed device on the project.
- B. Hose Bibb: Bronze or brass construction, replaceable stem assembly, hose thread spout, complete with vandal resistant lockshield and ASSE 1011 integral vacuum breaker. Provide chrome plated and with removable key where exposed in public areas.
- C. Wall Hydrant: Bronze or brass construction, replaceable stem assembly, hose thread spout, non-freeze, self-draining type with integral vacuum breaker. ASSE 1019. Unless specifically noted otherwise, provide recessed complete with heavy cast aluminum or nickel plated brass lockable box and loose key operator.
- D. Roof/Post Hydrant: Free-standing, low-lead, self-draining, non-freeze hydrant with cast iron handle and hose thread brass spout atop galvanized pipe riser. Complete with ASSE 1052 anti-siphon vacuum breaker. For rooftop applications provide complete with manufacturer's recommended mounting hardware for a secure installation and coordinate with roofing contractor to ensure a watertight seal is provided per the roofing system and any local code requirements.
- E. ACCEPTABLE MANUFACTURERS:
 - 1. J.R. Smith
 - 2. Zurn
 - 3. Mifab
 - 4. Watts
 - 5. Wade
 - 6. Chicago (interior use hose bibbs only)
 - 7. Woodford
 - 8. Prier

2.2 RECESSED VALVE BOX

- A. Washing Machine: Pre-formed plastic rough-in box with brass long shank valves with wheel handles, threaded drain fitting for waste, and matching secured faceplate. PVC constructed box, faceplate, and bracket will be acceptable within dwelling units only, in residential occupancies only.
- B. Refrigerator: Pre-formed plastic rough-in box with brass long shank valve with wheel or quarter-turn handle and matching secured faceplate. PVC constructed box, faceplate, and bracket will be acceptable within dwelling units only, in residential occupancies only.
- C. ACCEPTABLE MANUFACTURERS:
 - 1. Guy Gray
 - 2. Mifab
 - 3. Sioux Chief
 - 4. Oatey

2.3 BACKFLOW PREVENTERS

- A. General Requirements: All assemblies shall be suited for the system anticipated working pressure and temperature as well as the intended orientation (vertical or horizontal) of the installation. All assemblies shall be lead-free per NSF 372, unless specifically noted otherwise on the Drawings.
- B. Strainer Requirements: Lead-free compliant strainers shall be provided at all backflow preventers on the upstream side of each assembly. Strainer bodies shall be either bronze/cast copper alloy or of cast iron/ductile iron construction with an FDA approved epoxy coating. Screens and internal components shall be stainless steel.
- C. Reduced Pressure Backflow Preventers: ASSE 1013; Bronze or FDA approved epoxy coated cast iron body with corrosion resistant internal parts and stainless steel springs; two independently operating, spring loaded check valves; intermediate internal pressure intermediate relief valve with water outlet; test cocks and isolation valves.
- D. Double Check Valve Assemblies: ASSE 1015; Cast copper alloy or FDA approved epoxy coated cast iron body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves, test cocks and isolation valves.
- E. Dual Check Valve with Intermediate Atmospheric Vent: ASSE 1012; Brass body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent.
- F. ACCEPTABLE MANUFACTURERS:
 - 1. Watts
 - 2. Wilkins
 - 3. Ames
 - 4. Febco
 - 5. Conbraco

2.4 WATER HAMMER ARRESTERS

- A. Engineered water hammer arresters: ASSE 1010 listed, lead-free, pre-charged, permanently sealed, maintenance- free, suited for concealed installation, with a working temperature range of 33 to no less than 212 degrees F and a maximum working pressure of no less than 250 psi during pressure surges. Stainless steel or copper body construction. Shall be sized and located in accordance with Plumbing Drainage Institute standard PDI-WH 201.
- B. ACCEPTABLE MANUFACTURERS:
 - 1. J.R. Smith
 - 2. Zurn

3. Mifab
4. Wade
5. P.P.P.

2.5 THERMOSTATIC MIXING VALVES

- A. Provide thermostatic mixing valves in accordance with manufacturer's recommendations and as indicated and scheduled on Drawings.
 1. Unless scheduled otherwise, all units other than under-counter point of use units shall be provided complete in lockable cabinet of 16 gage (1.5 mm) prime coated steel when located in finished areas.
 2. All under-counter point of use units shall be provided complete with integral checks and dual stainless steel strainers on inlets for protection against fouling.
- B. Types and Requirements:
 1. Where hot and cold water is supplied to emergency safety fixtures, the temperature shall be controlled by a temperature actuated mixing valve complying with ASSE 1071.
 2. Valves for individual showers are addressed in Section 22 40 00 - Plumbing Fixtures
 3. (Master) mixing valves serving multiple showers, each with a single tempered water supply pipe, shall conform to ASSE 1069 or CSA B125.3. Such valves shall be provided complete with unions, checks, and ball valves at all connections as well as a temperature gauge on the outgoing water line.
 4. Mixing valves serving (athletic area) whirlpool applications shall conform to ASSE 1070 / ASME A112.1070 / CSA B125.70 or CSA B125.3. Such valves shall also be configured with appurtenances as described above.
 5. Mixing valves supplying tempered water to lavatories and sinks shall conform to ASSE 1070 / ASME A112.1070 / CSA B125.70 or CSA B125.3.
- C. ACCEPTABLE MANUFACTURERS:
 1. Bradley
 2. Powers
 3. Symmons
 4. Acorn
 5. Leonard
 6. MGI Controls

2.6 FLOOR DRAINS AND FLOOR SINKS

- A. Provide floor drains and floor sinks in accordance with manufacturer's recommendations, as appropriate for floor construction per ASME A112.6.3, and as indicated and scheduled on Drawings.
- B. Provide clamping devices for all drains in membrane floor areas.
- C. ACCEPTABLE MANUFACTURERS:
 1. J.R. Smith
 2. Zurn
 3. Mifab
 4. Watts
 5. Wade
- D. Provide drains of suitable and compatible material for specialized piping systems conveying acid waste.

2.7 CLEANOUTS

- A. General: Provide cleanouts as indicated and scheduled on Drawings and also as required by the prevailing code, whether shown on the Drawings or not.

- B. Construction: All cleanouts shall have tapered PVC, ABS, or polypropylene plugs.
- C. Provide clamping devices for all cleanouts in membrane floor areas.
- D. Provide cleanouts of suitable and compatible material for specialized piping systems conveying acid waste.
- E. Types:
 - 1. Finished floor cleanouts: Provide cast iron body, with adjustable floor level assembly, and round nickel bronze scoriated top.
 - 2. Resilient or tile finished floor cleanouts: Provide cast iron body, with adjustable floor level assembly, and round nickel-bronze top with gasketed water tight cover and depressed top to receive flooring finish material.
 - 3. Interior finished wall cleanouts: Provide cast iron tee body or cleanout ferrule as required for wall construction and provide counter-sunk plug with stainless steel access cover and securing screw(s).
 - 4. Interior unfinished accessible cleanouts: Caulked or threaded type. Provide bolted stack cleanouts on vertical rainwater leaders.
- F. ACCEPTABLE MANUFACTURERS:
 - 1. J.R. Smith
 - 2. Zurn
 - 3. Mifab
 - 4. Watts
 - 5. Wade

2.8 INTERCEPTORS

- A. General requirements:
 - 1. Provide in type, materials of construction, and with appurtenances as indicated on the Drawings and as required for a complete, functioning, and compliant installation. This shall include, but not necessarily be limited to, the following: venting, flow control, inlet and outlet piping adapters/transitions, and cleanouts.
 - 2. Unless specifically noted otherwise, each interceptor shall be provided with an approved sample well/sampling port in accordance with local AHJ requirements.
 - 3. All interceptors shall be of flow rate/capacity, size, and design as suited to the waste stream being served and in accordance with local AHJ requirements.
 - 4. Buried interceptors and sample wells shall be provided with suitable extensions up to finished grade/paving.
 - 5. Buried interceptors and sample wells shall be provided with approved and suitable access lids/manhole covers.
 - a. In vehicular traffic areas these shall be provided in material and load rating accordingly, suited for the weight of the traffic to be encountered.
 - b. In no case shall lids be rated for anything less than pedestrian traffic.
 - c. All lids shall be lined/gasketed for odor control.
 - 6. Where steel constructed interceptors and sample wells are provided buried, vaulted, or in-floor they shall be fully coated on the interior and exterior for corrosion resistance.
 - 7. Interceptors and sample wells shall not be provided of a material or at an installed depth they are not suited for. Maximum installation depths and bedding-backfill-bury requirements shall be adhered to in strict accordance with the manufacturer's recommendations.
 - 8. Buried interceptors and sample wells in high water table locations or otherwise subject to bouyant force conditions shall be provided complete with the manufacturer's approved anchoring kit. The same shall apply to unburied interceptors and sample wells in flood prone locations.

9. Interceptor and sample well placement and installation shall be coordinated accordingly with adjacent items and equipment, floor/slab construction, site paving/grading, etc. to ensure a compliant installation and all required service and maintenance access.
 10. IAPMO (UPC), ICC (IPC), and local AHJ approval.
 11. Polyethylene constructed interceptors and sample wells shall be lifetime guaranteed.
 12. Provide manufacturer's safety device/access restrictor at each lid/cover to prevent accidental entry into tank/well.
- B. Grease Interceptors:
1. Hydromechanical grease interceptors shall be ASME A112.14.3 / PDI-G 101 compliant.
 2. Gravity grease interceptors shall be IAPMO / ANSI Z1001 compliant.
 3. Concrete constructed grease interceptors shall be provided complete with interior 3mm HDPE liner and exterior bitumastic coating from the manufacturer.
 4. Grease interceptors shall have a maximum operating temperature of no less than 150 degrees F continuous.
 5. Polyethylene constructed grease interceptors shall be third party performance tested. For hydromechanical units, this documentation shall include actual grease retention capacity in pounds.
- C. Acceptable manufacturers (where such units are detailed/specified on the Drawings):
1. Steel constructed: Park-USA, Highland Tank
 2. Precast concrete constructed: Park-USA, Old Castle Precast
 3. Fiberglass reinforced plastic (FRP) constructed: Zurn Green Turtle
 4. Polyethylene constructed: Schier, Striem (also acceptable for point-of-use PVC constructed)
- D. Solids/Hair Interceptor - Point of Use
1. Construction: Lacquered cast iron body with stainless steel strainer/sediment bucket unless specified otherwise on Drawings.
 2. ACCEPTABLE MANUFACTURERS:
 - a. J.R. Smith
 - b. Zurn
 - c. Mifab
 - d. Watts
 - e. Wade

2.9 ROOF DRAINS, PLANTER DRAINS, AND OVERFLOW NOZZLES

- A. Roof drains (RD): ASME A112.6.4; Lacquered cast iron body with sump, removable aluminum dome strainer, membrane flange and clamp with integral gravel stop, adjustable underdeck clamp, roof sump receiver, waterproofing anchor flange, adjustable extension as required for insulation, perforated or slotted ballast guard extension for inverted roof.
- B. Roof overflow drains (OD): Lacquered cast iron body and features similar to roof drain, with 2 inch external water dam or pipe extended to 2 inches above flood elevation.
- C. Planter drains: Lacquered cast iron body with flange, integral clamping collar, seepage openings and either adjustable perforated standpipe (length as necessary) with secured dome or dome with secured stainless steel screen.
- D. ACCEPTABLE MANUFACTURERS:
1. J.R. Smith
 2. Zurn
 3. Mifab

- 4. Watts
- 5. Wade

PART 3 - EXECUTION

3.1 INSTALLATION AND APPLICATION

- A. Install specialties in accordance with manufacturer's instructions to provide intended performance.
- B. Install equipment specific drains appropriately located to serve the equipment. Drain placement shall not conflict with housekeeping pads, casework, equipment access, clear space for foot travel, etc. In kitchens and similar settings final drain locations must be carefully coordinated to ensure that equipment casters, table legs, etc. do not bear upon drain grates.
- C. Water hammer arresters:
 - 1. The contractor shall provide water hammer arresters as shown on Drawings and also in accordance with PDI-WH 201, whether shown on Drawings or not.
 - 2. Water hammer arresters shall be PDI certified and sized and placed as recommended by manufacturer.
 - 3. Provide above lay-in ceiling, within chase or wall or above solid ceiling complete with access panel, or otherwise accessible location complete with isolation valve to facilitate replacement.
 - 4. Provide for both domestic hot and cold water services.
 - 5. The provision of air chambers for the control of water hammer shall not be acceptable.
- D. Backflow preventers:
 - 1. Provide strainers at all backflow preventers.
 - 2. Contractor shall certify all newly installed backflow preventers and provide proof of certification to the Owner.
 - 3. Pipe relief line from backflow preventer via manufacturer's air gap assembly, full size to nearest suitable drain. Such routing shall not pose a trip hazard. Where a suitable drain of appropriate size is not provided, route line to the outdoors.
 - 4. All backflow preventers shall be securely supported with wall supports and/or pipe stands as appropriate for the size and weight of the unit and shall be installed with sufficient access and clearance for testing and maintenance. Unless specifically noted otherwise on Drawings, all backflow preventers shall be installed at 48"-60" above finished floor.
 - 5. Unless specifically noted otherwise on the Drawings, outdoor installations shall be housed within an appropriately sized, ASSE 1060 Class I freeze and vandal protective insulated, marine grade aluminum constructed enclosure complete with drain panel and removable/movable panel(s) for device maintenance and testing. Provide complete with manufacturer's recommended electric heater. Safe-T-Cover by Hydrocowl.
- E. Cleanouts:
 - 1. Provide two-way cleanouts at all waste outfalls from the building.
 - 2. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at all cleanouts for access and for rodding of drainage system.
 - 3. Wall cleanouts provided at the end of horizontal piping runs shall be installed vertically above the flow line of the pipe served.
 - 4. All cleanouts outside of building not in paved areas shall be set in an 18" x 18" x 4" thick concrete pad, flush with final grade.

5. All cleanouts shall be the same nominal size as the pipe they serve, up to 4 inches. For pipes larger than 4 inches, provide a 4 inch cleanout.
- F. Interceptors:
1. Indoors, coordinate with casework to ensure that all interceptors are readily accessible and removable for servicing and cleaning.
 2. Indoors, coordinate with casework to ensure that all point of use interceptors do not interfere with required accessibility requirements. Provide offset(s) as required and in accordance with code.
 3. Provide approved sampling well downstream of centralized interceptors and separators and in all such locations where required by the local Authority Having Jurisdiction.
 4. Installation shall be in accordance with the manufacturer's recommendations.
 5. The following general installation requirements shall apply to concrete constructed interceptors, however these requirements are not intended to supercede the manufacturer's recommendations, which shall govern.
 - a. The bottom of the excavation shall be covered with clean sand or pea gravel to a depth of no less than one foot, suitably graded and leveled. Limestone shall not be acceptable.
 - b. If the installation location has significant variation in ground water levels, the bedding material shall be fine gravel or pea gravel rather than sand.
 - c. The backfill shall be free from any material which may cause damage to the tank coating (if any) and placed accordingly.

END OF SECTION

SECTION 22 11 21
NATURAL GAS PIPING SYSTEMS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 22 02 00, are included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. The scope of the work shall include the furnishing and complete installation of the piping system covered by this section, with all appurtenances, ready for the Owner's use. This shall include, but not necessarily be limited to, the following:
 - 1. Pipe and pipe fittings.
 - 2. Adapters, transitions, final flexible connectors.
 - 3. Valves, regulators, and regulator vents.
 - 4. Metering.
 - 5. Testing.
- B. Coordinate in advance with the local gas utility provider and:
 - 1. Ensure an unobstructed and acceptable pathway for the incoming gas service.
 - 2. Ensure compliant gas meter location(s) with all required clearances and maintenance access.
 - 3. Pay for all fees & inspections and secure all necessary permits required for a complete and operating gas service to the project.

1.3 RELATED WORK

- A. Section 22 05 29 - Hangers and Support for Plumbing Piping and Equipment
- B. Section 22 05 53 - Identification for Plumbing Piping and Equipment
- C. Section 22 30 00 - Plumbing Equipment

1.4 REFERENCES

- A. ANSI LC 4/CSA 6.32 - Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems.
- B. ANSI Z21.80/CSA 6.22 - Line Pressure Regulators.
- C. ASME B1.20.1 - Pipe Threads, General Purpose, Inch.
- D. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300.
- E. ASME B16.9 - Factory-Made Wrought Butt welding Fittings.
- F. ASME B16.11 - Forged Fittings, Socket-welding and Threaded.
- G. ASME B31.8 - Gas Transmission and Distribution Piping Systems.
- H. ASME BPVC - Boiler and Pressure Vessel Code.
- I. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
- J. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- K. ASTM A105/A105M - Standard Specification for Carbon Steel Forgings for Piping Applications.
- L. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

- M. ASTM A197/A197M - Standard Specification for Cupola Malleable Iron.
- N. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- O. ASTM D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings.
- P. ASTM D2683 - Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
- Q. ASTM F3226/F3226M - Standard Specification for Metallic Press-Connect Fittings for Piping and Tubing Systems.
- R. NFPA 54 - National Fuel Gas Code.
- S. NSF 61 - Drinking Water System Components - Health Effects.

1.5 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by the same manufacturer throughout.
- B. Valves: Manufacturer's name, size, and pressure rating shall be cast or marked on valve body or handle.
- C. Piping shall be labeled along its entire length indicating size, class, material specification, manufacturer's name and country of origin.
- D. Foreign pipe, fittings or valves are unacceptable.
- E. Welding Materials and Procedures: Conform to ASME BPVC and applicable state labor regulations.
- F. Welders Certification: In accordance with ASME BPVC-IX.
- G. Materials, design, fabrication, and testing-inspection shall conform to the requirements of ASME B31.1.

1.6 SUBMITTALS

- A. Submit product data under provisions of Division One.
- B. Include pipe materials, pipe fittings, valves, regulators, and accessories. Provide manufacturer's catalog information, product certifications, and country of origin. Indicate valve data and ratings.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division One.
- B. Record actual locations of valves, regulators, and meter(s).

1.8 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division One.
- B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.9 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with a minimum of 5 years documented experience and must be a domestic manufacturer.
- B. Installer: Company specializing in performing the work of this section with a minimum of 5 years documented experience.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. DELIVERY: Deliver clearly labeled piping and valves to; and store, protect and handle products on site in accordance with the provisions of Division One.

- B. **TIMING AND COORDINATION:** Arrange for delivery of materials to allow for minimum storage time at the project site. Coordinate with the scheduled time of installation.
- C. **ACCEPTANCE:** Accept product on site in original factory packaging. Receive valves on site in shipping containers with labeling in place. Inspect for damage. Damaged valves shall not be acceptable.
- D. **STORAGE:** Store materials in a clean, dry location, protected from weather and damage.
- E. Provide temporary protective coating on steel valves.
- F. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- G. Protect installed piping systems from entry of foreign materials by providing temporary covers, as completing sections of the work, and isolating parts of completed systems. Tape will not be allowed as an acceptable end cover.

1.11 EXTRA MATERIALS

- A. Furnish under provisions of Division One.

1.12 REGULATORY REQUIREMENTS

- A. Perform and provide all work in accordance with plumbing and building codes having jurisdiction.
- B. Ensure compliance with fire marshal, utility provider, and Texas Railroad Commission requirements.
- C. All sleeves passing through return air plenum space shall be of compliant material.

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

- A. Piping, not buried: All such gas piping shall be ASTM A53/A53M schedule 40 black steel pipe as manufactured by U.S. Steel Tubular Products, Wheatland Tube, Youngstown Pipe & Steel, or approved equal domestic manufacturer.
- B. Pipe fittings and joining, not buried: Provide threaded fittings and joints for pipe sizes 2" and smaller. Provide schedule 40 weld fittings with welded joints for all piping 2-1/2" and larger. All steel pipe fittings shall be as follows:
 - 1. The dimensions and design shall conform to ASME B16.11 for forged steel fittings, ASME B16.9 for butt welding fittings, and ASME B16.3 for threaded malleable iron fittings.
 - 2. The material shall conform to ASTM A105/A105M for all forged carbon steel fittings, ASTM A234/A234M for all wrought carbon steel fittings, and ASTM A197/A197M for all malleable iron fittings.
 - 3. All welding fittings shall be factory-made and shall be full line size, for each tee, branch, elbow, etc., with reducers after fittings, if required. Weldbend Corporation or approved equal domestic manufacturer.
 - 4. All threads shall be taper pipe threads and conform to ASME B1.20.1.
 - 5. All threaded fittings shall black Class 150 malleable iron by Ward Manufacturing or approved equal domestic manufacturer. Threaded joints shall be made up with graphite and oil or Teflon tape.
 - 6. All pipe fittings shall be from a domestic manufacturer.

- C. Fittings and joints for unburied steel pipe in sizes 1/2" through 4" may be Viega MegaPress-G mechanical press-connect system joints with carbon steel alloy fittings with corrosion-resistant zinc/nickel coating and HNBR elastomeric sealing elements rated to 125 psi maximum with a temperature range of -40 to 180 degrees F. All fittings, couplings, and adapters shall be the product of a single system manufacturer and only that manufacturer's approved press tools, kits, and jaws shall be used.
 - 1. Fittings shall be certified to ANSI LC 4/CSA 6.32 and ASTM F3226/F3226M.
 - 2. All installers shall be trained by the fitting manufacturer's appointed representative and carry such credentials for the duration of the project.
 - 3. The fitting manufacturer's representative shall conduct periodic inspections of the installation and shall provide written reports of such inspections to the Contractor and Engineer, including any observed deviations from the manufacturer's recommended installation practices.
 - 4. Manufacturer's recommended installation practices and two-step pressure test protocol shall be strictly adhered to.
 - 5. **Acceptable system manufacturers: Viega MegaPress-G only.**
- D. Unions and valves are not permitted above ceilings or in walls or in chases.
- E. Piping, buried, outside the building with 5 pound working pressure or less shall be as follows:
 - 1. The pipe shall be PE 2708/2406 yellow medium density polyethylene (MDPE) with socket heat fusion joints and fittings per ASTM D2513. Pipe sizes 1/2" through 6" shall be SDR 11.
 - 2. All socket heat fusion fittings shall be D.O.T. approved and meet ASTM D2513, ASTM D2683 and ASME B31.8 codes.
 - 3. All gas valves below grade shall be ASTM D2513 polyethylene constructed ball type with NBR seat and seals, rated for natural gas use. Hubbell/Lyall or approved equivalent. All such valves shall be placed in a cast-iron valve box of an adequate size for accessibility and maintenance.
 - 4. All transition meter risers shall be 100% pressure tested, D.O.T. approved, IAPMO/UPC and CSA listed, anodeless service type, fusion coupled only. All gas carrying steel parts shall meet or exceed ASTM A53/A53M and all polyethylene components shall conform to ASTM D2513. Electrostatically bonded epoxy coated exterior steel casing. Hubbell/Continental Industries or approved equal.
 - 5. The contractor shall take thermal expansion under consideration during installation. The contractor shall follow all requirements set by the manufacturer to protect the system from damage due to thermal expansion.
 - 6. The contractor shall provide detector tape approximately 12" above all gas piping.
 - 7. Wrap pipe with 18 gauge minimum copper tracer wire. Tracer wire shall be secured to piping where it extends above buried location and tagged.
- F. Gas piping installed in unventilated spaces shall be routed in properly vented continuous sleeve where required by the building code.
- G. Gas valves shall be UL listed as follows:
 - 1. Ball valves:
 - a. Basis of design: Nibco T585-70-UL for 1/4" to 1" and T580-70-UL for 1-1/4" to 3".
 - b. Acceptable alternate manufacturers: Apollo, Milwaukee.
 - 2. Plug Valves: ASTM A126 cast iron quarter turn plug valve with no less than 175 psi maximum cold working pressure (CWP).
 - a. DeZurik Eccentric plug valve
 - b. Flowserve/Nordstrom short pattern all-iron lubricated plug valve, Super Nordstrom or Nordstrom Bolted Gland type.

- H. Gas pressure regulators:
 - 1. Shall be capable of reducing the incoming gas pressure to the intended outgoing gas pressure at the capacities required by the system gas demand.
 - 2. Shall be installed in accordance with manufacturer's recommendations, accessible for servicing, and protected against physical damage accordingly.
 - 3. Shall not be located above ceilings or in similar installations.
 - 4. Shall be provided with factory-installed overpressure protection devices (OPD's) where required. Reference NFPA 54, Section 5.8 in particular.
 - 5. Line pressure regulators shall be listed in accordance with ANSI Z21.80/CSA 6.22.
 - 6. Each regulator shall be provided complete with:
 - a. An upstream shutoff valve
 - b. A capped test tee fitting oriented downward for sediment trap and testing purposes, located between the regulator and upstream shutoff valve
 - c. Unions on both sides of and within 1 foot of the regulator
 - d. A capped test tee fitting not less than 10 pipe diameters downstream of the regulator outlet, for testing purposes
 - 7. Shall be as manufactured by Belgas, Sensus/Rockwell, Emerson/Fisher, Maxitrol, or approved equal.
- I. All gas regulators located inside the building shall be vented to the outdoors with schedule 40 black steel pipe. This includes all regulators provided with mechanical and plumbing equipment and all other regulators provided under this contract.
 - 1. Vent piping shall be the full size of regulatory port opening, or as recommended by the regulator manufacturer.
 - 2. Each vent shall be run independently of any other regulator vents.
 - 3. Vent sizing: for every 10 feet equivalent length of run, the vent pipe shall be increased by one nominal pipe size.
 - 4. Each vent shall terminate at a height and in a location no less than 10'-0" from any door/window/outside air intake and no less than 3'-0" from a possible source of ignition.
 - 5. Each vent shall be located and designed to prevent the entry of water, insects, or other foreign materials that could cause blockage. Each vent shall terminate with an elbow oriented downward, fitted with 12x12 mesh stainless steel screen in the outlet.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. All piping, valves, and appurtenances shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.
- B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.
- C. All underground gas piping shall be laid on 6" of wet compact banksand approximately 24" below grade and buried in a manner to protect it from damage. Backfill trench with wet compacted banksand to 6" above pipe. The remainder of backfill shall be selected backfill and shall meet all compaction requirements set forth by the general trenching and backfill requirements.
- D. Provide lever handle gas valve, drip leg and union at each piece of equipment and where indicated.
- E. All gas valves with serve an isolation or shut-off function shall be line-sized unless specifically noted otherwise.

- F. At kitchen appliances provide commercial grade, ANSI Z21.69/ANSI Z21.24 compliant flexible connections, stationary or moveable (as necessary for the equipment served) of suitable lengths.
- G. All gas lines entering building shall be valved on the exterior of the building above grade. All gas lines entering (or leaving) buildings shall be sleeved through the exterior wall above grade and sealed watertight.
- H. Refer to Section 22 05 53 for valve and piping identification requirements, including painting and labeling (pipe markers). Provide as specified.
- I. Refer to Section 22 05 29 for pipe hanger and support requirements. Provide as specified.
- J. Gas piping shall not be routed through or beneath a building slab unless specifically indicated as such on the Drawings. For such installations:
 - 1. The gas piping shall be sleeved, sealed, and vented to the outdoors in accordance with the requirements of NFPA 54 or the prevailing gas code, or whichever is the more stringent requirement.
 - 2. All sleeves must be of suitable material for the installed location. This shall include, but is not necessarily limited to, providing sleeves of compliant material and construction where passing through return air plenum spaces.
- K. Provide an accessibly located valved and capped test tee for each distinct system to facilitate regular pressure testing of all gas piping from the outlet of the meter to each inlet valve of each appliance. Reference Texas Administrative Code Title 16, Part 1, Chapter 8, Subchapter C, Rule 8.230 for additional information as necessary.

3.2 TESTING OF GAS PIPING SYSTEMS

- A. All gas system testing shall be in compliance with local codes or as required in NFPA 54 National Fuel Gas Code, whichever is the more stringent requirement. Additionally, in school facilities all such testing shall be performed in accordance with the Texas Administrative Code, Railroad Commission of Texas testing requirements for natural gas piping systems. Reference Rule 8.230 in particular.
- B. All work shall be performed by a Journeyman Plumber holding current State and local licenses.
- C. All tests shall be accomplished during normal working hours and after having given due notification to building owner, construction manager or designee, of tests to be performed. All tests shall be performed in the presence of and witnessed by the building owner's representative or designee.
- D. All gas system piping shall be subjected to a pneumatic test pressure of 60 psig for not less than 2 hours upon completion of all rough-in work and prior to covering. While the systems are subjected to this air pressure test, all joints shall have a soapy water solution applied and shall be observed for leaks. During test period there shall be no perceptible drop in test gage pressure.
- E. A final test shall be performed after all portions of the piping system are completely installed and covered. The entire system shall be tested, with all system outlets plugged or capped, before any equipment or appliances are connected to the piping.
 - 1. Final test shall be with mercury, measured with a manometer or slope gage. Test pressures shall in no case be less than one and one half times the normal operating pressure or as listed below; which ever is the greater:
 - a. 10.5 inches mercury (5 psig) for systems designed for 0.25 psig or less
 - b. 21.0 inches mercury (10 psig) for systems designed for greater than 0.25 psig
 - 2. Tests shall prove absolutely tight, showing no perceptible drop for the entire test period, which shall be as follows:
 - a. No less than 30 minutes for systems designed for less than 5 psig

- b. No less than 60 minutes for systems designed for 5 psig or greater
- F. Purge air from test piping before connecting equipment or appliances. Purge air to outdoors or to ventilated space of sufficient volume to prevent accumulation of flammable mixtures.

END OF SECTION

**SECTION 22 30 00
PLUMBING EQUIPMENT**

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. The Basic Materials and Methods, Section 22 02 00, are included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. The scope of the work shall include the furnishing and complete installation of the equipment covered by this Section, with all appurtenances, ready for the Owner's use.
- B. Include the following work in addition to items normally part of this Section:
 - 1. Domestic Water Heaters
 - 2. In-line Circulator Pumps
 - 3. Domestic Pressure Booster Systems
 - 4. Sump Pumps and Sewage Ejectors

1.3 RELATED SECTIONS

- A. Section 22 05 29 - Hangers and Support for Plumbing Piping and Equipment
- B. Section 22 05 48 - Vibration and Seismic Controls for Plumbing Piping
- C. Section 22 10 00 - Plumbing Piping
- D. Section 22 11 19 - Plumbing Specialties
- E. Section 26 05 19 - Wire, Cable and Related Materials

1.4 REFERENCES

- A. 10 CFR 430, Appendix E to Subpart B - Uniform Test Method for Measuring the Energy Consumption of Water Heaters.
- B. ANSI Z21.10.3 - Gas-Fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating and Instantaneous.
- C. ANSI Z21.22 - American National Standard for Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems.
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- E. ASME A17.1 - Safety Code for Elevators and Escalators Includes Requirements for Elevators, Escalators, Dumbwaiters, Moving Walks, Material Lifts, and Dumbwaiters with Automatic Transfer Devices.
- F. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels.
- G. ASSE 1012 - Performance Requirements for Backflow Preventers with an Intermediate Atmospheric Vent.
- H. ASTM A351/A351M - Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
- I. ICC (IECC) - International Energy Conservation Code.
- J. NFPA 54 - National Fuel Gas Code.
- K. NFPA 70 - National Electrical Code.
- L. SCAQMD 1146.2 - Emissions of Oxides of Nitrogen from Large Water Heaters and Small Boilers and Process Heaters.
- M. UL 441 - Standard for Gas Vents.

- N. UL 1453 - Standard for Electric Booster and Commercial Storage Tank Water Heaters.
- O. UL 1738 - Standard for Venting Systems for Gas-Burning Appliances, Categories II, III, and IV.

1.5 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by the same manufacturer throughout.
- B. Perform Work in accordance with Authorities Having Jurisdiction.
- C. Provide pumps with manufacturer's name, model number, and rating/capacity identified.
- D. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:
 - 1. American Gas Association (AGA).
 - 2. National Sanitation Foundation (NSF).
 - 3. American Society of Mechanical Engineers (ASME).
 - 4. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).
 - 5. National Electrical Manufacturers' Association (NEMA).
 - 6. Underwriters Laboratories (UL).
 - 7. American Society of Plumbing Engineers (ASPE)
- E. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.

1.6 SUBMITTALS

- A. Submit under provisions of Division One.
- B. Shop Drawings:
 - 1. Include water heater and packaged heating system dimensions, sizes and locations of all connections, and performance data.
 - 2. Include dimensions of tanks, tank lining and insulation methods, anchors, attachments, lifting points, sizes and locations of all connections and drains.
 - 3. Include water softening equipment dimensions, sizes and locations of all connections, performance data and capacities, backwash requirements.
 - 4. Include booster system skid dimensions, sizes and locations of all connections, and performance data. Include such information for any field connected items, including, but not necessarily limited to, hydro-pneumatic tanks.
 - 5. Include manufacturer's recommended space requirements, clearances, and maintenance access.
- C. Product Data:
 - 1. Include dimension drawings of water heaters indicating components and connections to other equipment and piping.
 - 2. Indicate pump type, materials of construction, capacity, power requirements, and any affected adjacent construction.
 - 3. Submit certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
 - 4. Provide electrical characteristics and power and controls connection requirements/capabilities.
- D. Manufacturer's Installation Instructions.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division One.
- B. Record actual locations of equipment.

- C. Provide written start-up reports.

1.8 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 22.
- B. Operation Data: Include manufacturer's operating instructions, common trouble conditions and remedies, and trouble-shooting protocols.
- C. Maintenance Data: Include routine maintenance items and corresponding intervals, identify typical replacement parts including part numbers and availability. Provide location and full contact information including after-hours maintenance/support telephone numbers for manufacturer authorized maintenance and repair companies.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. DELIVERY: Deliver clearly labeled equipment to; and store, protect and handle products on site in accordance with the provisions of Division One.
- B. TIMING AND COORDINATION: Arrange for delivery of equipment to allow for minimum storage time at the project site. Coordinate with the scheduled time of installation.
- C. ACCEPTANCE: Accept equipment on site in original factory packaging. Inspect for damage. Damaged equipment shall not be acceptable.
- D. STORAGE: Store equipment in a clean, dry location, protected from weather and damage.

1.10 EXTRA MATERIALS

- A. Furnish under provisions of Division One.
- B. Provide two sets of electric water heater elements.

1.11 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two weeks prior to the proposed training session for review and approval.
- B. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes, and corrections.
 - 6. On site demonstration.

1.12 REGULATORY REQUIREMENTS

- A. Conform to AGA, NSF, NFPA 54, NFPA 70 and UL 1453 requirements for water heaters.
- B. Conform to ASME BPVC-VIII-1 for manufacture of pressure vessels for heat exchangers.
- C. Conform to water heater minimum efficiency requirements prescribed by ICC (IECC) and ASHRAE Std 90.1 I-P
- D. Water heaters shall be tested and rated in compliance with 10 CFR 430, Appendix E to Subpart B or ANSI Z21.10.3 as applicable.

1.13 WARRANTY

- A. Provide one year warranty under provisions of Division One, unless specifically noted otherwise.

- B. Warranty: Include coverage of domestic water heaters and packaged systems, water storage tanks, water softeners, and domestic pressure booster systems.

PART 2 - PRODUCTS

2.1 COMMERCIAL GAS FIRED WATER HEATER (STORAGE TYPE)

- A. Acceptable Manufacturers:
 - 1. A.O. Smith
 - 2. State
 - 3. Rheem
 - 4. Lochinvar
 - 5. Bradford White
 - 6. Bock
- B. Type: Automatic, natural gas-fired, vertical storage.
- C. Tank: Seamless Glass lined steel tank construction, ASME labeled (unless indicated otherwise on Drawings). Factory applied foam insulation and trim with a heavy gauge, corrosion-resistant enameled steel jacket.
- D. Burner and heat exchanger: High efficiency, **modulating** gas burner that automatically adjusts the input based on demand. Submerged combustion chamber within tank. Direct spark ignition. Long life, scale resistant heat exchanger lined both externally and internally.
- E. Accessories: Maintenance free, non-sacrificial powered anodes; brass water connections and dip tube, drain valve, ASME rated temperature and pressure relief valve, hand-hole cleanout, condensate neutralization kit.
- F. Approvals:
 - 1. Design certified by Underwriters Laboratories (UL), Inc. to ANSI Z21.10.3
 - 2. Thermal efficiency and standby loss requirements of the U.S. Department of Energy and current edition of ASHRAE Std 90.1 I-P
 - 3. Design certified by Underwriters Laboratories (UL), Inc. to NSF Standard 5 for 180 degrees F water.
 - 4. Complies with SCAQMD 1146.2 and the prevailing local requirements for low-NOx emissions.
 - 5. By AGA as automatic storage water heater and automatic circulating tank water heater for operation at 180 degrees F.
 - 6. Approval for 0" clearance to combustibles
- G. Controls: Integrated solid-state temperature and ignition control device with integral diagnostics, precise adjustable temperature control to 180 degrees F, graphic user interface, fault history display, and digital temperature readout. Capability for remote monitoring.
- H. Provide training per 1.11.

2.2 COMMERCIAL ELECTRIC WATER HEATERS (STORAGE TYPE)

- A. Acceptable Manufacturers:
 - 1. A.O. Smith
 - 2. State
 - 3. Rheem
 - 4. Lochinvar
 - 5. Bradford White
 - 6. Bock
- B. Type: Factory-assembled and wired, electric, vertical storage.

- C. Tank: Glass lined welded steel; 4 inch diameter inspection port (when applicable), thermally insulated with minimum 2 inches glass fiber encased in corrosion-resistant steel jacket; baked-on enamel finish.
- D. Controls: Automatic water thermostat with externally adjustable temperature range from 110 to 170 degrees F (approximate, based on element configuration), replaceable elements of zinc plated copper or nickel chromium alloy, high temperature limit cutoff, enclosed controls and electrical junction box.
- E. Accessories: Brass water connections and dip tube, drain valve, high-density magnesium anode, and ASME rated temperature and pressure relief valve.
- F. Provide training per 1.11.

2.3 THERMAL EXPANSION TANKS

- A. Acceptable Manufacturers:
 - 1. Watts
 - 2. Amtrol
 - 3. Elbi
 - 4. Bell and Gossett
- B. Rating: Ensure suitable pressure rating of tank for expected system pressure.
- C. Construction: Welded steel construction per ASME BPVC-VIII-1, corrosion-proof anti-microbial polypropylene liner, long-life heavy duty butyl compound diaphragm, stainless steel system connection, factory pre-charged, complete with welded air charge fitting with protective cap. Suitable for in-line installation or factory provided with stand/legs for floor-mounted installation.

2.4 IN-LINE CIRCULATOR PUMPS

- A. Acceptable Manufacturers:
 - 1. Grundfos
 - 2. Bell & Gossett
 - 3. Armstrong
- B. Variable speed capable circulator pump controlled by integral variable frequency drive with features and functions as described below:
 - 1. Type: Wet, canned-rotor, maintenance-free design.
 - 2. Housing: ASTM A351/A351M stainless steel with flanged connections.
 - 3. Maximum Operating Pressure: Suited for no less than 150 psig.
 - 4. Maximum Fluid Temperature: Suited for no less than 200 degrees F.
 - 5. Impeller: Composite.
 - 6. Motor: Electronically commutated (EC) permanent magnet motor suited for speed control via integrated frequency converter.
 - 7. Control features: Integrated display on controller box, built-in differential-pressure and temperature sensor, multiple pump control modes - including the capability to be set to maintain constant return water temperature concurrent with a "not to exceed" maximum flow rate. Bluetooth ready and BMS capable.
 - 8. Basis of Design: Grundfos Magna 3 series, -GF-N with performance as scheduled on the Drawings.

2.5 SUMP PUMPS AND SEWAGE EJECTORS

- A. Acceptable Manufacturers:
 - 1. Grundfos
 - 2. Weil
 - 3. Hydromatic
 - 4. Barnes

5. Zoeller
- B. Type and Arrangement:
 1. Refer to Drawings for pump types, performance requirements, and power requirements.
 2. Refer to Drawings for basin ("station") sizes, depths, inlets, outlets, and construction. All sealed basins shall be properly vented.
 3. **With the exception of elevator sump pump applications**, at a minimum each pump installation shall be duplexed (with equally performing pumps, each sized for the operational condition) unless specifically identified otherwise on the Drawings.
- C. Electrical: Motor thermal overload protection. Voltage, phase, and horsepower as indicated on Drawings.
- D. Construction: Cast iron pump body with carbon and ceramic mechanical seals. 100% baked on powder coated epoxy finish. Stainless steel external hardware.
- E. Impeller: Bronze or stainless steel non-clogging vortex type with stainless steel shaft.
- F. Controls/Alarm General Requirements:
 1. Provide indoor/outdoor alarm system and pump control complete with NEMA 4X waterproof enclosure, automatic alternation of pumps, audible alarm, silence switch, red alarm beacon, and HOA switch.
 2. Provide corrosion resistant floats with power cords and configuration for pumps on/off and high water alarm.
 3. Capable of single point power connection.
 4. Provide an auxiliary set of contacts for connection or remote alarm circuit to BAS.
 5. At elevator sumps, in lieu of float control, provide an approved oil sensing and alarm system complete with control & alarm panel to govern pump operation. See-Water, Inc. or pre-approved equivalent.
- G. General Requirements:
 1. Each pump shall be arranged to function independently in case of overload or mechanical failure.
 2. Each pump receiving the discharge of water closets or urinals must have a pumping capacity of 20 gpm minimum and must also have 2 inch diameter solids handling capacity (unless a grinder type pump is employed).
 3. Each pump discharge line shall be 3 inch minimum. However, a 2 inch discharge shall be acceptable for elevator sump pump applications.
 4. The discharge pipe from each pump shall be provided with an accessible line sized swing check valve and gate or ball valve. Valve shall be located in accordance with the prevailing code.
 5. Basins shall be gas tight and of sufficient size and shape to physically accommodate pumps and appurtenances, inlet and outlet pipes, and to ensure acceptable run times per manufacturer's recommendations.
 6. Pumps shall be provided with suitable provisions to ensure easy removal for inspection, maintenance and replacement. This may require appurtenances such as (but not necessarily limited to): guide rail systems with either stainless steel or galvanized pipe rails, quick disconnect sealing flanges at pumps, and corrosion resistant chains or cables attached to brackets atop the pump bodies.
 7. Elevator sump pump applications shall comply with the requirements of the prevailing code and ASME A17.1
- H. Provide training per 1.11.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

- A. Install in accordance with manufacturer's instructions and to AGA, NSF, NFPA 54 and UL requirements.
- B. Coordinate with plumbing piping and related work to achieve an operating system.
- C. For gas-fired equipment, provide intake air, exhaust venting and associated piping in accordance with the requirements herein, local code requirements, and the manufacturer's recommendations.
 - 1. The material and installation provided must not only be compatible with the equipment served but must also be suited to and acceptable per project conditions.
 - 2. Any material to provided in a return air plenum must be compliant for such use.
 - 3. All piping and associated fittings provided shall be listed and labeled and tested in accordance with the applicable UL standard: UL 441 for Category I appliances and UL 1738 for Category II, III, and IV appliances.
 - 4. All flue system components, including, but not limited to: piping, fittings, transitions/adapters, supports, penetrations/terminations, and drain fittings shall be supplied from the same manufacturer.
 - 5. The pipe material shall be listed as an approved product for use with the equipment manufacturer. Compatibility with the equipment manufacturer shall be verified and documented.
 - 6. Any plastic piping outdoors shall be painted with latex paint for UV protection unless it is already furnished with such documented protection from the manufacturer.
- D. Provide a properly sized thermal expansion tank downstream of the associated check valve in the cold water supply to the heater.
- E. Provide a thermometer at the hot water outlet piping from each water heater (excluding instantaneous tankless electric water heaters).
- F. Provide a line sized shut-off valve in the cold water supply to and in the hot water outlet from each heater, close to each heater.
- G. Provide a vacuum relief valve in the cold water line above the top of each storage water heater. Devices shall comply with ANSI Z21.22.
- H. Provide approved heat traps at all storage type water heaters not furnished from the manufacturer with integral heat traps or heat trap nipples.
- I. Provide an approved combination temperature and pressure (T&P) relief valve at each water heater (excluding instantaneous tankless electric water heaters). Devices shall comply with ANSI Z21.22.
- J. Provide a line size plug cock in the gas supply close to each gas-fired water heater.
- K. Provide approved dielectric couplings at all hot and cold water connections to each heater/tank, and at the T&P relief valve connection.
- L. All tank type water heaters with more than 20 gallons of storage capacity shall be floor mounted on a concrete housekeeping pad, unless specifically indicated otherwise on the Drawings.
- M. Each tank type water heater shall be installed within a suitably sized galvanized drain pan. Securely elevate the base of each heater above the floor of the drain pan with structurally sound, non-ferrous, non-absorbent supports. Drain pan shall have no less than a 3/4" piped drain outlet.
- N. All heater drain lines shall be full size and routed to approved indirect waste receptors. Provide copper piping **except for** those drain lines serving condensate drain connections at condensing type equipment. For condensate drain lines provide schedule 40 PVC pipe and fittings with solvent welded joints.

- O. Provide manufacturer's condensate neutralization kit at all condensing type, gas-fired equipment to neutralize acidic condensate waste prior to discharge into an approved indirect waste receptor.
- P. Startup:
 - 1. Startup of all equipment shall be in strict accordance with manufacturer's recommendations.
 - 2. Ensure that storage type water heaters are full of water and downstream fixtures have been run for no less than 3 minutes in order to purge any trapped air from the tank prior to equipment startup.
- Q. In addition to the requirements above, at all domestic water heating equipment classified as a boiler, ensure to provide an approved backflow preventer with an intermediate atmospheric vent downstream of the cold water isolation valve and prior to the cold water inlet connection to the equipment. All such devices shall be ASSE 1012 compliant.

3.2 PUMP INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide air cock and drain connection on horizontal pump casings.
- C. Provide line sized isolating valve and strainer on suction and line sized soft seated check valve and balancing valve on discharge.
- D. Provide line sized isolating valve and line sized soft seated check valve on each submersible or sump pump discharge. Ensure to drill a 3/16" diameter horizontal weep hole near the base of the discharge piping to allow for venting and prevent air lock of the pump.
- E. Provide line sized isolating valve and strainer at inlet and line sized soft seated check valve and line sized isolating valve at outlet of each in line circulator pump. Provide unions on both sides of pump.
- F. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. Provide supports under elbows on pump suction and discharge line sizes 4 inches and over.
- G. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
- H. Align and verify alignment of base mounted pumps prior to start-up. Provide alignment certificate to engineer prior to start-up.

END OF SECTION

**SECTION 22 40 00
PLUMBING FIXTURES**

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 22 02 00 - Basic Materials and Methods for Plumbing shall be included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. The scope of the work shall include the furnishing and complete installation of the fixtures covered by this Section, with all appurtenances, ready for the Owner's use.
- B. Include the following work in addition to items normally part of this Section:
 - 1. Plumbing Fixtures
 - 2. Fixture Carriers
 - 3. Faucets, Supplies, and Trim
 - 4. Flushometers

1.3 RELATED WORK

- A. Section 22 05 29 - Hangers and Support for Plumbing Piping and Equipment
- B. Section 22 10 00 - Plumbing Piping
- C. Section 22 11 19 - Plumbing Specialties
- D. Section 22 30 00 - Plumbing Equipment

1.4 REFERENCES

- A. ASME A112.4.3 - Plastic Fittings for Connecting Water Closets to the Sanitary Drainage System
- B. ASME A112.6.1M - Supports for Off-the-Floor Plumbing Fixtures for Public Use.
- C. ASME A112.18.1 - Plumbing Supply Fittings
- D. ASME A112.18.2 - Plumbing Waste Fittings
- E. ASME A112.18.9 - Protectors/Insulators for Exposed Waste and Supplies on Accessible Fixtures
- F. ASME A112.19.1 - Enameled Cast Iron and Enameled Steel Plumbing Fixtures
- G. ASME A112.19.2 - Ceramic Plumbing Fixtures
- H. ASME A112.19.3 - Stainless Steel Plumbing Fixtures
- I. ASME A112.19.7 - Hydromassage Bathtub Systems
- J. NSF/ANSI 61 - Drinking Water System Components - Health Effects
- K. ANSI Z358.1 - Emergency Eyewash and Shower Equipment
- L. ASSE 1016 - Performance Requirements for Individual Thermostatic, Pressure Balancing, and Combination Pressure Balancing and Thermostatic Control Valves for Individual Fixture Fittings.
- M. ASSE 1037 - Performance Requirements for Pressurized Flushing Devices for Plumbing Fixtures
- N. ADA (Americans with Disabilities Act)
- O. TAS (Texas Accessibility Standards)

1.5 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by the same manufacturer throughout.

- B. Warranty: Warrant the work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from defective or non-conforming materials and workmanship.
- C. Defects shall include, but not necessarily be limited to, the following:
 - 1. Noisy operation.
 - 2. Noticeable deterioration of finish.
 - 3. Leakage of water.

1.6 SUBMITTALS

- A. Submit under provisions of Division One.
- B. Submit product data under provisions of Division One.
- C. Include component sizes, rough-in requirements, service sizes, finishes, materials, dimensions, performance information, and accessories.
- D. Manufacturer's Installation Instructions: Indicate assembly and support requirements.

1.7 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division One.
- B. Provide pre-printed operating and maintenance instructions for each item specified. Instruct and demonstrate the proper operation and maintenance to the Owner's designated representative.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. DELIVERY: Deliver clearly labeled specialties to; and store, protect and handle products on site in accordance with the provisions of Division One.
- B. TIMING AND COORDINATION: Arrange for delivery of materials to allow for minimum storage time at the project site. Coordinate with the scheduled time of installation.
- C. ACCEPTANCE: Accept specialties on site in original factory packaging. Inspect for damage. Damaged specialties shall not be acceptable.
- D. STORAGE: Store materials in a clean, dry location, protected from weather and damage.

1.9 FIELD MEASUREMENTS

- A. Verify that field measurements are as indicated on the Contract Documents.
- B. Confirm and field coordinate that millwork is constructed with adequate provisions for the installation of counter top lavatories and sinks.

PART 2 - PRODUCTS

2.1 PLUMBING FIXTURES

- A. GENERAL: Provide plumbing fixtures in accordance with manufacturer's recommendations and as indicated and scheduled on Drawings. Acceptable manufacturers of each fixture type are as indicated below.
 - 1. Provide floor-affixed fixture carriers as appropriate for all wall-hung plumbing fixtures unless specifically noted otherwise.
 - 2. Fixture drilling shall match faucet spread and match any related trim and accessories.
- B. WATER CLOSETS, URINALS, LAVATORIES (Vitreous China)
 - 1. American Standard
 - 2. Kohler
 - 3. Zurn
 - 4. Sloan

- 5. Toto
- C. SINKS - COUNTER MOUNTED (Stainless Steel)
 - 1. Elkay
 - 2. Just
 - 3. Acorn
- D. SINKS - FREESTANDING (Stainless Steel)
 - 1. Elkay
 - 2. Just
 - 3. Advance Tabco
 - 4. Amtekco Industries
- E. SHOWER ENCLOSURES
 - 1. Comfort Designs
 - 2. Aquarius Bathware
 - 3. Hamilton Bathware
- F. WASH FOUNTAINS AND SOLID SURFACE LAVATORY SYSTEMS
 - 1. Acorn
 - 2. Bradley
 - 3. Willoughby Industries
- G. MOP SINKS
 - 1. Stern-Williams
 - 2. Fiat
 - 3. E.L. Mustee & Sons
- H. DRINKING FOUNTAINS AND WATER COOLERS
 - 1. Halsey Taylor
 - 2. Elkay
 - 3. Haws
 - 4. Oasis

2.2 FAUCETS, SUPPLIES, AND TRIM

- A. GENERAL: Provide faucets, supplies, and trim in accordance with manufacturer's recommendations, as appropriate for fixtures to be served, and as indicated and scheduled on Drawings. Acceptable manufacturers for each type of appurtenance are as indicated below.
 - 1. Flushometer flush rate shall match gallon-per-flush criteria of fixtures served.
 - 2. Strainers shall be heavy cast brass chrome plated with matching grid type strainer, with or without overflow as required, 17 gauge seamless brass tailpiece of length determined by installation requirements. Provide complete with washers and brass locknut.
 - 3. P-traps shall be 17 gauge seamless chrome plated brass, adjustable type. Provide complete with cleanout plug, chrome plated brass slip nuts, wall bend, and wrought brass escutcheon of depth determined by installation requirements.
 - 4. Angle stops shall be lead-free commercial pattern chrome plated brass, quarter turn ball type with loose key handles. Provide complete with chrome plated copper supply risers and wrought brass escutcheon of depth determined by installation requirements.
 - 5. Toilet seats shall be commercial grade and provided complete with stainless steel posts and self-sustaining check hinges.
 - 6. Pipe trim insulation shall be compliant, white molded vinyl, fade/discoloration-resistant, bacteria/fungal-resistant insulation.

7. Where an exposed flush valve assembly will conflict with the installation height of a grab bar or where there will be insufficient clearance above the top cover of an exposed flush valve for maintenance access relative to the installation height of a grab bar, provide an offset type flush valve tube. Make water rough-in and other adjustments as necessary for a compliant and functioning installation.
- B. FAUCETS
1. Chicago
 2. T&S Brass
 3. Zurn
 4. Moen Commercial
 5. Delta Commercial
 6. American Standard
 7. Kohler
 8. Symmons Commercial
 9. Speakman
- C. SHOWER VALVES
1. Acorn
 2. MGI Controls
 3. Bradley
 4. Symmons Commercial
 5. Chicago
 6. Powers
 7. Zurn
 8. Speakman
- D. FLUSHOMETERS
1. Sloan
 2. Zurn
 3. Moen Commercial
 4. Delta Commercial
 5. American Standard
 6. Toto
- E. SUPPLY STOPS
1. McGuire
 2. Zurn
 3. Chicago
 4. Dearborn Brass
 5. Brasscraft
- F. CHROME PLATED TUBULAR BRASS
1. McGuire
 2. Zurn
 3. Kohler
 4. Dearborn Brass
 5. Brasscraft
- G. TOILET SEATS
1. Church
 2. Bemis
 3. American Standard
 4. Zurn
 5. Toto
 6. Centoco
- H. PIPE TRIM INSULATION

1. Truebro
2. McGuire
3. Plumberex

2.3 FIXTURE CARRIERS

- A. GENERAL: ASME A112.6.1M; Provide floor-affixed fixture carriers as appropriate for all wall-hung plumbing fixtures unless specifically noted otherwise. Fixture carrier foot supports shall be securely anchored to the floor with 1/2" bolts and anchors at all locations.
 1. Chair type carriers shall be adjustable, with coated cast iron body with integral no hub waste and vent connections, complete with gasketed adjustable faceplate assembly, adjustable nipple with test cap, neoprene bowl gasket, lugs for floor and wall attachment, threaded fixture studs, and hardware. Provide single or double type of vertical or horizontal configuration as required and with auxiliary inlet as required.
 2. Lavatory carriers shall be adjustable, with steel uprights and welded base feet, coated cast iron support brackets, cast or ductile iron concealed support arms, alignment rod, complete with leveling and support hardware. Provide single or back to back configuration as required.
 3. Drinking fountain and urinal carriers shall be adjustable, with steel uprights and welded base feet, upper and lower bearing plates, threaded rods, and mounting hardware. Provide single or side-by-side configuration as required
- B. ACCEPTABLE MANUFACTURERS
 1. J.R. Smith
 2. Zurn
 3. Mifab
 4. Watts
 5. Wade
 6. Josam

PART 3 - EXECUTION

3.1 PREPARATION

- A. EXAMINATION OF CONDITIONS: Examine conditions affecting this work. Report unsatisfactory conditions to the proper authority and do not proceed until those conditions have been corrected. Commencing work implies acceptance of existing conditions as satisfactory to the outcome of this work.
- B. Coordinate cutting of roof construction to receive drains to required invert elevations.

3.2 INSTALLATION

- A. Install fixtures in locations and heights as shown on Drawings and as directed by the Architect.
- B. Install materials plumb, level, securely, and in accordance with manufacturer's recommendations.
- C. All rough-in pipe openings for final connections with supply, waste, vent, and storm systems shall be closed with caps or plugs during early stages of construction and installation. Tape shall not be considered sufficient protection.
- D. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

- E. Provide ball valves in piping serving batteries of fixtures. Label stops "Hot" and "Cold." Valves shall be located above accessible ceilings. If ceilings are not accessible, provide access panels of adequate size to ensure valves are fully accessible and can be fully operated.
- F. Provide lockable ball valves in piping serving emergency safety fixtures and clearly label such valves as to the fixtures served.
- G. Plumbing fixtures shall be supported by a concealed carrier where required to properly support the fixture specified. All carriers to be securely mounted, bolted and checked prior to concealment.
- H. Caulk around fixtures with best grade white silicone caulking. Do not use grout.
- I. All handles on supply and drainage fittings or other brass items shall be properly lined up and adjusted. Fittings shall not be left in any haphazard manner.
- J. Fixtures shall have individual chrome plated heavy pattern loose key quarter-turn cutoff stops on supply lines, complete with escutcheons. Where same are not specified as a part of the fixture trim, they shall be installed as close to fixtures as possible in the hot and cold water supply. A loose key for each stop shall be provided to the Owner.
- K. Install each fixture with trap, easily removable for servicing and cleaning.
- L. All showers and similar installations shall be installed with type "L" copper pipe between shower valve and shower head rough-in. The termination point shall have a brass drop ear elbow for shower head arm connection. Contractor shall provide proper anchoring support.

3.3 INTERFACE WITH OTHER PRODUCTS

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.
- B. Review architectural drawings. Confirm configuration and orientation of shower controls and trim prior to rough-in and installation.

3.4 ADJUSTING

- A. Adjust work under provisions of Division One.
- B. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.5 CLEANING

- A. Clean work under provisions of Division One.
- B. At completion clean plumbing fixtures and appurtenances.

3.6 PROTECTION OF FINISHED WORK

- A. Protect finished Work under provisions of Division One.
- B. Do not permit use of fixtures.

3.7 ADA ACCESSIBLE FIXTURES

- A. At all locations required to be accessible, such fixtures, controls, and final installations shall comply with the requirements of ADA and any applicable state accessibility standards. Install fixtures to heights, indicated on architectural drawings.
- B. All exposed water supply and drain pipes under accessible lavatories and sinks shall be insulated with securely fastened pipe trim insulation kits of the proper model for the fixtures specified.

- C. Wall mounted drinking fountains and coolers which protrude into passages or corridor space, whether single or paired with an adjacent accessible fixture, shall be supplied with a matching skirt or apron to lower the underside clearance of the non-accessible fixture equal to that required for accessible fixture.

END OF SECTION

SECTION 22 61 00
COMPRESSED AIR SYSTEMS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 22 02 00 - Basic Materials and Methods for Plumbing shall be included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. The scope of the work shall include the furnishing and complete installation of the system covered by this Section, with all appurtenances, ready for the Owner's use.
- B. Include the following work in addition to items normally part of this Section:
 - 1. Compressed air pipe and fittings.
 - 2. Transitions, connectors, and valves.
 - 3. Filters, regulators, pressure gauges.
 - 4. Compressor and air dryer equipment.
- C. Refer to Division 26 sections for the following work not covered by this Section, and coordinate accordingly.
 - 1. Power supply wiring from power source to power connection on compressed air equipment. Include starters, disconnects, and required electrical devices, except where furnished or factory-installed by equipment manufacturer.
 - 2. Interlock wiring between electrically-operated compressed air equipment units and between equipment and any field-installed control devices, except where factory-installed by equipment manufacturer.
- D. Provide the following electrical work as part of this section, complying with requirements of Division 26 sections: Control wiring between field-installed controls, indicating devices, and unit control panels.

1.3 RELATED WORK

- A. Section 22 05 29 - Hangers and Support for Plumbing Piping and Equipment
- B. Section 22 05 48 - Vibration and Seismic Controls for Plumbing Piping
- C. Section 22 05 53 - Identification for Plumbing Piping and Equipment

1.4 REFERENCES

- A. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- B. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- C. ASME B31.3 - Process Piping.
- D. ASME B31.9 - Building Services Piping.
- E. ASME BPVC - Boiler and Pressure Vessel Code.
- F. ASTM B32 - Standard Specification for Solder Metal.
- G. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
- H. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
- I. CAGI - The Compressed Air and Gas Handbook.
- J. CAGI 3075 - B19.1 - Safety Standard for Compressor Systems.
- K. NSF 61 - Drinking Water System Components - Health Effects.
- L. NSF 372 - Drinking Water System Components - Lead Content.
- M. ASME Section IX -Welding and Brazing Qualifications.

- N. ASME B16.14 - Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads.
- O. ASTM A47 - Standard Specification for Ferritic Malleable Iron Castings.
- P. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.
- Q. ASTM B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
- R. AWS A5.8 -Specification for Filler Metals for Brazing and Braze Welding.
- S. AWS 5.31 - Specification for Fluxes for Brazing and Braze Welding.
- T. ASSE 1079 -Performance Requirements for Dielectric Pipe Unions.

1.5 QUALITY ASSURANCE

- A. Valves: Manufacturer's name, size, and pressure rating shall be cast or marked on valve body or handle.
- B. Piping shall be labeled along its entire length indicating size, class, material specification, manufacturer's name and country of origin.
- C. Foreign pipe, fittings or valves are unacceptable.
- D. Codes and Standards:
 - 1. ASME Compliance: Provide compressed air pressure vessels and relief valves in accordance with ASME BPVC; provide ASME Code Symbol Stamp.
 - 2. ASME Compliance: Fabricate and install compressed air systems in accordance with ASME B31.3 and ASME B31.9.
 - 3. CAGI Compliance: Fabricate and install compressed air systems in accordance with Compressed Air and Gas Institute Standards CAGI 3075 - B19.1.
 - 4. UL Compliance: Provide electrical components which are UL listed and have UL label affixed.

1.6 SUBMITTALS

- A. Submit under provisions of Division One.
- B. Product Data: Submit manufacturer's technical product data for compressed air pipe and fittings, connectors, filters, regulators, equipment and tanks. Include installation instructions for filters, regulators, equipment and tanks.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division One.
- B. Record actual locations of valves.

1.8 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division One.
- B. Operation Data: Include manufacturers' instructions, start-up data, and trouble-shooting check lists for compressors, tanks, air dryers, and regulators.
- C. Maintenance Data: Include manufacturers' literature, cleaning and maintenance procedures, replacement parts lists, and repair data for compressors, tanks, air dryers, regulators, and filters. Include wiring diagrams for electrically powered equipment.

1.9 QUALIFICATIONS

- A. Manufacturer: Company regularly engaged in the manufacture of compressed air systems equipment and products, of the types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

- B. Installer: Firm with at least 3 years of successful installation experience on projects with compressed air systems work similar to that required for the project.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. DELIVERY: Deliver clearly labeled equipment, tanks, piping and valves to; and store, protect and handle products on site in accordance with the provisions of Division One.
- B. TIMING AND COORDINATION: Arrange for delivery of materials to allow for minimum storage time at the project site. Coordinate with the scheduled time of installation.
- C. ACCEPTANCE: Accept equipment, tanks, and products on site in original factory packaging. Receive equipment, tanks, and valves on site in shipping containers with labeling in place. Inspect for damage. Damaged equipment, tanks, or valves shall not be acceptable.
- D. STORAGE: Store materials in a clean, dry location, protected from weather and damage.
- E. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- F. Protect installed piping systems from entry of foreign materials by providing temporary covers, as completing sections of the work, and isolating parts of completed systems. Tape will not be allowed as an acceptable end cover.

PART 2 - PRODUCTS

2.1 PIPE, FITTINGS, CONNECTORS, AND VALVES

- A. Pipe and fittings shall be:
 - 1. Copper Tubing: ASTM B88, Type L, hard drawn.
 - 2. Fittings: ASME B16.18, cast bronze or ASME B16.22 wrought copper alloy solder joint pressure fittings.
 - 3. Joints between copper pipe and fittings shall be made in accordance with ASTM B828 using ASTM B32 Alloy HB lead-free solder.
- B. Connectors at all piping to air compressors shall be:
 - 1. Flexible metallic type (no rubber or plastic components) connectors, capable of compensating for lateral movement and vibration.
 - 2. Suited for the maximum system operating pressure.
 - 3. Manufactured complete with section of 300 series stainless corrugated steel hose with outer braid, with inlet and outlet connections as required based on equipment connection size.
 - 4. Provided with double braid design to increase working pressure rating as necessary.
 - 5. Metraflex Company SSTC series or approved equivalent.
- C. Valves shall be:
 - 1. Ball type, all bronze cast construction two-piece 600 psi body, blow-out proof stem, Teflon seated, lead-free, with stainless steel trim (including ball, stem, and valve handle). Threaded connections. Certified lead-free to NSF 61/NSF 372 and suited to 180 degrees F.
 - 2. Basis of design (bronze valves):
 - a. NIBCO T-585-66-LF (full port) for all sizes up through 2".
 - b. NIBCO T-580-66-LF (conventional port) for sizes 2-1/2" and 3".
 - 3. Valves 4" and larger shall be split body stainless steel construction, 275 psi cold working pressure, blow-out proof stem, PTFE seated, type 316 stainless steel trimmed, class 150, full port design with manual gear operator. NIBCO F-515-S6-F-66-FS.

4. Acceptable alternate manufacturers: Apollo, Milwaukee.

2.2 AIR COMPRESSORS

- A. Acceptable Manufacturers:
 1. Ingersoll Rand
 2. Champion
 3. Gardner Denver
 4. Quincy Compressor
 5. Saylor-Beall
- B. Reciprocating type, electric driven, tank mounted air compressor assembly complete with:
 1. Cast iron constructed compressor pump(s)
 2. NEMA rated ODP electric motor
 3. ASME coded receiver tank with 0-300 psi air pressure gauge, ASME safety relief valve, manual drain and automatic tank drain
 4. Mounted and wired motor starter(s), magnetic
 5. Industrial grade intake filter and silencer
 6. Air cooled aftercooler
 7. Automatic start/stop operation with NEMA 1 pressure switch
 8. Vibration isolators
 9. Single point electrical connection, voltage indicated on Drawings.
- C. Compressor shall be designed to deliver the scheduled capacity as indicated on the Drawings.

2.3 AIR DRYERS

- A. Acceptable Manufacturers:
 1. Ingersoll Rand
 2. Champion
 3. Gardner Denver
 4. Quincy Compressor
 5. Saylor-Beall
- B. Unless indicated otherwise on the Drawings: Refrigerated type, floor mounted, electric-powered air dryer from the same manufacturer as the associated compressor unit and matched to the scheduled compressor capacity. Single point electrical connection, voltage indicated on Drawings.

2.4 APPURTENANCES

- A. Provide in-line central system air filters (1 micron rating unless indicated otherwise on Drawings), suited for the system demand, complete with pressure gauge and isolation valves. Located both upstream and downstream of the air dryer.
- B. Provide a regulator based, single point air system pressure controller, downstream of the final filter to adjust outgoing system pressure as indicated on the Drawings or as indicated by the Owner. Provide complete with pressure gauges on both sides of unit.
- C. Provide final filter/regulators, each complete with isolation valve, drain valve, and quick connect fitting(s) at each general purpose air drop.

2.5 BASIC VIBRATION CONTROL

- A. Provide heavy duty rubber vibration isolators beneath each air compressor unit complete with lag screws and other required hardware to mount the equipment to a concrete housekeeping pad in accordance with manufacturer's recommendations.

- B. Provide spring type hanger accessories for air system piping hangers adjacent to the compressor for a distance of no less than 20 feet. Eaton B-Line B3262 series or equivalent.
- C. General: Adhere to the requirements of Section 22 05 48.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. General requirements for piping:
 - 1. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
 - 2. Remove any scale, oil and dirt, on inside and outside, before assembly.
 - 3. Prepare piping connections to equipment with flanges or unions.
 - 4. Confirm pipe placement and elevation prior to any installation.
 - 5. All piping shall be installed free of sags and bends.
 - 6. Make branch connections from the top of the associated main.
 - 7. Provide piping with 1% downward slope in the direction of flow
 - 8. Provide a drip leg with drain valve at starting point of air system piping and provide auxiliary drain points as necessary (bottoms of risers and at low points).
- B. General requirements for valves:
 - 1. Install valves with stems upright or horizontal, not inverted.
 - 2. Valves shall be line-sized unless specifically noted otherwise.
 - 3. Provide clearance for access to valves and operable fittings. Valves that must be installed beyond reasonable reach shall be provided with a chain operator.
 - 4. Provide access doors where valves and operable fittings are not otherwise accessible. Access doors shall be of approved types set in locations pre-approved by submittal to the Architect.
- C. Install all materials in accordance with the manufacturer's published instructions.
- D. Route piping in an orderly manner, parallel and perpendicular to building column grid lines, unless indicated otherwise on Drawings, and maintain gradients.
- E. Install piping to conserve building space and not conflict with other trades or interfere with intended use of space.
- F. Group piping whenever practical at common elevations.
- G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- H. Support and label all piping, valves, and equipment in accordance with the requirements of related Sections.
- I. Provide male adapters each side of threaded valves in copper piped system. Sweat solder adapters to tube prior to make-up of threaded connections
- J. Solder joints shall be wiped clean at each joint, remove excess metal while molten and flux residue when cooled.
- K. Route drain lines to approved disposal points or indirect waste receptors.

3.2 INSTALLATION OF EQUIPMENT

- A. Ensure all compressed air equipment is provided with sufficient clearances for installation, operation, inspection, and maintenance and in accordance with manufacturer's recommendations.
- B. Provide 4" thick reinforced concrete housekeeping pad(s) for base-mounted equipment, to extend no less than 4" from equipment footprint on all sides. Cast anchor bolt inserts into pad(s).

- C. Provide compressor air intake from the outside air, with open end of intake pipe well hooded and screened to prevent rain and dust or dirt from entering. Route intake piping full size and as short and direct as possible, with long radius elbows where bends are necessary. For long lengths of run, piping shall be upsized accordingly.
- D. Intake pipe shall be located no less than 6 feet above ground and located clear from any exhaust outlets to prevent contamination.
- E. Slope discharge piping away from the compressor with sufficient pitch to prevent either condensate or oil draining back into the compressor.
- F. Provide union downstream of all valves at equipment or apparatus connections.
- G. Electrical Wiring: Install electrical devices furnished by manufacturer but not provided factory-mounted. Furnish a copy of the manufacturer's wiring diagram submittal to the Electrical Installer.
- H. Verify that electrical wiring installation is in accordance with the manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to the equipment installer.

3.3 CLEANING, TESTING, AND FIELD QUALITY CONTROL

- A. Blow out the system piping to ensure it is clear and free of all foreign matter or installation residue prior to connecting equipment or filters.
- B. Provide Architect/Engineer with reasonable advance notice of system testing, no less than 48 hours prior.
- C. Piping system shall be tested for leaks and integrity with clean, dry air at 150% of the system working pressure (but in no case less than 150 psi) for no less than one hour, with no leakage detected. If leaks are present, they shall be repaired. Test shall be repeated after repairs are completed and shall continue until such time as the entire test period expires without the discovery of any leaks.
- D. Gauges for pressure testing shall be incremented for 2% or less of the required test pressure with a pressure range not exceeding twice the test pressure applied.
- E. Start-up and test equipment for proper operation in accordance with manufacturer's recommendations. Test all alarms for both high pressure and low pressure conditions.
- F. Prior to turnover of the system to the Owner, ensure that all system filters are new and clean.

END OF SECTION

SECTION 23 02 00
BASIC MATERIALS AND METHODS FOR HVAC

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all Work herein.
- B. The Contract Drawings indicate the extent and general arrangement of the systems. If any departure from the Contract Drawings is deemed necessary by the Contractor, details of such departures and the reasons therefore, shall be submitted to the Architect/Engineer for review as soon as practicable. No such departures shall be made without the prior written approval of the Architect/Engineer.
- C. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name, make or catalog number, such reference shall not be construed as limiting competition; and the Contractor, in such cases, may at his option use any article, device, product, material, fixture, form or type of construction which in the judgment of the Architect/Engineer, expressed in writing, is the equivalent of that specified.

1.2 SCOPE OF WORK

- A. The Work included under this Contract consists of the furnishing and installation of all equipment and material necessary and required to form complete and functioning systems in all of their various phases, all as shown on the accompanying Drawings and/or described in these Specifications. The Contractor shall review all pertinent drawings, including those of other contracts, prior to commencement of Work.
- B. This Division requires the furnishing and installing of all items as specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, transportation, storage, equipment, utilities, all required permits, licenses and inspections. All work performed under this Section shall be in accordance with the Project Manual, Drawings and Specifications and is subject to the terms and conditions of the Contract.
- C. The approximate locations of Mechanical (HVAC) items are indicated on the Drawings. These Drawings are not intended to give complete and accurate details in regard to location of outlets, apparatus, etc. Exact locations are to be determined by actual measurements at the building, and will in all cases be subject to the review of the Owner or Engineer, who reserves the right to make any reasonable changes in the locations indicated without additional cost to the Owner.
- D. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.
- E. Any discrepancies within the Contract Documents or between the Contract Documents and actual job-site conditions shall be reported to the Owner or Engineer so that they will be resolved prior to bidding. Where this cannot be done at least seven (7) working days prior to bid, the greater or more costly of the discrepancy shall be bid. All labor and materials required to perform the work described shall be included as part of this Contract.

- F. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and fully operating system in cooperation with other trades.
- G. It is the intent of the above "Scope" to give the Contractor a general outline of the extent of the Work involved; however, it is not intended to include each and every item required for the Work. Anything omitted from the "Scope" but shown on the Drawings, or specified later, or necessary for a complete and functioning heating, ventilating and air conditioning system shall be considered a part of the overall "Scope".
- H. The Contractor shall rough-in fixtures and equipment furnished by others from rough-in and placement drawings furnished by others. The Contractor shall make final connection to fixtures and equipment furnished by others.
- I. The Contractor shall participate in the commissioning process as required; including, but not limited to, meeting attendance, completion of checklists, and participation in functional testing.

1.3 SCHEMATIC NATURE OF CONTRACT DOCUMENTS

- A. The Contract Documents are schematic in nature in that they are only to establish scope and a minimum level of quality. They are not to be used as actual working construction drawings. The actual working construction drawings shall be the reviewed shop drawings.
- B. All duct or pipe or equipment locations as indicated on the documents do not indicate every transition, offset, or exact location. All transitions, offsets, clearances and exact locations shall be established by actual field measurements, coordination with the structural, architectural and reflected ceiling plans, and other trades. Submit shop drawings for review.
- C. All transitions, offsets and relocations as required by actual field conditions shall be performed by the Contractor at no additional cost to the Owner.
- D. Additional coordination with electrical contractor may be required to allow adequate clearances of electrical equipment, fixtures and associated appurtenances. Contractor to notify Architect and Engineer of unresolved clearances, conflicts or equipment locations.

1.4 SITE VISIT AND FAMILIARIZATION

- A. Before submitting a bid, it will be necessary for each Contractor whose work is involved to visit the site and ascertain for himself the conditions to be met therein in installing his work and make due provision for same in his bid. It will be assumed that this Contractor in submitting his bid has visited the premises and that his bid covers all work necessary to properly install the equipment shown. Failure on the part of the Contractor to comply with this requirement shall not be considered justification for the omission or faulty installation of any work covered by these Specifications and Drawings.
- B. Understand the existing utilities from which services will be supplied; verify locations of utility services, and determine requirements for connections.
- C. Determine in advance that equipment and materials proposed for installation fit into the confines indicated.

1.5 WORK SPECIFIED IN OTHER SECTIONS

- A. Finish painting is specified. Prime and protective painting are included in the work of this Division.
- B. Owner and General Contractor furnished equipment shall be properly connected to Mechanical (HVAC) systems.

- C. Furnishing and installing all required Mechanical (HVAC) equipment control relays and electrical interlock devices, conduit, wire and J-boxes are included in the Work of this Division.

1.6 PERMITS, TESTS, INSPECTIONS

- A. Arrange and pay for all permits, fees, tests, and all inspections as required by governmental authorities.

1.7 DATE OF SUBSTANTIAL COMPLETION

- A. The date of final acceptance shall be the date of substantial completion. Refer to Division One for additional requirements.
- B. The date of final acceptance shall be documented in writing and signed by the Architect, Owner and Contractor.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
- B. Deliver products to the project at such time as the project is ready to receive the equipment, pipe or duct - properly protected from incidental damage and weather damage.
- C. Damaged equipment, duct or pipe shall be promptly removed from the site and new, undamaged equipment, pipe or duct shall be installed in its place promptly with no additional charge to the Owner.

1.9 NOISE AND VIBRATION

- A. The heating, ventilating and air conditioning systems, and the component parts thereof, shall be guaranteed to operate without objectionable noise and vibration.
- B. Provide foundations, supports and isolators as specified or indicated, properly adjusted to prevent transmission of vibration to the building structure, piping and other items.
- C. Carefully fabricate ductwork and fittings with smooth interior finish to prevent turbulence and generation or regeneration of noise.
- D. All equipment shall be selected to operate with minimum of noise and vibration. If, in the opinion of the Architect, objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of the Work, the Contractor shall rectify such conditions without extra cost to the Owner.

1.10 DELEGATED DESIGN FOR ANCHORAGE OF ROOF MOUNTED EQUIPMENT

- A. The Contractor shall engage a qualified professional engineer to design all roof mounted equipment curbs, equipment supports, equipment tie downs, equipment connections, and methods of attachment for components that are to be anchored to the building structure. The design shall comply with wind load and uplift requirements utilizing design criteria per ICC (IBC) and ASCE 7 unless criteria is otherwise indicated in the Construction Documents.
- B. Submittal: Signed and sealed engineering analysis data and accompanying details, drawings, and supplemental installation information shall be submitted to the engineer for review.

1.11 APPLICABLE CODES AND STANDARDS

- A. Obtain all required permits and inspections for all work required by the Contract Documents and pay all required fees in connection thereof.

- B. Arrange with the serving utility companies for the connection of all required utilities and pay all charges, meter charges, connection fees and inspection fees, if required.
- C. Comply with all applicable codes, specifications, local ordinances, industry standards, utility company regulations and the applicable requirements which includes and is not limited to the following nationally accepted codes and standards:
 - 1. Air Moving & Conditioning Association, AMCA.
 - 2. American Standards Association, ASA.
 - 3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., ASHRAE.
 - 4. American Society of Mechanical Engineers, ASME.
 - 5. American Society of Plumbing Engineers, ASPE.
 - 6. American Society of Testing Materials, ASTM.
 - 7. American Water Works Association, AWWA.
 - 8. National Bureau of Standards, NBS.
 - 9. National Fire Protection Association, NFPA.
 - 10. Sheet Metal & Air Conditioning Contractors' National Association, SMACNA.
 - 11. Underwriters' Laboratories, Inc., UL.
 - 12. International Building Code, IBC.
 - 13. International Energy Conservation Code, IECC.
 - 14. International Fire Code, IFC.
 - 15. International Fuel Gas Code, IFGC.
 - 16. International Mechanical Code, IMC.
- D. Where differences existing between the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the nationally accepted codes and standards, the more stringent or costly application shall govern. Promptly notify the Engineer in writing of all differences.
- E. When directed in writing by the Engineer, remove all work installed that does not comply with the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the above listed nationally accepted codes and standards, correct the deficiencies, and complete the work at no additional cost to the Owner.

1.12 DEFINITIONS AND SYMBOLS

- A. General Explanation: A substantial amount of construction and Specification language constitutes definitions for terms found in other Contract Documents, including Drawings which must be recognized as diagrammatic and schematic in nature and not completely descriptive of requirements indicated thereon. Certain terms used in Contract Documents are defined generally in this article, unless defined otherwise in Division 01.
- B. Definitions and explanations of this Section are not necessarily either complete or exclusive, but are general for work to the extent not stated more explicitly in another provision of the Contract Documents.
- C. Indicated: The term "Indicated" is a cross-reference to details, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in Contract Documents. Where such terms as "Shown", "Noted", "Scheduled", "Specified" and "Detailed" are used in lieu of "Indicated", it is for the purpose of helping the reader locate cross-reference material, and no limitation of location is intended except as specifically shown.

- D. Directed: Where not otherwise explained, terms such as "Directed", "Requested", "Accepted", and "Permitted" mean by the Architect or Engineer. However, no such implied meaning will be interpreted to extend the Architect's or Engineer's responsibility into the Contractor's area of construction supervision.
- E. Reviewed: Where used in conjunction with the Engineer's response to submittals, requests for information, applications, inquiries, reports and claims by the Contractor the meaning of the term "Reviewed" will be held to limitations of Architect's and Engineer's responsibilities and duties as specified in the General and Supplemental Conditions. In no case will "Reviewed" by Engineer be interpreted as a release of the Contractor from responsibility to fulfill the terms and requirements of the Contract Documents.
- F. Furnish: Except as otherwise defined in greater detail, the term "Furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.
- G. Install: Except as otherwise defined in greater detail, the term "Install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance.
- H. Provide: Except as otherwise defined in greater detail, the term "Provide" is used to mean "Furnish and Install", complete and ready for intended use, as applicable in each instance.
- I. Installer: Entity (person or firm) engaged by the Contractor, or its Subcontractor or Sub-subcontractor for performance of a particular unit of work at the project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance. It is a general requirement that such entities (Installers) be expert in the operations they are engaged to perform.
- J. Imperative Language: Used generally in Specifications. Except as otherwise indicated, requirements expressed imperatively are to be performed by the Contractor. For clarity of reading at certain locations, contrasting subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor or, when so noted, by other identified installers or entities.
- K. Minimum Quality/Quantity: In every instance, the quality level or quantity shown or specified is intended as minimum quality level or quantity of work to be performed or provided. Except as otherwise specifically indicated, the actual work may either comply exactly with that minimum (within specified tolerances), or may exceed that minimum within reasonable tolerance limits. In complying with requirements, indicated or scheduled numeric values are either minimums or maximums as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to Owner or Engineer via a request for information (RFI) for decision before proceeding.

- L. Abbreviations and Symbols: The language of Specifications and other Contract Documents including Drawings is of an abbreviated type in certain instances, and implies words and meanings which will be appropriately interpreted. Actual word abbreviations of a self-explanatory nature have been included in text of Specifications and Drawings. Specific abbreviations and symbols have been established, principally for lengthy technical terminology and primarily in conjunction with coordination of Specification requirements with notations on Drawings and in Schedules. These are frequently defined in Section at first instance of use or on a Legend and Symbol Drawing. Trade and industry association names and titles of generally recognized industry standards are frequently abbreviated. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicate. Except as otherwise indicated, graphic symbols and abbreviations used on Drawings and in Specifications are those recognized in construction industry for indicated purposes. Where not otherwise noted symbols and abbreviations are defined by the latest ASHRAE Fundamentals Handbook, Chapter 39 "Abbreviations and Symbols", ASME and ASPE published standards.

1.13 DRAWINGS AND SPECIFICATIONS

- A. These Specifications are intended to supplement the Drawings and it will not be the province of the Specifications to mention any part of the Work which the Drawings are competent to fully explain in every particular and such omission is not to relieve the Contractor from carrying out portions indicated on the Drawings only.
- B. Should items be required by these Specifications and not indicated on the Drawings, they are to be supplied even if of such nature that they could have been indicated thereon. In the event of discrepancy between Drawings and Specifications, or within either Drawings or Specifications, the greater or more costly of the discrepancy shall be estimated and the matter referred to the Architect or Engineer for review with a request for information and clarification at least seven (7) working days prior to bid opening date for issuance of an addendum.
- C. The listing of product manufacturers, materials and methods in the various sections of the Specifications, and indicated on the Drawings, is intended to establish a standard of quality only. It is not the intention of the Owner or Engineer to discriminate against any product, material or method that is the equivalent of the standards as indicated and/or specified, nor is it intended to preclude open, competitive bidding. The fact that a specific manufacturer is listed as an acceptable manufacturer should not be interpreted to mean that the manufacturer's standard product will meet the requirements of the project design, Drawings, Specifications and space constraints.
- D. The Architect or Engineer and Owner shall be the sole judge of quality and equivalence of equipment, materials and methods.
- E. Products by other reliable manufacturers, other materials, and other methods, will be accepted as outlined, provided they have equivalent capacity, construction, and performance. However, under no circumstances shall any substitution be made without the written permission of the Architect or Engineer and Owner. Request for prior approval must be made in writing 10 calendar days prior to the bid date without fail.
- F. Wherever a definite product, material or method is specified and there is not a statement that another product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method is the only one that shall be used without prior approval.

- G. Wherever a definite material or manufacturer's product is specified and the Specification states that products of similar design and equivalent construction from the specified list of manufacturers may be substituted, it is the intention of the Owner or Engineer that products of manufacturers that are specified are the only products that will be acceptable and that products of other manufacturers will not be considered for substitution without approval.
- H. Wherever a definite product, material or method is specified and there is a statement that "OR EQUIVALENT" product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method or an "OR EQUIVALENT" product, material or method may be used if it complies with the Specifications and is submitted for review to the Engineer as outline herein.
- I. Where permission to use substituted or alternative equipment on the project is granted by the Owner or Engineer in writing, it shall be the responsibility of the Contractor or Subcontractor involved to verify that the equipment will fit in the space available which includes allowances for all required Code and maintenance clearances, and to coordinate all equipment structural support, plumbing and electrical requirements and provisions with the Mechanical (HVAC) Design Documents and all other trades, including Division 26.
- J. Changes in architectural, structural, electrical, mechanical, and plumbing requirements for the substitution shall be the responsibility of the bidder wishing to make the substitution. This shall include the cost of redesign by the affected designer(s). Any additional cost incurred by affected Subcontractors shall be the responsibility of this bidder and not the Owner.
- K. If any request for a substitution of product, material or method is rejected, the Contractor will automatically be required to furnish the product, material or method named in the Specifications. Repetitive requests for substitutions will not be considered.
- L. The Owner or Engineer will investigate all requests for substitutions when submitted in accordance with the requirements listed above; and if accepted, will issue a letter allowing the substitutions.
- M. Where equipment other than that used in the design as specified or shown on the Drawings is substituted (either from an approved manufacturers list or by submittal review), it shall be the responsibility of the substituting Contractor to coordinate space requirements, building provisions and connection requirements with their respective trade(s) and all other trades; and to pay all additional costs to other trades, the Owner, the Architect or Engineer, if any, due to the substitutions.

1.14 SUBMITTALS

- A. Coordinate with Division 01 for submittal timetable requirements, unless noted otherwise within thirty (30) days after the Contract is awarded. The Contractor shall submit an electronic copy of a complete set of shop drawings and complete data covering each item of equipment or material. The submittal of each item requiring a submittal must be received by the Architect or Engineer within the above thirty-day period. The Architect or Engineer shall not be responsible for any delays or costs incurred due to excessive shop drawing review time for submittals received after the thirty (30) day time limit. The Architect and Engineer will retain a copy of all shop drawings for their files. All literature pertaining to items subject to Shop Drawing submittal shall be submitted at one time. Submittals shall be placed in one electronic file in PDF format and bookmarked for individual specification sections. Individual electronic files of submittals for individual specifications shall not be permitted. Each submittal shall include the following items:

1. A cover sheet with the names and addresses of the Project, Architect, MEP Engineer, General Contractor and the Subcontractor making the submittal. The cover sheet shall also contain the section number covering the item or items submitted and the item nomenclature or description.
 2. An index page with a listing of all data included in the Submittal.
 3. A list of variations page with a listing of all variations, including unfurnished or additional required accessories, items or other features, between the submitted equipment and the specified equipment. If there are no variations, then this page shall state "NO VARIATIONS". Where variations affect the work of other Contractors, then the Contractor shall certify on this page that these variations have been fully coordinated with the affected Contractors and that all expenses associated with the variations will be paid by the submitting Contractor. This page will be signed by the submitting Contractor.
 4. Equipment information including manufacturer's name and designation, size, performance and capacity data as applicable. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.
 5. Dimensional data and scaled drawings as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances clearly indicated and labeled at a minimum scale of $1/4" = 1'-0"$, as required to demonstrate that the alternate or substituted product will fit in the space available.
 6. Identification of each item of material or equipment matching that indicated on the Drawings.
 7. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Drawings and Specifications. Any options or special requirements or accessories shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method.
 8. Additional information as required in other Sections of this Division.
 9. Certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Drawings and Specifications, signed and dated in long hand. Submittals that do not comply with the above requirements shall be returned to the Contractor and shall be marked "REVISE AND RESUBMIT".
- B. Refer to Division 00 and Division 01 for additional information on shop drawings and submittals.
- C. Equipment and materials submittals and shop drawings will be reviewed for compliance with design concept only. It will be assumed that the submitting Contractor has verified that all items submitted can be installed in the space allotted. Review of shop drawings and submittals shall not be considered as a verification or guarantee of measurements or building conditions.
- D. Where shop drawings and submittals are marked "REVIEWED", the review of the submittal does not indicate that submittals have been checked in detail nor does it in any way relieve the Contractor from his responsibility to furnish material and perform work as required by the Contract Documents.
- E. Shop drawings shall be reviewed and returned to the Contractor with one of the following categories indicated:
1. REVIEWED: Contractor need take no further submittal action, shall include this submittal in the O&M manual and may order the equipment submitted on.

2. REVIEWED AS NOTED: Contractor shall submit a letter verifying that required exceptions to the submittal have been received and complied with including additional accessories or coordination action as noted, and shall include this submittal and compliance letter in the O&M manual. The contractor may order the equipment submitted on at the time of the returned submittal providing the Contractor complies with the exceptions noted.
 3. NOT APPROVED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is not approved. The Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or Drawings. Contractor shall not order equipment that is not approved. Repetitive requests for substitutions will not be considered.
 4. REVISE AND RESUBMIT: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked revise and resubmit. The Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or provide as noted on previous shop drawings. Contractor shall not order equipment marked revise and resubmit. Repetitive requests for substitutions will not be considered.
 5. CONTRACTOR'S CERTIFICATION REQUIRED: Contractor shall resubmit submittal on material, equipment or method of installation. The Contractor's stamp is required stating that the submittal meets all conditions of the Contract Documents. The stamp shall be signed by the General Contractor. The submittal will not be reviewed if the stamp is not placed and signed on all shop drawings.
 6. MANUFACTURER NOT AS SPECIFIED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked manufacturer not as specified. The Contractor will automatically be required to furnish the product, material or method named in the Specifications. Contractor shall not order equipment when submittal is marked manufacturer not as specified. Repetitive requests for substitutions will not be considered.
- F. Materials and equipment which are purchased or installed without submittal review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by the Owner or Engineer for any reason shall be at the expense of the Contractor. The responsible Contractor shall remove the material and equipment noted above and replace with specified equipment or material at his own expense when directed in writing by the Architect or Engineer.
- G. Shop Drawing Submittals shall be complete and checked prior to submission to the Engineer for review.
- H. Submittals are required for, but not limited to, the following items subject to project requirements:
1. Coordination Drawings
 2. Common Motor Requirements for HVAC Equipment
 3. Expansion Fittings and Loops for HVAC Piping
 4. Hangers and Support for Piping and Equipment HVAC
 5. Vibration and Seismic Controls for HVAC Piping and Equipment
 6. Testing, Adjusting, and Balancing
 7. Duct Insulation
 8. HVAC Piping Insulation
 9. Energy Management and Control System
 10. Above Ground Hydronic Piping
 11. Refrigerant Piping

12. Metal Ductwork
 13. Ductwork Accessories
 14. HVAC Fans
 15. High-Volume Low-Speed Propeller Fans
 16. Air Distribution Devices
 17. HVAC Gravity Ventilators
 18. Air Filters
 19. Flue Pipe Systems
 20. Gas Fired Furnaces
 21. Split System Air-Conditioners - Wall-Mounted
 22. Fan Coil Unit
 23. Electric Unit Heaters
- I. Refer to other Division 23 sections for additional submittal requirements. Provide samples of actual materials and/or equipment to be used on the Project upon request of the Owner or Engineer.

1.15 COORDINATION DRAWINGS

- A. Prepare coordination drawings to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
 - a. Wall and type locations.
 - b. Clearances for installing and maintaining insulation.
 - c. Locations of light fixtures and sprinkler heads.
 - d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - e. Equipment connections and support details.
 - f. Exterior wall and foundation penetrations.
 - g. Routing of storm and sanitary sewer piping.
 - h. Fire-rated wall and floor penetrations.
 - i. Sizes and location of required concrete pads and bases.
 - j. Valve stem movement.
 - k. Structural floor, wall and roof opening sizes and details.
 2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
 3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.
- B. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.

- C. By submitting coordination drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

1.16 RECORD DOCUMENTS

- A. Prepare Record Documents in accordance with the requirements of Division 00 and Division 01, in addition to the requirements specified in Division 23.
- B. The Contractor shall maintain a separate set of clearly and legibly marked Record Drawings on the job site to record all changes and modifications, including, but not limited to the following: work details, alterations to meet site conditions, and changes made by "Change Order" notices. Mark the drawings with colored pencil(s). These shall be available for review by the Owner, Architect or Engineer during the entire construction stage.
- C. The Record Drawings shall be updated concurrently as construction progresses, and in no case less frequently than a daily basis. They shall indicate accurate dimensions for all buried or concealed work, precise locations of all concealed pipe or duct, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents. All dimensions shall include at least two dimensions to permanent structure points.
- D. Record Drawings shall indicate, at a minimum, the following installed conditions:
 - 1. Duct mains and branches, size and location, for both exterior and interior; locations of dampers, fire dampers, duct access panels, and other control devices; filters, fuel fired heaters, fan coils, condensing units, and roof-top A/C units requiring periodic maintenance or repair.
 - 2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.
 - 3. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 - 4. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
 - 5. Contract Modifications, actual equipment and materials installed.
- E. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified herein to record the locations and invert elevations of underground installations.
- F. If the Contractor does not keep an accurate set of Record Drawings, the pay request may be altered or delayed at the request of the Architect. Delivery of Record Documents is a condition of final acceptance. Record Drawings shall be furnished in addition to Shop Drawings.
- G. The Contractor shall submit an electronic copy of the record documents in PDF format and one (1) full size set of Record Drawing prints to the Architect or Engineer for review prior to scheduling the final inspection at the completion of the work. The drawings shall have the name(s) and seal(s) of the Engineer(s) removed or blanked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS

DATE:

(NAME OF GENERAL CONTRACTOR)

BY: _____

(SIGNATURE)
(NAME OF SUBCONTRACTOR)
BY: _____
(SIGNATURE)

1.17 OPERATING AND MAINTENANCE MANUALS

- A. Prepare operating and maintenance manuals in accordance with Division 00 and Division 01 and, in addition to the requirements specified in those Divisions, include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - a. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - b. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - c. Servicing instructions and lubrication charts and schedules.

1.18 CERTIFICATIONS AND TEST REPORTS

- A. Submit a detailed schedule for completion and testing of each system indicating scheduled dates for completion of system installation and outlining tests to be performed and scheduled date for each test. This detailed completion and test schedule shall be submitted at least 90 days before the projected substantial completion date.
- B. Test result reporting forms shall be submitted for review no later than the date of the detailed schedule.
- C. Submit 4 copies of all certifications and test reports to the Architect or Engineer for review adequately in advance of substantial completion of the Work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.
- D. Certifications and test reports to be submitted shall include, but not be limited to, those items outlined in Section 23 02 00.

1.19 OPERATING AND MAINTENANCE MANUALS

- A. Prepare Operations and Maintenance manuals in accordance with the requirements of Division 01 and Division 23. In addition to the requirements of other Sections, this shall include the following information for equipment items:
 - 1. Identifying names, name tags designations and locations for all equipment.
 - 2. Valve tag lists with valve number, type, color coding, location and function.
 - 3. Reviewed Shop Drawing submittals with exceptions noted compliance letter.
 - 4. Fabrication drawings.
 - 5. Equipment and device bulletins and data sheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable, i.e., description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and model numbers of replacement parts.

6. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 7. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 8. Servicing instructions and lubrication charts and schedules.
 9. Equipment and motor name plate data.
 10. Wiring diagrams.
 11. Exploded parts views and parts lists for all equipment and devices.
 12. Color coding charts for all painted equipment and conduit.
 13. Location and listing of all spare parts and special keys and tools furnished to the Owner.
 14. Furnish recommended lubrication schedule for all required lubrication points with listing of type and approximate amount of lubricant required.
- B. Coordinate with Division 01 for Operations and Maintenance manual requirements. Unless noted otherwise, bind together in "D ring" style three-ring binders (National model no. 79-883 or equivalent). Binders shall be large enough to allow ¼" of spare capacity. Include three (3) sets with all approved Shop Drawing submittals, fabrication drawings, bulletins, maintenance instructions, operating instructions and parts exploded views and lists for each and every piece of equipment furnished under this Specification. All sections shall be typed and indexed into sections with tabbed insertable dividers, labeled for easy reference. Utilize the individual specification section numbers shown in the Mechanical Specifications as an organization guideline. Bulletins containing information about equipment that is not installed on the project shall be properly marked up or stripped and reassembled. All pertinent information required by the Owner for proper operation and maintenance of equipment supplied by Division 23 shall be clearly and legibly set forth in memoranda that shall, likewise, be bound with bulletins.
- C. In addition to the bound "hard-copy" Operation and Maintenance manuals referenced above, provide an identical electronic copy in searchable PDF format, with all sections bookmarked within the file for easy reference. Provide a USB flash drive with the final manual to the Owner.
- D. Operating and Maintenance Manuals shall be turned over to the Owner or Engineer for review a minimum of fourteen (14) working days prior to the beginning of the operator training period.
- E. Operating and Maintenance Manuals which the Engineer deems incomplete, poorly organized, or otherwise unacceptable will be rejected in writing. The Contractor will subsequently be required to again turn over Operating and Maintenance Manuals, with all deficiencies corrected, until deemed acceptable by the Engineer.

1.20 OPERATOR TRAINING

- A. The Contractor shall furnish the services of factory trained specialists to instruct the Owner's operating personnel. The Owner's operator training shall include a minimum of 12 hours of onsite training in three (3) shifts of four (4) hours each.
- B. Before proceeding with the instruction of Owner Personnel, prepare a typed outline in triplicate, listing the subjects that will be covered in this instruction, and submit the outline for review by the Owner. At the conclusion of the instruction period, obtain the signature of each person being instructed on each copy of the reviewed outline to signify that he has a proper understanding of the operation and maintenance of the systems and resubmit the signed outlines.
- C. Refer to other Division 23 Sections for additional Operator Training requirements.

1.21 FINAL COMPLETION

- A. At the completion of the Work, all equipment and systems shall be tested and faulty equipment and material shall be repaired or replaced. Refer to Sections of Division 23 for additional requirements.
- B. Clean and adjust all air distribution devices and replace all air filters immediately prior to Substantial Completion.
- C. Touch up and/or refinish all scratched equipment and devices immediately prior to Substantial Completion.

1.22 CONTRACTOR'S GUARANTEE

- A. Use of the HVAC systems to provide temporary service during construction period will not be allowed without permission from the Owner in writing; and, if granted, shall not cause the warranty period to start, except as defined below.
- B. Contractor shall guarantee to keep the entire installation in repair and perfect working order for a period of one year after the date of the Substantial Completion, and shall furnish (free of additional cost to the Owner) all materials and labor necessary to comply with the above guarantee throughout the year beginning from the date of Substantial Completion, Beneficial Occupancy by the Owner, or the Certificate of Final Payment as agreed upon by all parties.
- C. This guarantee shall not include cleaning or changing filters except as required by testing, adjusting and balancing.
- D. All air conditioning compressors shall have parts and labor guarantees provided by the equipment manufacturer for a period of not less than 5 years beyond the date of Substantial Completion.
- E. Refer to Sections in Division 23 for additional guarantee or warranty requirements.

1.23 TRANSFER OF ELECTRONIC FILES

- A. Project documents are not intended or represented to be suitable for reuse by Architect/Owner or others on extensions of this project or on any other project. Any such reuse or modification without written verification or adaptation by Engineer, as appropriate for the specific purpose intended, will be at Architect/Owner's risk and without liability or legal exposure to Engineer or its consultants from all claims, damages, losses and expense, including attorney's fees arising out of or resulting thereof.
- B. Because data stored in electronic media format can deteriorate or be modified inadvertently, or otherwise, without authorization of the data's creator, the party receiving the electronic files agrees that it will perform acceptance tests or procedures within sixty (60) days of receipt, after which time the receiving party shall be deemed to have accepted the data thus transferred to be acceptable. Any errors detected within the sixty (60) day acceptance period will be corrected by the party delivering the electronic files. Engineer is not responsible for maintaining documents stored in electronic media format after acceptance by the Architect/Owner.
- C. When transferring documents in electronic media format, Engineer makes no representations as to the long term compatibility, usability or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by Engineer at the beginning of the Project.
- D. Any reuse or modifications will be at the Contractor's sole risk and without liability or legal exposure to Architect, Engineer or any consultant.

- E. The Texas Board of Architectural Examiners (TBAE) has stated that it is in violation of Texas law for persons other than the Architect of record to revise the Architectural drawings without the Architect's written consent.
 - 1. It is agreed that "MEP" hard copy or computer-generated documents will not be issued to any other party except directly to the Architect/Owner. The Contract Documents are contractually copyrighted and cannot be used for any other project or purpose except as specifically indicated in AIA B-141 Standard Form of Agreement Between Architect and Owner.
 - 2. If the client, Architect or Owner of the project requires electronic media for "record purposes", then AutoCAD/ Revit documents will be prepared by Engineer on electronic media such as removable memory devices, flash drives or CD's. These documents can also be submitted via file transfer protocols. AutoCAD/ Revit files will be submitted with all title block references intact to permit the end user to only view and plot the drawings. Revisions will not be permitted in this configuration.
 - 3. At the Architect/Owner's request, Engineer will assist the Contractor in the preparation of the submittals and prepare one copy of AutoCAD/ Revit files on electronic media or submit through file transfer protocols. The electronic media will be prepared with all indicia of documents ownership removed. The electronic media will be prepared in a ".rvt" or ".dwg" format to permit the end user to revise the drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Provide materials and equipment manufactured by a domestic United States manufacturer and assembled in the United States for all local and Federal Government projects. These materials and equipment shall comply with "Buy American Act."
- B. Access Doors: Provide access doors as required for access to equipment, valves, controls, cleanouts and other apparatus where concealed. Access doors shall have concealed hinges and screw driver cam locks.
- C. All access doors located in wet areas such as restrooms, locker rooms, shower rooms, kitchen and any other wet areas shall be constructed of stainless steel.
- D. Access Doors: shall be as follows:
 - 1. Plaster Surfaces: Milcor Style K.
 - 2. Ceramic Tile Surface: Milcor Style M.
 - 3. Drywall Surfaces: Milcor Style DW.
 - 4. Install doors only in locations approved by the Architect.

2.2 EQUIPMENT PADS

- A. Provide 6-inch-high concrete pads for indoor floor mounted equipment. Pads shall conform to the shape of the equipment with a minimum extension of 6 inch beyond the equipment on all sides. Top and sides of pads shall be troweled to a smooth finish, equivalent to the floor. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise.
- B. Provide 6-inch-high concrete pads for all exterior mounted equipment. Pads shall conform to the shape of the equipment with a minimum extension of 6 inch beyond the equipment on all sides. Provide a 4-foot monolithic extension to the pad in front of the equipment for service when mounted on a non-finished area (i.e. landscape, gravel, clay, etc.) Top and sides of pads shall be troweled to a smooth finish. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise.

PART 3 - EXECUTION

3.1 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected via reviewed submittals.
- B. Refer to equipment specifications in Divisions 2 through 48 for additional rough-in requirements.

3.2 MECHANICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate mechanical systems, equipment, and materials installation with other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
 - 7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
 - 8. Install systems, materials, and equipment to conform with architectural action markings on submittal, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, resolve conflicts and submit proposed solution to the Architect for review.
 - 9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
 - 10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as possible, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location and label.
 - 11. Install access doors where units are concealed behind finished surfaces. Refer to paragraph 2.1 in this section and architect for access doors specifications and location.
 - 12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
 - 13. Provide roof curbs for all roof mounted equipment. Coordinate with roof construction for pitched roof. Provide roof curbs which match the roof slope and provides a level top for equipment installation. Refer to Architectural drawings and details.

14. The equipment to be furnished under these Specifications shall be essentially the standard product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the product of the same manufacturer.
15. The Architectural and Structural features of the building and the space limitations shall be considered in selection of all equipment. No equipment shall be furnished which will not suit the arrangement and space limitations indicated.
16. Lubrication: Prior to start-up, check and properly lubricate all bearings as recommended by the manufacturer.
17. Where the word "Concealed" is used in these Specifications in connection with insulating, painting, piping, ducts, etc., it shall be understood to mean hidden from sight as in chases, furred spaces or suspended ceilings. "Exposed" shall be understood to mean the opposite of concealed.
18. Identification of Mechanical Equipment:
 - a. Mechanical equipment shall be identified by means of nameplates permanently attached to the equipment. Nameplates shall be engraved laminated plastic or etched metal. Submittals shall include dimensions and lettering format for approval. Attachment shall be with escutcheon pins, self-tapping screws, or machine screws.
 - b. Tags shall be attached to all valves, including control valves, with nonferrous chain. Tags shall be brass and at least 1-1/2 inches in diameter. Nameplate and tag symbols shall correspond to the identification symbols on the temperature control submittal and the "as-built" drawings.
19. Provide construction filters for all air handling units, fan coil unit, VAV boxes, and all other air handling equipment during the entire construction period.
20. Provide temporary construction strains for all strainers in the hydronic systems during the initial flushing of the systems.

3.3 CUTTING AND PATCHING

- A. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
- B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
 1. Uncover Work to provide for installation of ill-timed Work.
 2. Remove and replace defective Work.
 3. Remove and replace Work not conforming to requirements of the Contract Documents.
 4. Remove samples of installed Work as specified for testing.
 5. Install equipment and materials in existing structures.
 6. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer/Owner's observation of concealed Work, without additional cost to the Owner.
 7. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers; refer to the materials and methods required for the surface and building components being patched; Refer to Paragraph 1.11 I for definition of "Installer."

- C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, mechanical ducts and HVAC units, and other mechanical items made obsolete by the new Work.
- D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
- E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

3.4 WORK SEQUENCE, TIMING, COORDINATION WITH OWNER, ARCHITECT AND ENGINEER

- A. The Owner will cooperate with the Contractor, however, the following provisions must be observed:
 - 1. A meeting will be held at the project site, prior to any construction, between the Owner's Representative, the General Contractor, the Sub-Contractors and the Engineer to discuss Contractor's employee parking space, access, storage of equipment or materials, and use of the Owner's facilities or utilities. The Owner's decisions regarding such matters shall be final.
 - 2. During the construction of this project, normal facility activities will continue in existing buildings until renovated areas are completed. Plumbing, fire protection, lighting, electrical, communications, heating, air conditioning, and ventilation systems shall be maintained in service within the occupied spaces of the existing building.
 - 3. Contractor shall not start-up any of the HVAC equipment unless the Owner, Architect and Engineer are signed off.
 - 4. Start-up for major HVAC equipment such as chillers, cooling towers, variable frequency drives and hot water boilers shall be performed by a factory technician. The start-up shall include a written report signed off by Contractor, Engineer and Owner.

3.5 DEMOLITION AND WORK WITHIN EXISTING BUILDINGS

- A. In the preparation of these documents every effort has been made to show the approximate locations of, and connections to, the existing piping, duct, equipment and other apparatus related to this phase of the Work. However, this Contractor shall be responsible for verifying all of the above information. This Contractor shall visit the existing site to inspect the facilities and related areas. This Contractor shall inspect and verify all details and requirements of all the Contract Documents, prior to the submission of a proposal. All discrepancies between the Contract Documents and actual job-site conditions shall be resolved by the contractor, who shall produce drawings that shall be submitted to the Architect/Engineer for review. All labor and materials required to perform the work described shall be a part of this Contract.
- B. All equipment and/or systems noted on the Drawings "To Remain" shall be inspected and tested on site to certify its working condition. A written report on the condition of all equipment to remain, including a copy of the test results and recommended remedial actions and costs shall be made by this Contractor to the Architect/Engineer for review.

- C. All equipment and/or systems noted on the Drawings "To Be Removed" shall be removed including, associated pipe and duct, pipe and duct hangers and/or line supports. Where duct or pipe is to be capped for future or end of line use, it shall be properly tagged with its function or service appropriately identified. Where existing equipment is to be removed or relocated and has an electric motor or connection, the Electrical Contractor shall disconnect motor or connection, remove wiring to a safe point and this Contractor shall remove or relocate motor or connection along with the equipment.
- D. During construction and remodeling, portions of the Project shall remain in service. Construction equipment, material, tools, extension cords, etc., shall be arranged so as to present minimum hazard or interruption to the occupants of the building. None of the construction work shall interfere with the proper operation of the existing facility; or be so conducted as to cause harm or danger to persons on the premises. All fire exits, stairs or corridors required for proper access, circulation or exit shall remain clear of equipment, materials or debris. The General Contractor shall maintain barricades, other separations in corridors and other spaces where work is conducted.
- E. Certain work during the demolition and construction phases may require overtime or night time shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner at least seventy-two (72) hours in advance in writing.
- F. Any salvageable equipment as determined by the Owner, shall be delivered to the Owner, and placed in storage at the location of his choice. All other debris shall be removed from the site immediately.
- G. Equipment, piping or other potential hazards to the occupants of the building shall not be left overnight outside of the designated working or construction area.
- H. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch or replace as required any damage that occurs as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction and to keep construction disrupted areas to a minimum. Coordinate with the Owner and other trades in scheduling and performance of the work.
- I. Include in the contract price all rerouting of existing pipe, duct, etc., and the reconnecting of the existing equipment as necessitated by field conditions to allow the installation of the new systems regardless of whether or not such rerouting, reconnecting or relocating is shown on the Drawings. Furnish all temporary pipe, duct, controls, etc., as required to maintain heating, cooling, and ventilation services for the existing areas with a minimum of interruption.
- J. All existing pipe, duct, materials, equipment, controls and appurtenances not included in the remodel or alteration areas are to remain in place.
- K. Pipe, duct, equipment and controls serving mechanical and other Owner's equipment, etc., which is to remain but is served by pipe, duct, equipment and controls that are disturbed by the remodeling work, shall be reconnected in such a manner as to leave this equipment in proper operating condition.
- L. No portion of the fire protection systems shall be turned off, modified or changed in any way without the express knowledge and written permission of the Owner's representative in order to protect systems that shall remain in service.
- M. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and operating system in cooperation with other trades with a minimum of disruption or downtime.

- N. Refer to Architectural Demolition and/or Alteration plans for actual location of walls, ceilings, etc., being removed and/or remodeled.

END OF SECTION

SECTION 23 02 01
COORDINATION DRAWINGS

5PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions 013100 and Supplementary Conditions apply to all Work herein.

1.2 COORDINATION DRAWINGS

- A. The Contractor shall take the lead in coordinating the Mechanical, Electrical, Plumbing, Communications, Electronic Safety/Security and Fire Protection systems within the building.
- B. The Contractor shall coordinate a three-dimensional (3D) model of the building which includes the Mechanical, Electrical, Plumbing, and Fire Protection systems. The Contractor will be provided with the REVIT model that was used to generate the contract documents, this file may be used as the background file. The Contractor shall replace the systems drawn with the actual shop drawing models. The Contractor is not limited to using REVIT and may use any 3D software in generating and combining the coordination model.
- C. Submitting the contract drawings as coordination drawings will not be acceptable.
- D. The model shall include detailed and accurate representations of all equipment to be installed based upon the reviewed equipment submittals.
- E. The Contractor shall hold a 3-D coordination meeting with all sub-contractors present to review the model and discuss coordination of the installation of the building systems.
- F. Upon completion of the coordination meeting, the Contractor shall submit the 3-D model and 1/4" scale drawings for review.
- G. The model shall detail major elements, components, and systems in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
- H. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
 - 1. Wall and type locations.
 - 2. Clearances for installing and maintaining insulation.
 - 3. Locations of light fixtures and sprinkler heads.
 - 4. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - 5. Equipment connections and support details.
 - 6. Exterior wall and foundation penetrations.
 - 7. Routing of storm and sanitary sewer piping.
 - 8. Fire-rated wall and floor penetrations.
 - 9. Sizes and location of required concrete pads and bases.
 - 10. Valve stem movement.
 - 11. Structural floor, wall and roof opening sizes and details.
- I. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
- J. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

- K. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.
- L. Sequence of Coordination - Below is hierarchy of model elements and the sequencing by which the models will be coordinated.
 - 1. Structural and Architectural model
 - 2. Miscellaneous steel
 - 3. Perform preliminary space allocation
 - 4. Identify hard constraints (locations of access panels, lights, A/V space requirements, etc.)
 - 5. Main and medium pressure ducts from the shaft out
 - 6. Main graded plumbing lines and vents
 - 7. Sprinkler mains and branches
 - 8. Cold and hot water mains and branches
 - 9. Lighting fixtures and plumbing fixtures
 - 10. Smaller sized ducts and flex ducts
 - 11. Smaller size cold water and hot water piping, flex ducts, etc.
- M. The Contractor shall not install any item until the coordination has been completed and reviewed by the Construction Manager, Owner, and A/E team.
- N. The Contractor shall be responsible for coordination of all items that will affect the installation of the work. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.
- O. By submitting shop drawings on the project, the Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all trades.

END OF SECTION

SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
- B. WORK SPECIFIED ELSEWHERE:
 - 1. Painting
 - 2. Automatic temperature controls
 - 3. Power control wiring to motors and equipment

1.3 WARRANTY

- A. Warrant the Work specified herein for one year and motors for five years beginning on the date of substantial completion.

1.4 REFERENCE STANDARDS

- A. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
- B. NEMA MG 00001 - Motors and Generators.

1.5 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures variations, and accessories.
- C. MOTOR NAMEPLATE INFORMATION: Manufacturer's name, address, utility and operating data.
- D. Refer to Division One for additional information.

1.6 DELIVERY AND STORAGE

- A. DELIVERY: Deliver clearly labeled, undamaged materials in the manufacturers' unopened containers.
- B. TIME AND COORDINATION: Deliver materials to allow for minimum storage time at the project site. Coordinate delivery with the scheduled time of installation.
- C. STORAGE: Store materials in a clean, dry location, protected from weather and abuse.

PART 2 - PRODUCTS

2.1 ELECTRIC MOTORS

- A. APPROVED MANUFACTURERS: Provide motors by a single manufacturer as much as possible.
 - 1. Baldor
 - 2. Marathon

3. Siemens-Allis
4. General Electric
5. U.S. Motor
- B. TEMPERATURE RATING: Provide insulation as follows:
 1. CLASS B: 40 degrees C maximum.
 2. CLASS F:
 - a. Between 40 degrees C and 65 degrees C maximum.
 - b. Totally enclosed motors.
- C. STARTING CAPABILITY: As required for service indicated five starts minimum per hour.
- D. PHASES AND CURRENT: Verify electrical service compatibility with motors to be used.
 1. UP TO 3/4 HP: Provide electronically commutated brushless DC single phase motors with built-in inverter and microprocessor-based control.
 2. 1 HP AND LARGER: Provide squirrel-cage AC induction polyphase motors.
 3. Name plate voltage shall be the same as the circuit's nominal voltage, serving the motor.
- E. SERVICE FACTOR: 1.15 for polyphase; 1.35 for single phase.
- F. FRAMES: U-frames 1.5 hp. and larger.
- G. BEARINGS: Provide sealed re-greaseable ball bearings; with top mounted Zerk lubrication fittings and bottom side drains minimum average life 100,000 hours typically, and others as follows:
 1. Design for thrust where applicable.
 2. PERMANENTLY SEALED: Where not accessible for greasing.
 3. SLEEVE-TYPE WITH OIL CUPS: Light duty fractional hp. motors or polyphase requiring minimum noise level.
- H. ENCLOSURE TYPE: Provide enclosures as follows, except where otherwise indicated:
 1. CONCEALED INDOOR: ODP (Open Drip Proof).
 2. EXPOSED INDOOR: Guard Protected.
 3. OUTDOOR TYPICAL: Type II. TEFC.
 4. OUTDOOR WEATHER PROTECTED: Type I. WPI.
 5. EXPLOSION PROOF, XP: For use in hazardous locations.
- I. OVERLOAD PROTECTION: Built-in sensing device for stopping motor in all phase legs and signaling where indicated for fractional horse power motors.
- J. NOISE RATING: "Quiet" except where otherwise indicated.
- K. All motors that are to be operated by a variable frequency drive shall be inverter duty rated motors.
- L. All motors operated by variable frequency drive shall be equipped with a maintenance free, conductive microfiber, shaft grounding ring with a minimum of two rows of circumferential microfibers to discharge electrical shaft currents within the motor and/or its bearings.
- M. EFFICIENCY: Minimum full load efficiency listed in the following table, when tested in accordance with IEEE 112, Method B, including stray load loss measure.

NEMA MG 00001 Efficiency - 1800 RPM Synchronous Speed		
Motor horsepower	Index Letter	Minimum Efficiency
3 - 5	G	89.5
7.5	G	91.0
10	F	91.7

15 - 20	E	93.0
25 - 30	E	93.6
40	D	94.1
50	C	95.0
60	C	95.0
75	C	95.0
100 - 125	B	95.4
150 - 200	B	95.8
NEMA MG 00001 Efficiency - 1200 RPM Synchronous Speed		
Motor horsepower	Index Letter	Minimum Efficiency
3 - 5	G	89.5
7.5	G	90.2
10	F	91.7
15	F	91.7
20	E	92.4
25 - 30	E	93.6
40 - 50	D	94.1
60	D	94.5
75	C	94.5
100 - 125	C	95.0
150 - 200	B	95.4

2.2 MOTOR CONTROLLERS (STARTERS)

- A. All motor controllers (for equipment furnished under Division 23) shall be furnished under Division 23 and installed under Division 26 unless otherwise noted on the plans.
 1. Starters shall be provided for 3 phase motors 1 horsepower and greater.
- B. Motor starters shall be furnished as follows.
 1. GENERAL: Motor starters shall be Square D Company Class 8536 across-the-line magnetic type, full-voltage, non-reversing (FAVOR) starter. All starters shall be constructed and tested in accordance with the latest NEMA standards, sizes and horsepower. ICE sizes are not acceptable. Starters shall be mounted in a general purpose dead front, painted steel enclosure and surface-mounted. Provide size and number of poles as shown and required by equipment served. Provide two speed, two winding or two speed, single winding motor starter as required for two speed motors.
 2. CONTACTS: Magnetic starter contacts shall be double break solid silver alloy. All contacts shall be replaceable without removing power wiring or removing starter from panel. The starter shall have straight-through wiring.
 3. OPERATING COILS: Operating coils shall be 120 volts and shall be of molded construction. When the coil fails, the starter shall open and shall not lock in the closed position.
 4. OVERLOAD RELAYS: Provide manual reset, trip-free Class 20 overload relays in each phase conductor in of all starters. Overload relays shall be melting alloy type with visual trip indication. All 3 phase and single phase starters shall have one overload relay in each underground conductor. Relay shall not be field adjustable from manual to automatic reset. Provide 6 overload relays for two speed motor starters.

5. PILOT LIGHTS: Provide a red running pilot light for all motor starters. Pilot lights shall be mounted in the starter enclosure cover. Pilot lights shall be operated from an interlock on the motor starter and shall not be wired across the operating coil.
 6. CONTROLS: Provide starters with HAND-OFF-AUTOMATIC switches. Coordinate additional motor starter controls with the requirements of Division 23. Motor starter controls shall be mounted in the starter enclosure cover.
 7. CONTROL POWER TRANSFORMER: Provide a single-phase 480 volt control power transformer with each starter for 120 volt control power. Connect the primary side to the line side of the motor starter. The primary side shall be protected by a fuse for each conductor. The secondary side shall have one leg fused and one leg grounded. Arrange transformer terminals so that wiring to terminals will not be located above the transformer.
 8. AUXILIARY CONTACTS: Each starter shall have one normally open and one normally closed convertible auxiliary contact in addition to the number of contacts required for the "holding interlock", remote monitoring, and control wiring. In addition, it shall be possible to field-install three more additional auxiliary contacts without removing existing wiring or removing the starter from its enclosure.
 9. UNIT WIRING: Unit shall be completely pre-wired to terminals to eliminate any interior field wiring except for line and load power wiring and HVAC control wiring.
 10. ENCLOSURES: All motor starter enclosures shall be NEMA 1, general purpose enclosures or NEMA-3R if mounted exposed to high moisture conditions. Provide NEMA 4X when located by cooling towers.
 11. POWER MONITOR: Provide a square "D" 8430 MPS phase failure and under-voltage relay, base and wiring required for starters serving all 3 phase motors. Set the under-voltage setting according to minimum voltage required for the motor to operate within its range.
- C. APPROVED MANUFACTURERS: Controller numbers are based on first named manufacturer. Provide one of the following manufacturer's.
1. Siemens.
 2. Square D.
 3. General Electric.
 4. Eaton.

2.3 COMBINATION MOTOR STARTERS

- A. GENERAL: Combination motor starters shall consist of a magnetic starter and a fusible or non-fusible disconnect switch in a dead front, painted steel NEMA 1 enclosure unless otherwise noted and shall be surface-mounted. Size and number of poles shall as shown and required by equipment served. Combination motor starters shall be as specified for motor starters in Paragraph 2.02-B, except as modified herein.
- B. DISCONNECT SWITCH: Disconnect switches shall be as specified in Section 26 28 16.
- C. APPROVED MANUFACTURERS: Controller numbers are based on first named manufacturer. Provide one of the following manufacturer's.
1. Siemens.
 2. Square D.
 3. General Electric.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All equipment shall be installed in accordance with the manufacturers' recommendations and printed installation instructions.
- B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractors' price shall include all items required as per manufacturers' requirements.
- C. Install in a professional manner. Any part or parts not meeting this requirement shall be replaced or rebuilt without extra expense to Owner.
- D. Install rotating equipment in static and dynamic balance.
- E. Provide foundations, supports, and isolators properly adjusted to allow minimum vibration transmission within the building.
- F. Correct objectionable noise or vibration transmission in order to operate equipment satisfactorily as determined by the Engineer.

END OF SECTION

SECTION 23 05 29
HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT - HVAC

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 WORK INCLUDED

- A. Pipe, and equipment hangers, supports and associated anchors.
- B. Sleeves and seals.
- C. Flashing and sealing equipment and pipe stacks.

1.3 RELATED WORK

- A. Section 23 05 48 - Vibration Controls for HVAC Piping and Equipment
- B. Section 23 07 16 - HVAC Equipment Insulation
- C. Section 23 07 19 - HVAC Piping Insulation
- D. Section 23 21 13 - Above Ground Hydronic Piping

1.4 REFERENCES

- A. ASME B31.1 - Power Piping.
- B. ASME B31.9 - Building Services Piping.
- C. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.5 QUALITY ASSURANCE

- A. Hangers and Supports for HVAC Piping: In conformance with ASME B31.1 and ASME B31.9.
- B. Hangers and Supports for HVAC Piping: In conformance with MSS SP-58.

1.6 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Division One.
- B. Indicate hanger and support framing and attachment methods.
- C. Provide delegated design submittal for equipment anchorage as required in specification 23 02 00 - Part 1.

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipes Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
- B. Hangers for Pipes Sizes 2 to 4 Inch: Carbon steel, adjustable clevis.
- C. Hangers for Pipes Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roller, double hanger.
- D. Multiple or Trapeze Hangers: Steel channels with welded spacers, pre-formed manufactured saddles and hanger rods; cast iron roller and stand for pipe sizes 6 inches and over.
- E. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.

- F. Wall Support for Pipe Sizes 4 Inches and over: adjustable steel yoke and cast iron roller.
- G. Vertical Support: Steel riser clamp.
- H. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
- I. Floor Support for Pipe Sizes 6 Inches and Over: Adjustable cast iron roller and stand, steel screws, and concrete pier or steel support.
- J. Roof Pipe Supports and Hangers: Galvanized Steel Channel System as manufactured by Portable Pipe Hangers, Inc. or approved equal.
 - 1. For pipes 2-1/2" and smaller - Type PP10 with roller
 - 2. For pipes 3" through 8" - Type PS
 - 3. For multiple pipes - Type PSE - Custom
- K. Copper Pipe Support and Hangers: Electro-galvanized with thermoplastic elastomer cushions; Unistrut "Cush-A-Clamp" or equal. Hangers: Plastic coated; Unistrut or equal.
- L. Shields for Vertical Copper Pipe Risers: Sheet lead.
- M. Pipe Rough-In Supports in Walls/Chases: Provide preformed plastic pipe supports, Sioux Chief "Pipe Titan" or equal.

2.2 HANGER RODS

- A. Galvanized Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.3 INSERTS

- A. Inserts: Malleable iron case with galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.4 FLASHING

- A. Metal Flashing: 20 gage galvanized steel.
- B. Lead Flashing: 4 lb. /sq. ft. sheet lead for waterproofing; 1 lb. /sq. ft. sheet lead for soundproofing.
- C. Caps: Steel, 20 gage minimum; 16 gage at fire resistant elements.
- D. Coordinate with roofing contractor/Architect for type of flashing on metal roofs.

2.5 EQUIPMENT CURBS

- A. Fabricate curbs of hot dipped galvanized steel.
- B. For metal roof construction, roof curbs shall be made of aluminum or stainless steel. Coordinate with Architectural Drawings and details.

2.6 SLEEVES

- A. Sleeves for Pipes through Non-fire Rated Floors: Form with 18 gage galvanized steel, tack welded to form a uniform sleeve.
- B. Sleeves for Pipes through Beams, Interior Walls, Exterior Walls, Footings, and Potentially Wet Floors: Form with steel pipe, Schedule 40, galvanized.
- C. Sleeves for Pipes through Fire Rated and Fire Resistive Floors and Fireproofing: Prefabricated fire rated steel sleeves including seals, UL listed, manufactured by Hilti.
- D. Fire Stopping Insulation: Glass fiber type, non-combustible, UL listed.
- E. Caulk: Paintable 25-year acrylic sealant.

- F. Pipe Alignment Guides: Factory fabricated, of cast semi-steel or heavy fabricated steel, consisting of bolted, two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

2.7 MECHANICAL SLEEVE SEALS

- A. Modular sealing element unit, designed for field assembly, to continuously fill annular space between pipe and sleeve and create watertight seal.
1. Approved Manufacturers:
 - a. Link-Seal by Garlock Pipeline Technologies (GPT)
 - b. Innerlynx by Advance Products & Systems, Inc.
 - c. MetraSeal by Metraflex Co.
 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material, size of pipe, and service requirements.
 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.8 FABRICATION

- A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- B. Design hangers without disengagement of supported pipe.
- C. Design roof supports without roof penetrations, flashing or damage to the roofing material.

2.9 FINISH

- A. Exposed steel hangers, supports, and appurtenances shall be hot-dipped galvanized. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 INSERTS

- A. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams. Coordinate with Structural Engineer for placement of inserts.
- B. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- C. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.
- D. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab. Verify with Structural Engineer prior to start of work.

3.2 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as follows:

PIPE SIZE	MAX. HANGER SPACING	HANGER DIAMETER
(Steel Pipe)		
1/2 to 1-1/4 inch	7'-0"	3/8"
1-1/2 to 3 inch	10'-0"	3/8"

4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
15 inch and over	10'-0"	7/8"
(Copper Pipe)		
1/2 to 1-1/4 inch	5'-0"	3/8"
1-1/2 to 2-1/2 inch	8'-0"	3/8"
3 to 4 inch	10'-0"	3/8"
6 to 8 inch	10'-0"	1/2"
(Cast Iron Pipe)		
2 to 3 inch	5'-0"	3/8"
4 to 6 inch	10'-0"	1/2"
8 to 10 inch	10'-0"	5/8"
12 to 14 inch	10'-0"	3/4"
15 inch and over	10'-0"	7/8"
(PVC Pipe)		
1-1/2 to 4 inch	4'-0"	3/8"
6 to 8 inch	4'-0"	1/2"
10 inch and over	4'-0"	5/8"

- B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
- C. Place a hanger within 12 inches of each horizontal elbow, and at the vertical to horizontal transition.
- D. Use hangers with 1-1/2 inch minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- F. Support vertical piping at every floor.
- G. For vertical shaft or chase applications where floor slab supported riser clamps cannot be provided to keep the pipe in alignment and to support the weight of the pipe and its contents, ensure to provide suitable fasteners, hardware, braces, unistrut, structural steel members, and appurtenances required to accommodate the pipe installation. Coordinate all such work with the project structural engineer to ensure that necessary members and attachment points are provided accordingly to bear the weight of the functioning piping.
- H. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- I. Support riser piping independently of connected horizontal piping.
- J. Install hangers with nut at base and above hanger; tighten upper nut to hanger after final installation adjustments.
- K. Portable pipe hanger systems shall be installed per manufacturer's instructions.
- L. Distances between supports are maximum distance. Supports shall be provided to carry the pipe/equipment load.

3.3 INSULATED PIPING

- A. Clamps: Attach galvanized clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.

- B. Saddles: Install galvanized protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation. Secure the full contact area of the saddle to the pipe insulation with 1/8" thick coat of mastic.
- C. Shields: Install protective shields MSS SP-58 Type 40 on cold and chilled water piping that has vapor barrier. Secure the full contact area of the shield to the pipe insulation with 1/8" thick coat of mastic.
- D. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

Nominal Pipe Size	Shield Length	Gauge Thickness
1/4 through 3-1/2 inch	12	18
4 inch	12	16
5 through 6 inch	18	16
8 through 14 inch	24	14
16 through 24 inch	24	12

- E. Provide galvanized sheet metal shields with high density insulation insert at hangers and supports as specified in 23 07 19 - HVAC Piping Insulation.
- F. High density insulation insert shall extend a minimum of 2" beyond the protective shield on each side.
- G. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

3.4 EQUIPMENT BASES AND SUPPORTS

- A. Provide equipment bases of concrete.
- B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
- C. Refer to specification 23 02 00 – Part 1 for anchorage requirements for roof mounted equipment.
- D. Construct support of steel members. Brace and fasten with flanges bolted to structure.
- E. Provide rigid anchors for pipes after vibration isolation components are installed.

3.5 FLASHING

- A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- B. Provide curbs for mechanical roof installations that extend minimum 8 inches above adjacent roofing surface. Contact Architect for all flashing details and roof construction. Seal penetrations watertight.

3.6 SLEEVES

- A. Sleeves shall be provided at the following locations:
 1. Piping passing through rated and non-rated floor assemblies, rated ceiling assemblies, and roof assemblies.
 2. Piping passing through concrete, masonry, and rated gypsum board walls and partitions.
 3. Piping passing through exterior wall assemblies above and below grade.
 4. Piping passing through non-rated gypsum board walls and partitions where indicated on the drawings or where exposed to view.
 5. Piping passing through structural members where indicated on the drawings or where exposed to view.

- 6. Any other locations indicated on the drawings.
- B. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- C. Extend sleeves through floors minimum one inch above finished floor level. Sleeves located in walls, ceilings, and structural members shall be flush with the outer surfaces of the assembly being penetrated.
- D. Where sleeved piping penetrates a floor, ceiling, or interior wall assembly, pack annular space between pipe and sleeve with UL listed fire stopping insulation and caulk seal airtight with fire barrier sealant. Provide close fitting metal collar or escutcheon covers at both sides of wall penetrations and exposed side of ceiling penetrations.
- E. Install all UL listed, prefabricated fire rated steel sleeves per the manufacturer's installation instructions to ensure fire rating is maintained.
- F. Sleeves at exterior walls below grade shall be sealed with mechanical sleeve seal. Install seal per manufacturer's installation instructions. Select type and number of sealing elements required for pipe material, pipe size, and service requirements. Position pipe in center of sleeve. Assemble mechanical sleeve seal and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal. Locations above grade shall be provided with close fitting metal collar or escutcheon covers at both sides of penetration.

END OF SECTION

SECTION 23 05 48
VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 WORK INCLUDED

- A. Vibration and sound control products.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Vibration and sound control products shall conform to ASHRAE criteria for average noise criteria curves for all equipment at full load conditions.
- C. Unless otherwise indicated, sound and vibration control products shall be provided by a single manufacturer.

1.4 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. VMC Group
- B. Mason Industries, Inc.
- C. Kinetics Noise Control, Inc.
- D. Vibration Eliminator Co., Inc.
- E. Vibro-Acoustics

2.2 GENERAL

- A. Provide vibration isolation supports for equipment, piping and ductwork, to prevent transmission of vibration and noise to the building structure that may cause discomfort to the occupants.
- B. Model numbers of VMC Group products are included for identification. Products of the listed manufacturers will be acceptable provided they comply with all the requirements of this specification.

2.3 SUSPENDED FANS AND FAN COIL UNITS

- A. Provide VMC Group model HS spring hangers sized for 1" static deflection.

2.4 CONDENSING UNITS

- A. Provide VMC Group model NRC, 1" thick ribbed elastomeric isolation pads sized for approximately 40 psi loading and 1/8" deflection.
- B. Pads shall be located in accordance with the condensing unit manufacturer's recommendations.

2.5 PIPING

- A. Provide VMC Group model HRS combination spring and elastomeric isolation hangers in mechanical equipment rooms, for a minimum distance of 50 feet from isolated equipment for all chilled water and hot water piping 1-1/2" diameter and larger. Isolators shall be sized for the same deflection as the isolators specified for the equipment up to a maximum of 2" deflection for at least the first three piping hangers; the remaining hangers shall have isolators sized for 1" deflection.
- B. Floor supported piping is required to be isolated with VMC Group model AW-1 open springs sized for 1" deflection.
- C. Provide line size flexible connectors at supply and return of pumps, chillers, and all other locations indicated on the mechanical drawings and details. Flexible pipe connectors shall be VMC Group model 2800 single sphere EPDM construction and shall include 150 lb. cadmium plated carbon steel floating flanges.

2.6 CORROSION PROTECTION

- A. All vibration isolators shall be designed and treated for resistance to corrosion.
- B. Steel components: PVC coated or phosphate coated and painted with industrial grade enamel. Nuts, bolts, and washers: zinc-electroplated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All equipment shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.
- B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.
- C. If internal isolation option is used on air handling units, the mechanical contractor shall verify proper adjustment and operation of isolators prior to start-up. All shipping brackets and temporary restraint devices shall be removed.
- D. The vibration isolation supplier shall certify in writing that he has inspected the installation and that all external isolation materials and devices are installed correctly and functioning properly.

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
- B. Refer to Architectural Sections for additional requirements.

1.3 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems.

PART 2 - PRODUCTS

2.1 VALVE AND PIPE IDENTIFICATION

- A. Valves:
 - 1. All valves shall be identified with a 1-1/2" diameter brass disc wired onto the handle. The disc shall be stamped with 1/2" high depressed black filled identifying numbers. These numbers shall be numerically sequenced for all valves on the job.
 - 2. The number and description indicating make, size, model number and service of each valve shall be listed in proper operational sequence, properly typewritten. Three copies to be turned over to Owner at completion.
 - 3. Tags shall be fastened with approved meter seal and 4 ply 0.018 smooth copper wire. Tags and fastenings shall be manufactured by the Seton Name Plate Company or approved equal.
 - 4. All valves shall be numbered serially with all valves of any one system and/or trade grouped together.
- B. Pipe Marking:
 - 1. All interior visible piping located in accessible spaces such as above accessible ceilings, equipment rooms, attic space, under floor spaces, etc., shall be identified with all temperature pipe markers as manufactured by W.H. Brady Company, 431 West Rock Ave., New Haven, Connecticut, or approved equal.
 - 2. All exterior visible piping shall be identified with UV and acid resistant outdoor grade acrylic plastic markers as manufactured by Set Mark distributed by Seton (Name plate Company Factory location 20 Thompson Road, Branford, Connecticut) or approved equal.
 - 3. Generally, markers shall be located on each side of each and every partition, on each side of every tee, on each side of every valve and/or valve group, on each side of every piece of equipment, and, for straight runs, at equally spaced intervals not to exceed 75 feet. In congested area, marks shall be placed on each pipe at the points where it enters and leaves the area and at the point of connection of each piece of equipment and automatic control valve. All markers shall have directional arrows.

4. Provide pipe markers that meet labeling requirements of ASME A13.1 for all refrigerant piping located in areas other than the room or space where the associated equipment is located. Pipe markers shall be located at intervals not exceeding 20 feet on the refrigerant piping or pipe insulation. The minimum height of the identification lettering shall be 1/2". The pipe identification shall indicate the refrigerant designation and safety group classification of the refrigerant used in the piping system. For Group A2, A3, B2, and B3 refrigerants, the identification shall also include the following statement: "DANGER – Risk of Fire or Explosion. Flammable Refrigerant." For any Group B refrigerant, the identification shall also include the following statement: "DANGER – Toxic Refrigerant".
5. Markers shall be installed after final painting of all piping and equipment and in such a manner that they are visible from the normal maintenance position. Manufacturer's installation instructions shall be closely followed.
6. Markers shall be colored as indicated below per ASME A13.1.

<u>SYSTEM</u>	<u>COLOR</u>	<u>LEGEND</u>
Chilled Water	Green	Chilled Water Supply; Chilled Water Return
Hot Water	Reddish Orange	Hot Water Supply; Hot Water Return
Condenser Water	Green	Condenser Water Supply; Condenser Water Return
Compressed Air	Blue	Compressed Air
Pneumatic Control	Yellow	Pneumatic Controls
Oxygen	Yellow	Oxygen
Nitrogen	Green	Nitrogen
Deionized Water	Green	Deionized Water
Steam	Yellow	Steam Supply; Steam Return

C. Pipe Painting:

1. All piping exposed to view shall be painted as indicated or as directed by the Architect in the field. Confirm all color selections with Architect prior to installation.

2.2 EQUIPMENT IDENTIFICATION

- A. Mechanical equipment shall be identified by means of nameplates permanently attached to the equipment. Nameplates shall be engraved laminated plastic or etched metal with minimum 1/2 inch high letters manufactured by Seton Company or approved equal. Submittals shall include dimensions and lettering format for approval. Attachment shall be with escutcheon pins, self-tapping screws, or machine screws.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All labeling equipment shall be installed as per manufacturer's printed installation instructions.
- B. Provide printable label on ceiling grids and access doors at all locations that provide access to mechanical equipment, valves, motorized dampers, and accessories located above ceiling. The label shall be white with black text with 1/4 inch high letters and shall identify the component that is accessible at that location.

- C. Provide printable label on ceiling grids and access doors at all locations that provide access to fire dampers, smoke dampers, and combination fire/smoke dampers located above ceiling. The label shall be white with red text with 1/2 inch high letters reading: FIRE/SMOKE DAMPER, SMOKE DAMPER, or FIRE DAMPER to identify the damper type that is accessible at that location.
- D. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractor's price shall include all items required as per manufacturer's requirements.
- E. All piping shall be cleaned of rust, dirt, oil and all other contaminants prior to painting. Refer to Division 9 for Architect's required paint system(s).

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 RELATED DOCUMENTS

- A. Approved submittal date on equipment installed, to accomplish the test procedures, outlined under paragraph 3.01 of this Section, will be provided by the Contractor.

1.3 DESCRIPTION

- A. The TAB of the air conditioning systems shall be performed by an impartial technical firm hired by the Owner whose operations are limited only to the field of professional TAB. The TAB work will be done under the direct supervision of a qualified engineer employed by the TAB firm.
- B. The TAB firm will be responsible for inspecting, adjusting, balancing, and logging the date on the performance of fans, dampers in the duct system, and air distribution devices. The Contractor and the various Subcontractors of the equipment installed shall cooperate with the TAB firm to furnish necessary data on the design and proper applications of the system components and provide labor and material required to eliminate deficiencies or malperformance.

1.4 QUALITY ASSURANCE

- A. **QUALIFICATIONS OF CONTRACTOR PERSONNEL:** Submit evidence to show that the personnel who shall be in charge of correcting deficiencies for balancing the systems are qualified. The Owner and Engineer reserve the right to require that the originally approved personnel be replaced with other qualified personnel if, in the Owner and Engineer's opinion, the original personnel are not qualified to properly place the system in condition for balancing.
- B. **QUALIFICATIONS OF TAB FIRM PERSONNEL:**
 - 1. A minimum of one registered Professional Engineer licensed in the State, is required to be in permanent employment of the firm.
 - 2. Personnel used on the jobsite shall be either Professional Engineers or technicians, who shall have been permanent, full time employees of the firm for a minimum of six months prior to the start of Work for that specified project.
 - 3. Evidence shall be submitted to show that the personnel who actually balance the systems are qualified. Evidence showing that the personnel have passed the tests required by the Associated Air Balance Council (AABC) shall be required.
- C. **CALIBRATION LIST:** Submit to the Engineer for approval, a list of the gauges, thermometers, velometer, and other balancing devices to be used in balancing the system. Submit evidence to show that the balancing devices are properly calibrated before proceeding with system balancing.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SERVICES OF THE CONTRACTOR

- A. The Drawings and Specifications have indicated valves, dampers, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions. Install these devices in a manner that leaves them accessible, and provide access as requested by the TAB firm.
- B. Have systems complete and in operational readiness prior to notifying the TAB firm that the project is ready for their services, and certify in writing to the Architect and Owner that such a condition exists.
- C. As a part of the Work of this Section, make changes in the sheaves, belts, and dampers or the addition of dampers required for correct balance of the new work as required by the TAB firm, at no additional cost to the Owner.
- D. Fully examine the existing system to be balanced, to determine whether or not sufficient volume dampers, balancing valves, thermometers, gauges, pressure and temperature taps, means of reading static pressure and total pressure in duct systems, means of determining water flow, and other means of taking data needed for proper water and air balancing are existing. Submit to the Engineer in writing a listing of omitted items considered necessary to balance existing systems. Submit the list and proposal as a cost add item.
- E. Verify that fresh air louvers are free of blockage, coils are clean and fresh air ducts to each air handling unit have individually adjustable volume regulating dampers.
- F. Provide, correct, repair, or replace deficient items or conditions found during the testing, adjusting, and balancing period.
- G. In order that systems may be properly tested, balanced, and adjusted as specified, operate the systems at no expense to the Owner for the length of time necessary to properly verify their completion and readiness for TAB period.
- H. Project construction schedules shall provide time to permit the successful completion of TAB services prior to Substantial Completion. Complete, operational readiness, prior to commencement of TAB services, shall include the following services of the Contractor:
 - 1. Construction status of building shall permit the closing of doors, windows, ceilings installed and penetrations complete, to obtain project operating conditions.
 - 2. AIR DISTRIBUTION SYSTEMS:
 - a. Verify installation for conformity to design. Supply, return, and exhaust ducts terminated and pressure tested for leakage as specified.
 - b. Volume and fire dampers properly located and functional. Dampers serving requirements of minimum and maximum outside air, return and relief shall provide tight closure and full opening, smooth and free operation.
 - c. Supply, return, exhaust and transfer grilles, registers and diffusers shall be installed.
 - d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be blanked and sealed to eliminate excessive bypass or leakage of air.
 - e. Fans (supply and exhaust) operating and verified for freedom from vibrations, proper fan rotation and belt tension; overload heater elements shall be of proper size and rating; record motor amperage and voltage and verify that these functions do not exceed nameplate ratings.

- f. Furnish or revise fan drives or motors as necessary to attain the specified air volumes.
- 3. AUTOMATIC CONTROLS:
 - a. Verify that control components are installed in accordance with project documents and functional, electrical interlocks, damper sequences, air and water resets, fire and freeze stats.
 - b. Controlling instruments shall be functional and set for design operating conditions. Factory precalibration of room thermostats and pneumatic equipment will not be acceptable.
 - c. The temperature regulation shall be adjusted for proper relationship between the controlling instruments and calibrated by the TAB Contractor. Advise Engineer of deficiencies or malfunctions.
- I. Contractor shall repair any insulation removed from piping system by TAB Contractor during water balancing.

3.2 SERVICES OF THE TAB FIRM

- A. The TAB firm will act as liaison between the Owner, Engineer, and the Contractor and inspect the installation of mechanical piping system, sheet metal work, temperature controls and other component parts of the heating, air conditioning and ventilating systems being retrofitted, repaired, or added under this Contract. The reinspection of the Work will cover that part related to proper arrangement and adequate provision for the testing and balancing and will be done when the Work is 80 percent complete.
- B. Upon completion of the installation and start-up of the mechanical equipment, to check, adjust, and balance system components to obtain optimum conditions in each conditioned space in the building. Prepare and submit to the Engineer complete reports on the balance and operations of the systems.
- C. Measurements and recorded readings of air, water, and electricity that appear in the reports will be done by the permanently employed technicians or engineers of the TAB firm.
- D. Make an inspection in the building during the opposite season from that in which the initial adjustments were made. At the time, make necessary modifications to the initial adjustments required to produce optimum operation of system components to affect the proper conditions as indicated on the Drawings. At time of opposite season check-out, the Owner's representative will be notified before readings or adjustments are made.
- E. In fan systems, the air quantities indicated on the Drawings may be varied as required to secure a maximum temperature variation of two degrees within each separately controlled space, but the total air quantity indicated for each zone must be obtained. It shall be the obligation of the Contractor to furnish or revise fan drive and motors if necessary, without cost to the Owner, to attain the specified air volumes.
- F. Participate in the commissioning process, which shall include but not be limited to attending commissioning meetings, coordinating work with and completing checklists as required by the commissioning team.

3.3 PROFESSIONAL REPORT

- A. Before the final acceptance of the report is made, the TAB firm will furnish the Engineer the following data to be approved by the Owner and Engineer:
 - 1. Summary of main supply, return and exhaust duct pitot tube traverses and fan settings indicating minimum value required to achieve specified air volumes.
 - 2. A listing of the measured air quantities at each outlet corresponding to the temperature tabulation as developed by the Engineer and TAB firm.

3. Air quantities at each return and exhaust air handling device.
4. Static pressure readings entering and leaving each supply fan, exhaust fan, filter, coil, balancing dampers and other components of the systems. Including the retrofit Work. These readings will be related to performance curves in terms of the CFM handled if available.
5. Motor current readings at each equipment motor on load side of capacitors. The voltages at the time of the reading shall be listed.
6. The final report shall certify test methods and instrumentation used, final velocity reading obtained, temperatures, pressure drops, RPM of equipment, amperage of motors, air balancing problems encountered, recommendations and uncompleted punch list items. The test results will be recorded on standard forms.
7. A summary of actual operating conditions shall be included with each system outlining normal and ventilation cycles of operation. the final report will act as a reference of actual operating conditions for the Owner's operating personnel.

3.4 BALANCING AIR CONDITIONING SYSTEM

A. GENERAL:

1. Place all equipment into full operation, and continue operating during each working day of balancing and testing. If the air conditioning system is balanced during Off-Peak cooling season Contractor shall return to rebalance air side system as required to put system in proper balance at that season.
2. The Contractor shall submit detailed balancing and recording forms for approval. After approval by the Engineer, prepare complete set of forms for recording test data on each system. All Work shall be done under the supervision of a Registered Professional Engineer. All instruments used shall be accurately calibrated to within 1% of scale and maintained in good working order.
3. Upon completion of the balancing and testing, the TAB Contractor shall compile the test data in report forms, and forward five copies to the Engineer for evaluation.
4. The final report shall contain logged results of all tests, including such data as:
 - a. Tabulation of air volume at each outlet.
 - b. Outside dry bulb and wet bulb temperature.
 - c. Inside dry bulb and wet bulb temperatures in each conditioned space room or area.
 - d. Actual fan capacities and static pressures. Motor current and voltage readings at each fan.

B. AIR SYSTEMS: Perform the following operations as applicable to balance and test systems:

1. Check fan rotation.
2. Check filters (balancing shall be done with clean filters).
3. Test and adjust blower rpm to design requirements.
4. Test and record motor full load amperes.
5. Test and record system static pressures, suction and discharge.
6. Test and adjust system for design cfm, return air and outside air ($\pm 2\%$). Change-out fan sheaves as required to balance system.
7. Test and record entering air temperatures, db and wb.
8. Test and record leaving air temperatures, db and wb.
9. Adjust all zones to design cfm ($\pm 2\%$).
10. Test and adjust each diffuser, grille, and register to within 5% of design.

C. AIR DUCT LEAKAGE: (From SMACNA Duct Standards latest edition) Test all ductwork (designed to handle over 1000 CFM) as follows:

1. Test apparatus

- a. The test apparatus shall consist of:
 - b. A source of high pressure air - a portable rotary blower or a tank type vacuum cleaner.
 - c. A flow measuring device consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated with its own calibration curve. Pressure and flow readings shall be taken with U-tube manometers.
2. Test Procedures
- a. Test for audible leaks as follows:
 - 1) Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
 - 2) Start the blower with its control damper closed.
 - 3) Gradually open the inlet damper until the duct pressure reaches 1.5 times the standard designed duct operating pressure.
 - 4) Survey all joints for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
 - b. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:
 - 1) Start blower and open damper until pressure in duct reaches 50% in excess of designed duct operating pressure.
 - 2) Read the pressure differential across the orifice on manometer No. 2. If there is no leakage, the pressure differential will be zero.
 - 3) Total allowable leakage shall not exceed one (1) percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
 - 4) Even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak which must be corrected.
- D. DX SYSTEMS:
1. Test and record suction and discharge pressures at each compressor and record ambient air temperature entering the condensing coils.
 2. Test and record unit full load amps and voltage.
 3. Test and record staging and unloading of unit required by sequence of operation or drawing schedule.
- E. Automatic temperature controls shall be calibrated; and all thermostats and dampers adjusted so that the control system is in proper operating condition, subject to the approval of the Engineer/Owner.
- F. The TAB Contractor shall report to Engineer all air distribution devices or other equipment that operate noisily so that corrective measures may be implemented by the Contractor at no additional cost to the Owner or Architect/Engineer.

END OF SECTION

SECTION 23 07 13 DUCT INSULATION

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 WORK INCLUDED

- A. External Duct Insulation
 - 1. Fiberglass / Glass Mineral Fiber Flexible Blanket Insulation
 - 2. Fiberglass / Glass Mineral Fiber Rigid Board Insulation
 - 3. Fiberglass / Glass Mineral Fiber Segmented Board Pipe and Tank Insulation
 - 4. Fiberglass / Glass Mineral Fiber Continuous Mat Pipe and Tank Insulation
 - 5. Fire-Rated High-Temperature Ceramic Fiber Flexible Blanket Insulation
- B. Internal Duct Insulation
 - 1. Fiberglass / Glass Mineral Fiber Flexible Duct Liner Insulation
 - 2. Fiberglass / Glass Mineral Fiber Rigid Plenum Liner Insulation
- C. Field-applied protective finishes
- D. Adhesives
- E. Mastics
- F. Lagging Adhesives
- G. Sealants
- H. Glass Fiber Fabric Reinforcing Mesh
- I. Securements

1.3 RELATED SECTIONS

- A. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC
- B. Section 23 05 53 - Identification for HVAC Piping and Equipment
- C. Section 23 31 13 - Metal Ductwork

1.4 REFERENCE STANDARDS

- A. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings; U.S. Environmental Protection Agency.
- B. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- C. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
- D. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- E. ASTM C165 - Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
- F. ASTM C423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
- G. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

- H. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- I. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation.
- J. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
- K. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
- L. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
- M. ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
- N. ASTM C1393 - Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks.
- O. ASTM C1729 - Standard Specification for Aluminum Jacketing for Insulation.
- P. ASTM C1767 - Standard Specification for Stainless Steel Jacketing for Insulation.
- Q. ASTM D1644 - Standard Test Methods for Nonvolatile Content of Varnishes.
- R. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- S. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.
- T. ASTM E136 - Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750 Degrees C.
- U. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.
- V. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.
- W. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- X. ASTM G22 - Standard Practice for Determining Resistance of Plastics to Bacteria.
- Y. ICC (IECC) - International Energy Conservation Code.
- Z. MIL-DTL-3316 - Adhesives, Fire-Resistant, Thermal Insulation.
- AA. NACIIS - North American Commercial and Industrial Insulation Standards Manual.
- BB. NAIMA FGDLs - North American Insulation Manufacturers Association (NAIMA) Fibrous Glass Duct Liner Standards.
- CC. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- DD. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- EE. SCAQMD 1168 - Adhesive and Sealant Applications.
- FF. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- GG. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- HH. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.
- II. UL 2824 - GREENGUARD Certification Program Method for Measuring Microbial Resistance from Various Sources Using Static Environmental Chambers.

1.5 QUALITY ASSURANCE

- A. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.
- B. All insulation shall be listed and labeled to have a composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) flame spread index of not more than 25 and smoke-developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723.

1. Exception: Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150.
- C. Duct and plenum insulation shall comply with minimum R-value requirements of ICC (IECC) and ASHRAE Std 90.1 I-P unless greater values are indicated otherwise in the contract documents.
- D. Adhesive and other insulation materials shall comply with NFPA 90A and NFPA 90B. Additionally, all adhesives and sealants used on the interior of the building (i.e., inside of the weatherproofing system and applied on-site) shall be comprised of low-emitting materials that comply with VOC limits prescribed by SCAQMD 1168.
- E. Vapor retarder mastics used on the interior of the building shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D
- F. Insulations shall not contain formaldehyde, asbestos, lead, mercury, mercury compounds, or polybrominated diphenyl ether fire retardants.
- G. Fiberglass insulations shall have a minimum of 50 percent recycled glass content.
- H. Fiberglass insulations shall be UL GREENGUARD Gold certified.

1.6 WARRANTY

- A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective, or nonconforming materials and workmanship.
- B. Defects shall include, but not be limited to, the following:
 1. Mildewing.
 2. Peeling, cracking, and blistering.
 3. Condensation on exterior surfaces.

1.7 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Deliver insulation materials to site in unopened containers with manufacturer's product name, ASTM standard designation, type and grade, maximum use temperature, nominal dimensions, manufacturer lot or date code.
- B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove such from project site.
- C. Store insulation indoors and keep free from exposure to UV and precipitation.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

- A. The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and approved before any insulation is installed.
- B. A sample quantity of each type of insulation and each type of application shall be installed and approval secured prior to proceeding with the main body of the Work.

2.2 ACCEPTABLE MANUFACTURERS

- A. Fiberglass/Glass mineral fiber materials shall be as manufactured by Knauf Insulation, Certain-Teed, Johns-Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor retarder, etc., as the types specified herein, subject to review by the Engineer.
- B. Adhesives, mastics, and sealants shall be as manufactured by 3M Company, Carlisle/Hardcast, Design Polymerics, Foster/Childers, Mon-Eco Industries, or Vimasco Corporation and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified herein, subject to review by the Engineer.
- C. Ceramic fiber materials shall be as manufactured by 3M Company, Alkegen/Unifrax, or Morgan Advanced Materials/Thermal Ceramics.
- D. Metal jacketing and fitting covers shall be as manufactured by Johns Manville or RPR Products, Inc.

2.3 EXTERNAL INSULATIONS

- A. Fiberglass / Glass Mineral Fiber Flexible Blanket Insulation: Glass fibers bonded with a thermosetting resin, complying with ASTM C1290 and ASTM C553, Type I, II, and III. Provide insulation with factory applied FSK vapor retarding facing complying with ASTM C1136, Type I, II, VIII, X. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.27 Btu x in. /h x sq. ft. x degrees F, or less. Maximum service temperature of 250 degrees F with facing, 350 degrees F for unfaced material. Provide Knauf Insulation Performance+ Duct Wrap with ECOSE Technology, Johns Manville Microlite FSK or approved equal.
- B. Fiberglass / Glass Mineral Fiber Rigid Board Insulation: Glass fibers bonded with a thermosetting resin, complying with ASTM C553 Type I, II, III, ASTM C612 Type IA, IB. Provide insulation with factory applied FSK facing vapor retarder facing complying with ASTM C1136, Type I, II. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.24 Btu x in. /h x sq. ft. x degrees F, or less. Maximum service temperature of 450 degrees F. Provide Knauf Insulation Earthwool Insulation Board with ECOSE Technology, Johns Manville 800 Series Spin-Glas or approved equal.
- C. Fiberglass / Glass Mineral Fiber Segmented Board Pipe and Tank Insulation: Glass fibers bonded with a thermosetting resin, complying with ASTM C1393, Category 1. Semi-rigid, segmented board in roll form with glass fibers adhered perpendicular to the vapor retarder facing. Provide insulation with factory applied FSK vapor retarder facing complying with ASTM C1136, Type II, IV, X. Compressive strength per ASTM C165 C165, not less than 120 PSF at 10% deformation. Thermal conductivity (k-value) at 100 degrees F mean temperature shall be 0.26 Btu x in. /h x sq. ft. x degrees F, or less. Maximum service temperature of 850 degrees F. Provide Knauf Insulation Earthwool Pipe & Tank Insulation with ECOSE Technology or approved equal.
- D. Fiberglass / Glass Mineral Fiber Continuous Mat Pipe and Tank Insulation: Glass fibers bonded with a thermosetting resin, complying with ASTM C1393; Type I, II, IIIA, IIIB Category 2. Semi-rigid, continuous mat in roll form. Provide insulation with factory applied FSK vapor retarder facing complying with ASTM C1136, Type II, IV, X. Compressive strength per ASTM C165, not less than 25 PSF at 10% deformation. Thermal conductivity (k-value) at 100 degrees F mean temperature shall be 0.25 Btu x in. /h x sq. ft. x degrees F, or less. Maximum service temperature of 850 degrees F. Provide Knauf Insulation KwikFlex Pipe & Tank Insulation, Johns Manville Micro-Flex or approved equal.

- E. Fire-Rated High-Temperature Ceramic Fiber Flexible Blanket Insulation: High-temperature ceramic fiber blanket thermal insulation encapsulated in a fiberglass reinforced aluminized polyester foil. Fire-rated blanket insulation shall have a nominal thickness of 1-1/2" and a nominal density of 6.0 pcf. Provide 3M Fire Barrier Duct Wrap 615+, Alkegen/Unifrax FyreWrap Elite 1.5, or Morgan Advanced Materials/Thermal Ceramics FireMaster FastWrap XL.

2.4 INTERNAL INSULATIONS

- A. Fiberglass / Glass Mineral Fiber Flexible Duct Liner Insulation: Rotary glass fibers bonded with thermosetting resin, complying with ASTM C1071 Type I. Airstream side to have a tightly bonded, black mat finish withstanding maximum rated air velocity of 6,000 ft/minute. Mat finish shall be treated with EPA-registered biocide for use in HVAC systems and verified to be microbially resistant in accordance with ASTM G21, ASTM G22, ASTM C1338, and UL 2824. The outer edges of the Liner shall have a factory applied encapsulating coating. Nominal density shall be 1.5 pcf minimum and when tested in accordance with ASTM C423 (Type A Mounting), shall provide a Noise Reduction Coefficient of 0.70 at 1.0", 0.80 at 1.5", and 0.95 at 2.0" thickness. Maximum service temperature of 250 degrees F. Thermal Conductivity (k-value) at 75 degrees F mean temperature shall be 0.24 Btu x in. /h x sq. ft. x degrees F, or less. Provide Knauf Insulation Performance+ Duct Liner with ECOSE Technology, Johns Manville Linacoustic RC or approved equal.
- B. Fiberglass / Glass Mineral Fiber Rigid Plenum Liner Insulation: Glass fibers bonded with thermosetting resin, complying with ASTM C1071 Type II. Airstream side to have a tightly bonded, black mat finish withstanding maximum rated air velocity of 5,000 ft/minute. Mat finish shall be treated with EPA-registered biocide for use in HVAC systems and verified to be microbially resistant in accordance with ASTM G21 and ASTM C1338. The outer edges of the Liner shall have a factory applied encapsulating coating. Nominal density shall be 3.0 pcf minimum and when tested in accordance with ASTM C423 (Type A Mounting), shall provide a minimum Noise Reduction Coefficient of 0.65 at 1.0", 0.85 at 1.5", at 0.95 at 2.0" thickness. Maximum service temperature of 250 degrees F. Thermal Conductivity (k-value) at 75 degrees F mean temperature shall be 0.23 Btu x in. /h x sq. ft. x degrees F, or less. Provide Knauf Insulation Performance+ Rigid Plenum Liner with ECOSE Technology, Johns Manville Linacoustic R-300 or approved equal.

2.5 FIELD-APPLIED PROTECTIVE FINISHES

- A. METAL JACKETING: Provide aluminum jacketing complying with ASTM C1729 or stainless steel jacketing complying with ASTM C1767. Metal jacketing shall have a minimum thickness of 0.016 inches.

2.6 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Fiberglass / Glass Mineral Fiber Adhesive: Comply with MIL-DTL-3316C, Class 2, Grade A. Provide Childers CP-82 or approved equal.
- C. Duct Liner Adhesive: Duct Liner adhesives shall comply with ASTM C916.

2.7 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.

- B. Vapor-Retarder Mastic: Water based; suitable for indoor and outdoor use on below ambient services. Water-Vapor Permeance shall be 0.09 perms at 55-mils dry film thickness when tested in accordance with ASTM E96/E96M, Procedure A. Service Temperature Range shall be -20 to +180 degrees F. Solids content shall be 59 percent by volume and 71 percent by weight per ASTM D1644. Provide Childers CP-35 or approved equal.

2.8 LAGGING ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
- B. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation. Service Temperature Range shall be 0 to +180 degrees F. Provide Childers CP-52 or approved equal.

2.9 SEALANTS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
- B. FSK and Metal Jacket Flashing Sealants shall be fire and water-resistant, flexible, elastomeric sealants with a service temperature range of -40 to +250 degrees F. Provide Childers CP-76 or approved equal.
- C. Fire Barrier Sealant shall be a latex-based, intumescent sealant that dries to form a monolithic firestop seal. Fire barrier sealant shall be firestop tested up to 4 hours in accordance with ASTM E814 and fire resistance tested in accordance with ASTM E1966. Provide 3M CP 25WB+ or approved equal.

2.10 GLASS FIBER FABRIC REINFORCING MESH

- A. Woven Glass Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch. Provide Childers Chil-Glas No. 10 or approved equal.

2.11 SECUREMENTS

- A. Bands
 - 1. Approved Manufacturers
 - a. Johns Manville
 - b. RPR Products
 - 2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing or closed seal.
 - 3. Aluminum: ASTM B209/B209M, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.
 - 4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Insulation Pins
 - 1. Approved Manufacturers
 - a. AGM Industries, Inc.
 - b. Midwest Fasteners, Inc.
 - c. GEMCO
 - d. Duro-Dyne
 - 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

3. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, minimum 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 4. Insulation Retaining Washers: Self-locking washers formed from 0.016 inch thick, galvanized steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- C. Staples
1. Outward-clinching insulation staples, nominal 1/2-inch-wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 GENERAL

- A. To ensure that external fiberglass/glass mineral fiber flexible blanket and rigid board insulation will achieve its highest possible performance and serve its intended purpose, install all mechanical insulation materials and associated accessories in accordance with manufacturer's published instructions and industry practices detailed by the NACIIS Manual as published by the Midwest Insulation Contractors Association (MICA).
- B. To ensure that internal fiberglass/glass mineral fiber flexible duct and rigid plenum liner insulation will achieve its highest possible performance and serve its intended purpose, install duct liner, plenum liner, and all associated accessories in accordance with manufacturer's published instructions and industry practices detailed by NAIMA FGDLS and SMACNA (DCS).
- C. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- D. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces, free of voids throughout the length of, ducts and fittings.
- E. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.

3.2 EXTERNAL DUCT INSULATION

- A. Fasten all longitudinal and circumferential laps with outward clinching staples 3" on center. On rectangular ducts over 24" wide apply as above and hold insulation in place on bottom side with mechanical pins and clips on 12" centers.
- B. Seal all joints, fastener penetrations and other breaks in vapor retarder with 3-inch wide strips of glass fiber fabric reinforcing mesh embedded between two coats of vapor retarder mastic.
- C. External duct wrap is required on all outside air ducts, supply and return air ducts that are not internally insulated. External duct wrap is also required on all exhaust and relief air ducts that are used in airside energy recovery systems. Any exhaust ductwork located in an unconditioned space that conveys air from conditioned spaces or vice versa shall also be provided with external duct wrap. Duct wrap shall be provided as follows:
 1. 1½" thick, 1.0 pcf density minimum; minimum installed R-value of 4.5 when ducts are located in directly conditioned spaces.
 2. 2" thick, 1.0 pcf density minimum; minimum installed R-value of 6.0 when ducts are located in indirectly conditioned spaces such as ceiling plenum space used for return air or located indoors concealed within chases or shafts.

3. 3" thick, 0.75 pcf density minimum; minimum installed R-value of 8.3 when ducts are located in unconditioned spaces.
- D. Any ductwork located in an air plenum that is comprised of materials that do not comply with the 25/50 flame and smoke rating per ASTM E84 or UL 723 testing requirements or UL 2043 for discrete products in plenums shall be provided with a single layer of duct wrap to establish a noncombustible rating per ASTM E136. Duct wrap products which are approved for such non-compliant combustible duct materials located in air plenums shall be 3M Fire Barrier Plenum Wrap 5A+ or Alkegen/Unifrax FyreWrap 0.5 Plenum. Insulation products for this application shall be installed in strict accordance with the manufacturer's instructions.

3.3 DUCT LINER

- A. Duct liner shall be kept clean and dry during transportation, storage, installation, and throughout the construction process care should be taken to protect the liner from exposure to the elements or damage from mechanical abuse.
- B. Duct liner shall be adhered to the sheet metal with a full coverage of approved adhesive complying with ASTM C916. All exposed leading edges and transverse joints shall be coated with factory-applied or field-applied edge coating, Childers CP-50A HV2 Black or approved equal and shall be neatly butted without gaps. Shop or field cuts shall be liberally coated with an edge coating. All coatings and adhesives shall be designed for duct liner application.
- C. Metal nosings shall be securely installed over transversely oriented liner edges facing the airstream at forward discharge and at any point where lined duct is preceded by unlined duct.
- D. When velocity exceeds 4,000 fpm (20.3 m/sec), use metal nosing on every leading edge. Nosing may be formed on duct or be channel or zee attached by screws, rivets or welds.
- E. Secure duct liner with mechanical fasteners that are adhered, weld-secured or impact-driven to hold to the duct metal, with retaining washers or integral cupped heads. Provide a minimum of 1 row of pins per duct side. Pin according to NAIMA FGDLS pinning schedule.
- F. Line supply and return ductwork at connection of fan-powered HVAC units to a point of 15 feet upstream and downstream of the equipment, 15 feet downstream of fan powered terminal units, and in return air boots.
- G. Duct liner shall be provided as follows:
 1. 1" thick, 1.5 pcf density minimum, with a minimum installed R-value of 4.2 when ducts are located in directly conditioned spaces.
 2. 1 ½" thick, 1.5 pcf density minimum, with a minimum installed R-value of 6.0 when ducts are located in indirectly conditioned spaces such as ceiling plenum space used for return air.
 3. 2" thick, 1.5 pcf density minimum, with a minimum installed R-value of 8.0 when ducts are located in indoor, unconditioned spaces or located outdoors.
 4. 1 ½" thick, 3.0 pcf density minimum, with a minimum R-value of 6.3 for rigid plenum liner applications.

3.4 EXPOSED DUCTWORK LOCATED INDOORS

- A. Duct required to be insulated by any section of this specification that is routed exposed in occupied spaces shall be double wall.

- B. Duct routed exposed shall be double wall with perforated inner liner and fiberglass/glass mineral fiber insulation. Provide 1" thick insulation when ductwork is located in conditioned spaces and 2" thick in unconditioned spaces, insulation density shall be a minimum of 1.0 pcf. Double wall duct shall be United McGill model Acousti-k27 for round or oval ducts and Rectangular-k27 for rectangular ducts or approved equal.

3.5 EXPOSED DUCT LOCATED OUTDOORS OR IN UNINHABITED CRAWLSPACES

- A. All rectangular metal ductwork located outdoors or in uninhabited crawlspaces shall be internally lined with fiberglass Duct Liner as specified and externally insulated with 2" thick, 6.0 pcf density fiberglass insulation board with FSK facing. The protective finish system shall be secured metal jacketing.
- B. All round and flat oval metal ductwork located outdoors or in uninhabited crawlspaces shall be internally lined with fiberglass Duct Liner as specified and externally insulated with 2" thick fiberglass pipe and tank insulation with FSK facing. The protective finish system shall be secured metal jacketing.
- C. Paint non-insulated duct. Coordinate color with Architect.

3.6 AIR DEVICE AND MISCELLANEOUS DUCT INSULATION

- A. The backside of all supply air devices shall be insulated with taped and sealed external duct wrap matching the thickness, density, and R-value of the associated duct system.
- B. The contractor shall install an additional layer of 1-½ inch thick external fiberglass / glass mineral fiber duct wrap on any portion of the supply air, return air, outside air, or exhaust air system that has condensation forming during any period of operation. The insulation shall be taped and vapor-sealed and located until all evidence of the condensation has been eliminated, at no additional cost to the Owner.

3.7 FIRE RATED ASSEMBLY PENETRATIONS

- A. Terminate insulation at fire damper sleeves for fire rated assembly penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
- B. Seal penetrations through fire rated assemblies with an approved fire barrier sealant. Refer to Division 7 for further requirements regarding "Through-Penetration Firestop Systems".

END OF SECTION

SECTION 23 07 19
HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for Owner's use.
- B. Furnish and install piping insulation to:
 - 1. Condensate drain piping.
 - 2. Refrigerant piping.
 - 3. All pipes subject to freezing conditions shall be insulated.
- C. Work specified elsewhere.
 - 1. Painting.
 - 2. Pipe hangers and supports.
- D. For insulation purpose piping is defined as the complete piping system including supplies and returns, pipes, valves, automatic control valve bodies, fittings, flanges, strainers, thermometer well, unions, reducing stations, and orifice assemblies.

1.3 RELATED SECTIONS

- A. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC
- B. Section 23 05 53 - Identification for HVAC Piping and Equipment
- C. Section 23 21 13 - Above Ground Hydronic Piping
- D. Section 23 23 00 - Refrigerant Piping

1.4 REFERENCE STANDARDS

- A. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings; U.S. Environmental Protection Agency.
- B. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- C. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
- D. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- E. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- F. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation.
- G. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
- H. ASTM C1617 - Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals.
- I. ASTM C1710 - Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form.
- J. ASTM C1729 - Standard Specification for Aluminum Jacketing for Insulation.
- K. ASTM C1767 - Standard Specification for Stainless Steel Jacketing for Insulation.

- L. ASTM D1644 - Standard Test Methods for Nonvolatile Content of Varnishes.
- M. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- N. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials.
- O. ASTM E136 - Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750 Degrees C.
- P. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.
- Q. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.
- R. ICC (IECC) - International Energy Conservation Code.
- S. MIL-A-24179 - Adhesive, Flexible Unicellular-Plastic Thermal Insulation.
- T. MIL-DTL-3316 - Adhesives, Fire-Resistant, Thermal Insulation.
- U. NACIIS - North American Commercial and Industrial Insulation Standards Manual.
- V. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- W. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- X. SCAQMD 1168 - Adhesive and Sealant Applications.
- Y. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- Z. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

1.5 QUALITY ASSURANCE

- A. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.
- B. All insulation shall be listed and labeled to have a composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) flame spread index of not more than 25 and smoke-developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723.
 - 1. Exception: Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150.
- C. All HVAC piping insulation thicknesses shall comply with ICC (IECC) and ASHRAE Std 90.1 I-P.
- D. Accessories, such as adhesives, mastics and cements shall have the same component ratings as listed above. Additionally, all adhesives and sealants used on the interior of the building (i.e., inside of the weatherproofing system and applied on-site) shall be comprised of low-emitting materials that comply with VOC limits prescribed by SCAQMD 1168.
- E. Adhesives, mastics, and sealants used on the interior of the building shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D
- F. All insulations shall not contain formaldehyde, asbestos, lead, mercury, mercury compounds, or polybrominated diphenyl ether fire retardants.
- G. All insulations shall be UL GREENGUARD Gold certified.
- H. Insulation materials applied to carbon steel shall be Mass Loss Corrosion Rate (MLCR) tested per ASTM C1617.
- I. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.
- J. Fiberglass insulations shall have a minimum of 50 percent recycled glass content.
- K. Foam insulation materials shall be manufactured without the use of chlorofluorocarbon (CFC) or hydrochlorofluorocarbon (HCFC) blowing agents.

1.6 WARRANTY

- A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials or workmanship.
- B. Defects shall include, but not be limited to, the following:
 - 1. Mildewing.
 - 2. Peeling, cracking, and blistering.
 - 3. Condensation on exterior surfaces.

1.7 SUBMITTALS

- A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
- B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, project variations, and accessories.

1.8 DELIVERY AND STORAGE

- A. Deliver insulation materials to site in unopened containers with manufacturer's product name, ASTM standard designation, type and grade, maximum use temperature, nominal dimensions, manufacturer lot or date code.
- B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove such from project site.
- C. Store insulation indoors and keep free from exposure to UV and precipitation.

PART 2 - PRODUCTS

2.1 HVAC PIPING INSULATION

- A. It is the intent of these specifications to secure superior quality workmanship resulting in an absolutely satisfactory installation of insulation from the standpoint of both function and appearance. Particular attention shall be given to valves, fittings, pumps, etc., requiring low temperature insulation to insure full thickness of insulation and proper application of the vapor seal. All flaps of vapor barrier jackets and/or canvas covering must be neatly and securely smoothed and sealed down.
- B. The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and reviewed prior to installation.
- C. A sample quantity of each type of insulation and each type application shall be installed and accepted prior to proceeding with the main body of the work. Condensation caused by improper installation of insulation shall be corrected by Installing Contractor. Any damage caused by condensation shall be made good at no cost to the Owner or Architect/Engineer.
- D. Any existing piping located in an air plenum that is comprised of materials that do not comply with the 25/50 flame and smoke rating per ASTM E84 testing requirements shall be provided with a single layer of high-temperature insulation to establish a noncombustible rating per ASTM E136. Insulation products which are approved for such non-compliant combustible piping materials located air plenums shall be 3M Fire Barrier Plenum Wrap 5A+ or Unifrax FyreWrap 0.5 Plenum. Insulation products for this application shall be installed in strict accordance with the manufacturer's instructions.

2.2 APPROVED MANUFACTURERS

- A. Calcium silicate materials shall be as manufactured by Johns Manville.

- B. Fiberglass/glass mineral fiber materials shall be as manufactured by Knauf Insulation, Johns Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor barrier, etc., as the types specified herein, subject to review by the Engineer.
- C. Adhesives, mastics, and sealants shall be as manufactured by 3M Company, Armacell, Foster/Childers, Mon-Eco Industries, or Vimasco Corporation and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified herein, subject to review by the Engineer.
- D. Flexible elastomeric cellular thermal insulation shall be as manufactured by Armacell.
- E. Phenolic foam insulation shall be as manufactured by Resolco, Inc. (Insul-Phen) or Polyguard (Poly-phen).
- F. Metal jacketing and fitting covers shall be as manufactured by Johns Manville or RPR Products.

2.3 MATERIALS

- A. CONDENSATE DRAINAGE PIPING: Provide flexible elastomeric cellular thermal insulation in accordance with ASTM C534/C534M. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.276 Btu x in. /h x sq. ft. x degrees F, or less. Maximum service temperature of 230 degrees F. Provide model "Armaflex Ultima", fire rated for use in environmental air plenums; insulation not required when piping is exposed on roof.
- B. REFRIGERANT PIPING: Provide flexible elastomeric cellular thermal insulation in accordance with ASTM C534/C534M. Provide model "Armaflex Ultima", fire rated for use in environmental air plenums for all indoor applications. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.276 Btu x in. /h x sq. ft. x degrees F, or less. Maximum service temperature of 230 degrees F. Provide model "AP Armaflex", with secured metal jacketing for all outdoor applications.
- C. FACTORY-APPLIED VAPOR RETARDERS - ALL SERVICE JACKETING (ASJ+): Vapor retarder jacket for interior applications shall be composed of an aluminum foil layer, reinforced with glass scrim, bonded to a layer of white kraft paper, interleaving with an outer polymer film leaving no paper exposed; complying with ASTM C1136.
- D. FIELD-APPLIED PROTECTIVE FINISHES
 - 1. METAL JACKETING: Provide aluminum jacketing complying with ASTM C1729 or stainless steel jacketing complying with ASTM C1767. Metal jacketing shall have a minimum thickness of 0.016 inches for piping sizes through 6" diameter, 0.020" for piping sizes 8" diameter through 10" diameter, and 0.024" for piping sizes 12" diameter through 24" diameter. Provide pre-formed fitting covers for all elbows and tees.
- E. HIGH DENSITY INSERTS
 - 1. Provide high density inserts at all pipe support locations as indicated herein to prevent excessive compression of the insulation. High density inserts shall have a minimum compressive strength of 100 psig. Pipe supports shall either be noncombustible, or be UL listed and labeled in accordance with UL 2043. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required. Refer to 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC .
 - 2. Provide 360° high density inserts at all pipe support locations for fiberglass insulation applications. High density inserts shall be calcium silicate for fiberglass insulation applications.

3. Provide 180° high density inserts at all pipe support locations for phenolic foam insulation applications for piping 4" diameter or larger. High density inserts shall be phenolic foam insulation meeting the compressive strength requirements indicated herein.
4. Provide 360° high density inserts at all pipe support locations for flexible elastomeric cellular thermal insulation applications. Provide ArmaFix EcoLight or equal.

2.4 INSULATING CEMENTS

- A. Mineral Fiber Insulating Cement: Comply with ASTM C195.

2.5 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
- B. Vapor-Retarder Mastic: Water based; suitable for indoor and outdoor use on below ambient services. Water-Vapor Permeance shall be 0.09 perms at 55-mils dry film thickness when tested in accordance with ASTM E96/E96M, Procedure A. Service Temperature Range shall be -20 to +180 degrees F. Solids content shall be 59 percent by volume and 71 percent by weight per ASTM D1644. Provide Childers CP-35 or approved equal.

2.6 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F. Provide Childers CP-97 or approved equal.
- C. Fiberglass / Glass Mineral Fiber Adhesive: Comply with MIL-DTL-3316C, Class 2, Grade A. Provide Childers CP-82 or approved equal.
- D. Flexible elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I. Provide Armacell Armaflex 520 BLV or approved equal.

2.7 LAGGING ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
- B. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation. Service Temperature Range shall be 0 to +180 degrees F. Provide Childers CP-52 or approved equal.

2.8 SEALANTS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
- B. Metal Jacket Flashing Sealants shall be fire and water-resistant, flexible, elastomeric sealants with a service temperature range of -40 to +250 degrees F. Provide Childers CP-76 or approved equal.
- C. Fire Barrier Sealant shall be a latex-based, intumescent sealant that dries to form a monolithic firestop seal. Fire barrier sealant shall be firestop tested up to 4 hours in accordance with ASTM E814 and fire resistance tested in accordance with ASTM E1966. Provide 3M CP 25WB+ or approved equal.

2.9 GLASS FIBER FABRIC REINFORCING MESH

- A. Woven Glass Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch. Provide Childers Chil-Glas No. 10 or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. To ensure that external fiberglass/glass mineral fiber flexible blanket and rigid board insulation will achieve its highest possible performance and serve its intended purpose, install all mechanical insulation materials and associated accessories in accordance with manufacturer's published instructions and industry practices detailed by the NACIIS Manual as published by the Midwest Insulation Contractors Association (MICA).
- B. All insulation shall be installed in accordance with the manufacturer's recommendations and printed installation instructions, including high density inserts at all hangers and pipe supports to prevent compression of insulation.
- C. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.
- D. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- E. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces, free of voids throughout the length of pipe and fittings.
- F. All heat recovery piping between air conditioning equipment and hydronic or domestic hot water piping shall be insulated per the High Temperature Surfaces Schedule below.
- G. Pipes located outdoors, in crawlspaces, or in tunnels shall be insulated same as concealed piping and be provided with metal jacketing with longitudinal 1/2" safety hem and 2 inch overlap. Jacketing shall be easily removed and replaced without damage. Jacket securement shall be by metal banding with clips. Banding material shall match jacketing material. Galvanized steel banding is not acceptable.
- H. All insulated piping located over driveways shall have an aluminum shield permanently banded over insulation to protect it from damage from car antennas.
- I. Installation of flexible elastomeric foam insulation shall be in accordance with ASTM C1710.
- J. Provide all HVAC piping insulation to comply with the ASHRAE Std 90.1 I-P Minimum Thickness Schedule and as indicated below.
 - 1. Minimum Insulation Thickness for Low Temperature Surfaces
 - a. Condensate drain lines: 1 inch
 - b. Refrigerant Piping
 - 1) 1½" and smaller: 1 inch
 - 2) Larger than 1½ inch: 1-½ inch
 - 2. Minimum Insulation Thickness for High Temperature Surfaces
 - a. Refrigerant Piping
 - 1) 1-½ inch and smaller: 1-½ inch
 - 2) Larger than 1-½ inch: 2 inch

3.2 FIRE RATED ASSEMBLY PENETRATIONS

- A. All pipe penetrations through walls and concrete floors shall be fire rated by applying rock mineral fiber insulation in the annular space between the pipe and its associated sleeve.
- B. Seal penetrations through fire rated assemblies with an approved fire barrier sealant. Refer to Division 7 for further requirements regarding "Through-Penetration Firestop Systems".

- C. All fire stopping material shall be installed in accordance with manufacturer's printed instructions.

END OF SECTION

SECTION 23 09 63
ENERGY MANAGEMENT AND CONTROL SYSTEM (EMCS)

PART 1 - GENERAL

1.1 GENERAL

- A. The Energy Management and Control System (EMCS) shall be comprised of a Local Area Network (LAN) infrastructure, Operator Workstations (OWS), Engineering Workstations (EWS), a Primary Network Server (PNS), Network Area Controllers (NAC), Application Specific Controllers (ASC), Unitary System Controllers (USC), and Field Devices installed within the facility. The EMCS Contractor shall provide a completely wired system. Wireless components and wireless communication are not acceptable.
- B. The Workstations, Primary Network Server, and Network Area Controllers shall be connected by a EMCS Contractor supplied and installed Local Area Network. The LAN shall comply with all IEEE Standards as outlined in the latest revision of IEEE 802: Local and Metropolitan Networks: Overview and Architecture.
- C. If the EMCS contractor wishes to connect to the Owner's Wide Area/Local Area Network as part of the control system network, the EMCS contractor shall acquire permission in writing and include the letter in the submittal. Any system that requires connection to the owner's network for communication between NAC, ASC, USC and/or field devices that is submitted without the written permission from the owner shall be rejected. The EMCS Contractor shall coordinate with the Owner and supply all required information.
- D. Access to the system, either locally in the building, or remotely from a central site or sites, shall be accomplished through standard web browsers, via the Internet and/or a local area network.
- E. All EMCS controllers and workstations shall communicate using the protocols and network standards as defined by ASHRAE Std 135, latest revision. Management level TCP/IP Ethernet network speeds shall be 1 Gbps minimum and the Automation Level MS/TP network speeds shall be 76.8 Kbps minimum.
- F. The Server shall gather data from the system and generate HTML pages accessible through a conventional web browser from all personal computers (PCs) connected to the network. System shall include any and all software and hardware to support at least 50 simultaneous users. The EMCS shall be compatible with all common web browsers.
- G. Facility Operators shall be able to view and configure systems through the standard web browser and all graphical/data representations shall appear identical, whether the user is on site or viewing via the Internet at a remote location. Standard operator functions such as control point manipulation, configuration and viewing of trends, schedules and alarms shall be performed through the standard browser. Each mechanical system and building floor plan shall be depicted on the operator workstation by point-and-click graphics.
- H. The EMCS shall directly control HVAC equipment as specified in the Sequence of Operations. Furnish Energy Conservation features such as Optimal Start/Stop, Night Setback, Setpoint Reset logic, and Demand Control Ventilation.

- I. The EMCS vendor shall provide the following additional services as part of this specification: warranty and service during the warranty period; submittals, samples and record documentation; comprehensive startup and testing of the EMCS with documentation; training services for the owner and facility operators; coordination with other contractors and suppliers; operator and technician training program, and shall cooperate fully with the Project Commissioning Agent.
- J. Products furnished under this specification but installed by others.
 - 1. Mechanical devices installed under Division 23 by the mechanical contractor or other suppliers:
 - a. Temperature sensing thermowells.
 - b. Automatic control valves and actuators.
 - c. Automatic control dampers and actuators not installed in air handling unit mixing boxes or louvers.
 - d. Damper actuators for automatic control dampers installed in air handling unit mixing boxes.
 - e. Damper actuators for variable air volume (VAV) terminal units.
 - f. Mounting cost of controller and actuator for variable air volume (VAV) terminal units.
 - 2. Electrical devices installed under Division 26 by the electrical contractor:
 - a. 120 VAC power to controllers and control panels at locations indicated on the drawings. Review and verify that these locations are adequate for the proposed EMCS.
 - b. Interlock wiring to duct mounted smoke detector or fire alarm shutdown relays to HVAC equipment motor starters and variable frequency drives (VFD).
- K. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

1.2 RELATED DOCUMENTS & REFERENCES

- A. Drawings and general provisions of the contract documents, apply to this section including:
 - 1. Division 01 for General Conditions and Supplementary Conditions.
 - 2. Division 21 for fire protection equipment.
 - 3. Division 22 for plumbing equipment and domestic water systems.
 - 4. Division 23 for mechanical equipment, ductwork, and piping systems.
 - 5. Division 26 for electrical equipment, lighting control, and fire alarm systems.
- B. The latest edition of the following standards and codes in effect as approved by the authority having jurisdiction and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
 - 1. ANSI MC85.1 - Terminology for Automatic Control.
 - 2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
 - 3. ASHRAE Std 135 - BACnet.
 - 4. BTL Mark by the BACnet Testing Laboratories.
 - 5. Uniform Building Code (UBC), including local amendments.
 - 6. UL 916 - Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
 - 7. NFPA 70, National Electrical Code (NEC).
 - 8. FCC Part 15, Subpart J, Class A.
 - 9. National Institute of Standards and Technology (NIST).
 - 10. IEEE 802: Local and Metropolitan Networks: Overview and Architecture.

1.3 RELATED WORK IN OTHER SECTIONS

- A. Refer to Division 00 and Division 01 for allowances and related contractual requirements.
- B. Refer to Division 21 for General Fire Protection Provisions and fire suppression pump.
 - 1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP is acceptable if IP interface is not available from equipment manufacturer.
 - 2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.
- C. Refer to Division 22 for General Plumbing Provisions, domestic water heating systems, domestic water pumping systems, domestic water metering, and natural gas metering.
 - 1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP is acceptable if IP interface is not available from equipment manufacturer.
 - 2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.
- D. Refer to Division 23 for General Mechanical Provisions for equipment such as chillers, cooling towers, boilers, pumps, air-handling units, terminal units, ventilation fans, variable frequency drives, unitary AC units, etc.
 - 1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP is acceptable if IP interface is not available from equipment manufacturer.
 - 2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.
- E. Refer to Division 26 for General Electrical Provisions for equipment such as electrical switchgear control, electrical power monitoring, emergency generators, lighting control system, etc.
 - 1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP is acceptable if IP interface is not available from equipment manufacturer.
 - 2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.

1.4 ELECTRICAL POWER PROVISIONS

- A. Primary power will be provided under Division 26 by the electrical contractor to the panel locations indicated on the mechanical & electrical drawings. Provide step down transformers within panel enclosures. Provide all necessary fuses and circuit protection devices.
- B. Power will be provided to the controllers serving fan powered terminal units with electric heat via the control transformer provided with the unit.
- C. All components of the EMCS shall be powered from the sources above. Provide final terminations from the locations indicated on the Division 23 Drawings.
- D. The EMCS Contractor shall provide any additional control power that is required as part of this contract and not indicated by other. This shall include all conduit, cabling, circuit breakers, etc.

- E. Controllers must remain powered even if the equipment they control is disabled. If hardwired interlocks or relays could interrupt controller power, the controllers shall use an independent power circuit to ensure continuous reporting to the EMCS.

1.5 CONTRACTOR QUALIFICATIONS

A. The EMCS Contractor shall:

1. Have a local staff of trained personnel capable of giving instructions and providing routine and emergency maintenance on the EMCS, all components and software/firmware and all other elements of the EMCS.
2. Have a proven record of experience in the supply and installation of equivalent BACnet systems over a minimum period of five years. Provide documentation of at least three projects of equivalent scale and complexity, if so requested by the Owner's Representative.
3. Be a factory certified representative of the native BACnet EMCS manufacturer for design, installation, and service of the proposed system.
4. Have comprehensive local service, training and support facilities for the total EMCS as provided. Maintain local, supplies of essential expendable parts.

1.6 SUBMITTALS

A. ALL DOCUMENTS SUBMITTED SHALL BE IN NATIVE PDF FORMAT. NO SCANS.

B. Shop Drawings:

1. The following information shall be included on the cover page for each shop drawing and equipment documentation submittal:
 - a. Project name with date. Refer to the applicable specifications by name and number.
 - b. Provide submittal number and re-submittal number and date as applicable.
 - c. Provided name and address of Consulting Engineer, Mechanical Contractor, General Contractor
2. Shop drawings shall be CAD generated, plot size of 8-1/2" x 11" or 11" x 17". Drawings shall include diagrams, mounting instructions, installation procedures, equipment details and software descriptions for all aspects of the system to be installed.
3. Provide schematic of systems indicating instrumentation locations, all interconnecting cables between supplied cabinets on a mechanical floor plan.
4. Software specifications and descriptions including operating sequences.
5. Provide a bill of material that indicates specific manufacturer, part number, part description and quantity of each device for all system components.
6. Provide a list of the wire labels to be installed on each end of the control wiring, at the device and the control panel terminal. Labels shall be machine generated, typed and legible with a maximum of 17 characters. The label description "AHU-1 SAT" shall indicate the supply air temperature of AHU-1.
7. Equipment Schematic: Provide an electronic equipment schematic for each piece of mechanical equipment. The schematic shall display all mechanical equipment characteristics including fans, dampers, valves, sensors and other applicable control devices. The schematic shall show wiring terminations to each control device as shown in the submittal and as-build documentation. Control devices shall be labeled by a symbol that can easily be identified in a bill of material that is shown on this graphic. The bill of material shall show the device symbol, description, manufacturer and part number.

8. Sequence of Operations: The control sequences shall be viewable for each piece of mechanical equipment and be in a text format as shown in the as built documentation. The sequence of operations shall be selectable at the applicable location for the control program.
- C. Control component submittals:
 1. Component technical data sheets with mounting and installation details.
 2. The documentation shall include comprehensive and complete details of the BIBB and automation level documentation including address, associated controller type, etc. as required and for the interface to the EMCS.
 3. Details of networks/communications equipment, cabling and protocols proposed. Provide schedule of cabling including details of proposed cable types.
 4. Module Drawing: Provide an electronic wiring diagram of each control module (as shown in submittal documentation). Diagram shall display wiring schematic and terminations to end devices. Diagram shall display each input and output terminals and label those that are used for the control application. Diagram shall display module type/name and network address.
 5. Field sensor and instrumentation specification sheets. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.
 6. Schedule and specification sheets for dampers, valves and actuators.
 7. Design and provide layout of all components of panel mounted control devices, terminal strips and power supplies.
- D. Colorgraphics: Provide sample layout of color graphic representations of the systems for review. The submittal shall indicate the quality of the graphic to be provided with the system with a sample of the specific control points to be included. Control points shall as a minimum include points indicated in the input/output summary, control schematic and primary controlling points defined in the sequences of operation. Provide a sample of a floor plan layout, typical AHU, terminal unit, outside air pretreatment unit, variable frequency drive, exhaust/supply fan, chiller plant and hot water plant. For control points to be provided by equipment BACnet integration provide sample of the control points, up to 25 total.
- E. Verification Reports: The submittal shall include a sample of the verification reports to be utilized during the verification section of this specification. Sample reports shall be approved as submitted or be modified by the engineer or owner's representative. The verification reports shall be included in the final Operation & Maintenance Manuals. Reports shall be provided in electronic PDF format.
 1. Project Systems Verification Form for each controller.
 - a. General information for each form shall include: project name; associated equipment with mark number; control panel number and location; controller number and model number; controller device instance number (address); MS/TP LAN segment number; verifying technician and date.
 - b. Each connected control point and device shall contain the following columns with a separate line for each connected physical point: point description (same as device label); input/output number for each connected control device (AI-XX, AO-XX, DI-XX, or DO-XX).
 - c. Check boxes confirming that the verification tasks have been completed: device location, proper termination at device; proper termination at control panel; sequence is verified; point trend is enabled.

- d. Data entry boxes indicating measured/confirmed values: preliminary control point value on the graphic; observed control point value; calibration or adjustment value to correct offset; final displayed point value on the color-graphic; date of verification; engineer or owner's representative verification.
 2. Control Panel Verification Form for each control panel.
 - a. General information: panel location and identification number; panel dimensions and NEMA rating; panel properly installed; Class 1 and Class 2 wiring are properly separated; correct voltage to the panel; no shorts or grounds in panel; no induce voltages in panel wiring; point to point termination match submittal; devices are mounted in the correct location; controller software revision number; address of controllers; panel device checkout is complete; panel startup is complete.
 3. Sequence of Operation Verification Form per piece of equipment (AHU, VAV, chiller, boiler, etc.).
 - a. General information: project name; system identifier; building area served; control panel and controller numbers; controller model number and instance number (address); MS/TP LAN segment number; name of verifying technician and date.
 - b. Each step of the sequence of operation for each piece of equipment shall be documented shall include a "description of test", "input to trigger test" and "expected outcome". A pass/fail checkbox shall indicate each of these actions. Provide space for technician approval with associated date.
- F. Operating and Maintenance (O&M) manuals: Provide O&M manual with full information to allow the owner to operate, maintain and repair installed products. Include trade names with model numbers, color, dimensions and other physical characteristics.
 1. Format: Produce on 8-1/2 x 11-inch pages, and bind in 3-ring/binders with durable plastic covers. Label binder covers with printed title "OPERATION AND MAINTENANCE MANUAL", title of project, and subject matter and "Number _ of _" of binder. Provide substantial dividers tabbed and titled by section/component number.
 2. Table of Contents for each volume:
 - a. Part 1: Directory with name, address and telephone number of Designer, Contractor and Subcontractors and Suppliers for each Project Manual section.
 - b. Part 2: Operation and maintenance instructions, arranged by Project Manual Section number where practical and where not, by system. Include:
 3. Product design criteria, functions, normal operating characteristic and limiting conditions. Installation, alignment, adjustment, checking instructions and troubleshooting guide. Operating instructions for start-up, normal operation, regulation and control, normal shutdown and emergency shutdown. Test data and performance curves.
 4. Spare parts list for operating products, prepared by manufacturers including detailed drawings giving location of each maintainable part, lists of spares recommended for user- service inventory and nearest source of in-stock spares.
- G. Record Documentation:
 1. Details of all alarm, diagnostic, error and other messages. Detail the Operator action to be taken for each instance.
 2. Detail special programs provided and provide a complete programming instruction manual. Detail operation of all software applications.
 3. Detailed list of the database for all installed devices.
 4. Record drawings shall be CAD generated and shall include final locations and point ID for each monitored and controlled device.

5. In addition to the required hard-copies, provide a CD-ROM with all of the record documentation in PDF format and a CD-ROM containing backup copies of all installed software and graphics.
6. Online as-built documentation: provide digital replications of as-builts that shall be accessible from each equipment graphic controlled or monitored by the EMCS.

1.7 WARRANTY

- A. Warranty work and the equipment provided under this contract shall be for a period of one year from the date of Substantial Completion. Warranty shall cover all components, system software, parts and assemblies supplied by this contractor and shall be guaranteed against defects in materials and workmanship for one (1) year from the date of Substantial Completion. Labor to troubleshoot, repair, reprogram or replace system components that have failed due to defects in materials and workmanship shall be provided by this contractor at no charge to the owner during the warranty period. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks. All warranty work shall be performed by the EMCS contractor's local service group.
- B. Warranty shall not include routine maintenance, e.g., equipment cleaning, mechanical parts lubrication, pilot lamp replacement, operational testing, etc. Warranty shall not cover repair or replacement of equipment damaged by under- or over-voltage, misuse, lack of proper maintenance, lightning, water damage from weather or piping failure.
- C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the EMCS contractor. The maximum acceptable response time to provide this service at the site shall be 24 hours, during normal working hours.

1.8 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 1. Purpose of equipment.
 2. Principle of how the equipment works.
 3. Important parts and assemblies.
 4. How the equipment achieves its purpose and necessary operating conditions
 5. Most likely failure modes, causes and corrections.
 6. On site demonstration that includes hands-on demonstration of the manipulation of setpoints, schedules and other adjustable elements of the system.
 7. The demonstration shall be on the actual, completed graphic interface pages for the specific project.
- B. Provide a second training session 3 months after initial session for any follow-up or additional training requested by owner's personnel. Allow 3 hours for the second training session.

1.9 OPERATOR WORKSTATION (OWS)

- A. The Operator Workstation shall be any personal computer, connected to the LAN, with appropriate web browser software installed.

1.10 ENGINEERING WORKSTATION (EWS)

- A. The Engineering Workstation shall be any personal computer, connected to the LAN, with a registered copy of the EMCS contractor supplied engineering and/or programming software installed. The EMCS contractor shall provide at least one copy of all required software(s), to enable the Owner complete editing/programming functions of all controllers, graphics, and control logic.
- B. The EMCS shall provide one personal computer (PC) which is compatible with the performance required by the EMCS Engineering Software if an engineering workstation is specified for the system.

PART 2 - PRODUCTS

2.1 ACCEPTABLE EMCS VENDORS

- A. ALERTON - Climatec
- B. AUTOMATED LOGIC - Branch Office
- C. SIEMENS - DAC, Inc.
- D. JOHNSON CONTROLS - Branch Office
- E. RELIABLE CONTROLS - Unify Energy Solutions - Enviromatic
- F. TRANE - Branch Office
- G. DELTA - Team Solutions
- H. DISTECH - Climatec

2.2 PRIMARY NETWORK SERVER (PNS)

- A. The EMCS Contractor shall provide and install the Primary Network Server as part of this system. The PNS shall utilize the Internet and provide efficient integration of standard open protocols. The PNS shall maintain comprehensive database management, alarm management and messaging services, and graphical user interface as follows:
 - 1. Support an unlimited number of users over the Internet/intranet with a standard web browser to access alarms, trend logs, graphics, schedules and configuration data. Access to the PNS shall be password protected utilizing authentication and encryption techniques. An audit trail of database changes indicating user, time stamp, and audit action shall be provided.
 - 2. Enterprise level information exchange using an SQL database and HTTP/HTML/XML text formats.
 - 3. Synchronize controller databases, database storage scheduling, control and energy management routines
 - 4. Alarm processing and routing which includes email, SMS text messages and paging.
 - 5. HTML based help system that includes comprehensive online system documentation.
 - 6. Support of multiple Network Area Controllers (NAC) connected to a Local Area Network.
- B. Server Functions
 - 1. It shall be possible to access all Network Area Controllers (NAC) via a single connection to the server through the Ethernet LAN. In this configuration, each Network Area Controller can be accessed from a single user login.
 - 2. The PNS shall provide the following functions, at a minimum:
 - a. The server shall provide complete access to distributed global data. The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.

- b. The server shall include a master clock service for its subsystems and provide time synchronization for all NACs.
 - c. The server shall provide scheduling for all NACs and their underlying field control devices.
 - d. The server shall provide demand limiting control that operates across all NACs. The network server shall be capable of multiple demand limiting programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
 - e. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to NACs. Each Network Area Controller supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
 - f. The server shall provide central alarm management for all NACs supported by the server. Alarm management shall include: routing of alarms to a video display, a printer, an email and pager; view and acknowledge alarms; query alarm logs based on user-defined parameters
 - g. The server shall provide central management of logged data for all NACs supported by the server. Logged data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include: viewing and printing log data; exporting log data to other software applications; query log data based on user-defined parameters
- 3. The Primary Network Server shall be capable of supporting the following open system drivers;
 - a. BACnet/IP
 - b. Modbus TCP
- C. Network Server Platform Requirements
 - 1. Rack-Mounted Server Computer Hardware: DELL PowerEdge R220 or equal, Intel Xeon Gold 3.0 GHz or higher, 32GB RAM, 2 TB hard drive, video card, 22" color monitor, and Ethernet adapter 1Gbps or higher.
 - 2. Operating system software shall be Microsoft Windows® 10 Professional or higher.

2.3 NETWORK AREA CONTROLLER (NAC)

- A. Provide one or more Network Area Controllers (NAC) to meet the sequence of operations and the type and quantity of devices being integrated into the system. The NAC shall provide the interface between the local area network and the field controllers. The NAC shall provide global supervisory control functions over the associated controllers and shall be capable of executing application control programs to provide: calendar functions; scheduling; trending; alarm monitoring and routing; time synchronization; integration of controller data for each applicable protocol; network management functions for all network devices. The user may view real-time information via web-based data.
- B. The Network Area Controller shall provide the following hardware features as a minimum: Ethernet Ports 100Mbps or higher, BACnet MS/TP ports, battery backup, DDR RAM memory, flash memory for long term data backup.
- C. Provide an uninterruptible power source (UPS) per network controller to maintain operation for 1 hours.

- D. The NAC shall be capable of operation over a temperature range of 32 to 122 °F and operation over a humidity range of 5 to 95% RH, non-condensing; storage temperatures of between 32 and 158 °F.
- E. The NAC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
- F. The NAC shall be capable of supporting the following open system drivers;
 - 1. BACnet/IP
 - 2. BACnet MS/TP
 - 3. Modbus TCP
 - 4. Modbus RTU
- G. Event Alarm Notification and actions: The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. Alarm conditions shall be routed to any defined user location whether connected to a local or wide-area network.
 - 1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to: alarm; return to normal; fault.
 - 2. Provide for the creation of a minimum of eight alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc. Allow timed routing of alarms by class, object, group, or node.
 - 3. Provide alarm generation from binary object "runtime" and/or event counts for equipment maintenance (i.e. filter status, fan run status). Authorized users shall be able to reset runtime or event count values with appropriate password control.
 - 4. Control equipment and network failures shall be treated as alarms and annunciated.
 - 5. Alarms shall be annunciated in any of the following manners as defined by the user: screen message text; e-mail of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on: day of the week, time of day and recipient.
 - 6. Color-graphic shall have flashing alarm object(s). Printed message may be routed directly to a dedicated alarm printer.
 - 7. The following shall be recorded by the NAC for each alarm (at a minimum): time and date; location (building, floor, zone, office number, etc.); associated equipment. Upon acknowledgement of the alarm the NAC shall document the time, date and authorized user. The number of alarm occurrences since the last acknowledgement shall be recorded.
 - 8. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user. Alarm actions may be initiated by user defined programmable objects created for that purpose.
 - 9. Alarm archiving: A log of all alarms shall be maintained by the NAC and/or a server and shall be available for review by the user. Provide a "query" feature to allow review of specific alarms by user defined parameters. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
- H. Data Collection and Storage: The NAC shall have the ability to collect data for any property of any object and store this data for future use.

1. The user shall designate the log as an interval log or deviation log. For an interval log, the object shall be configured for time of day, day of week and the sample collection interval. For deviation log, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
2. All log data shall be stored in a relational database in the NAC and the data shall be accessed from the server or a standard web browser. All log data, when accessed from the server, shall be capable of being manipulated using standard SQL statements.
3. All log data shall be available to the user in the following data formats: HTML, XML, plain text, comma separated values, as a minimum.
4. The NAC shall have the ability to archive its log data either locally or remotely to the server or other NAC on the network.
- I. Local Access: The NAC shall provide redundancy of system access to the local controllers at the remote building if the Primary Network Server should lose communication or be off-line. The NAC shall maintain setpoint and scheduling features, access to the color-graphic displays, maintain trend logs and reports. Upon restoration of communication with the PNS the archived information shall be transmitted to the server for archiving.

2.4 SOFTWARE FOR THE NAC

- A. The distributed architecture of the operating system for the PNS and NACs shall provide the operator a comprehensive interface to allow the operator to configure and customize the EMCS to optimize the HVAC system to save energy, schedule and maintain equipment and provide occupant comfort. The provided graphical toolset shall allow the operator to create applications in a drag and drop environment.
 1. Input/output capability shall allow the operator to request the current value or status of the control point; command/override equipment to a specific state; add, change or delete control points, alarm limits and controllers; change descriptors to control points and equipment; modify parameters; create or modify DDC loops.
- B. Operator System Access: Via software password with five access levels at workstations and at each control unit.
- C. Color graphic tools shall allow the user to create equipment and floor plan graphics from a standard library of symbols; allow custom generation of symbols; utilize over 64 or more colors; create real-time dynamic data for the graphics. Up to 60 control points may be displayed on each graphic.
 1. Provide a link between compatible graphics to minimize the paths to additional information. For example, provide the link from the zone sensor to the VAV terminal to the air handling unit and to the central plant. Web pages shall be provided to allow the operator to zoom into specific areas of the facility and then link the space to the floor plan to the overall building and then to the facility site plan.
 2. Graphical tools shall allow the creation of bar graphs, pie graphs and other tools to visualize control information such as run time hours, energy consumed and occupant comfort.

- D. Alarm processing tools shall allow the operator to create alarm messages that include as a minimum: time of alarm, point descriptor, alarm condition and remote annunciation. Critical alarms shall be displayed, archived to a storage device or printed on a alarm printer. Alarms shall be displayed in order of occurrence and have an optional audible alarm indicator.
 - 1. Print alarm messages, up to 60 characters in length, for each alarm point specified.
 - 2. Alarms may be routed to other devices including web-enabled cell phones, pagers, tablet PCs and designated personal computers on the network or Internet.
 - 3. Operator specifies when alarm requires acknowledgment. Continue to indicate unacknowledged alarms after return to normal. An alarm log shall be maintained to archive alarms for future reference with the above specified parameters as well as indicating the person acknowledging the alarm.
 - 4. The graphical display shall indicate the number of the current unacknowledged alarms by individual building site or by sum of all campus-wide facilities.
 - 5. The operator may create and forward an e-mail message to another user directly from the graphical interface so that the message can be read when the second user logs on to the system.
- E. Upon a power failure to equipment in the facility, the EMCS shall automatically start equipment upon the restoration of power. Program a time delay between individual equipment restart on a schedule to minimize demand charges from the utility company.
- F. Custom reports may be created by the operator with a requested time and date manually or automatically. All reports may be logged to a storage device for future reference. The data reports shall allow customization and scaling of the X-Y coordinates; plotting of tabular reports; provide multi-point graphical reports with not less than eight variables on the same report. Print reports on daily, weekly, monthly, yearly or scheduled basis as scheduled.
- G. The network server current operating system, database, color-graphics, custom reports shall be backed up automatically to a remote server or storage device as directed by the owner's representative.
- H. Maintenance Management capability shall allow the system to monitor and log the run-time for HVAC equipment; schedule maintenance reports that include recommended material and labor for the assigned task.

2.5 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. All devices required for single loop control shall be terminated on a single controller. (for example, CHW loop pressure control. The differential pressure sensor and the pump VFD ramp signal.)
- B. ASCs shall be capable of implementing control strategies for the system based on information from any or all connected inputs. The AC shall utilize factory pre-programmed global strategies that may be modified by field personnel on-site. Global control algorithms and automated control functions should execute via a 32-bit processor
- C. Programming shall be object-oriented using control program blocks that will support a minimum of 500 Analog Values and 500 Binary Values. Analog and binary values shall support standard BACnet priority arrays. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing.
- D. Controller shall have adequate data storage to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1 year (cumulative). Battery shall be a field-replaceable (non-rechargeable) lithium type. The onboard, battery-backed real time clock must support schedule operations and trend logs.

- E. The base unit of the ASC shall host various I/O combinations including universal inputs, binary outputs, and switch selectable analog outputs (0-10V or 0-20 mA). Inputs shall support thermistors, 0-5VDC, 0-10VDC, 4-20mA, dry contacts and pulse inputs directly.
- F. All binary outputs shall have onboard Hand-Off-Auto switches and a status indicator light. HOA switch position shall be monitored. The position of each HOA switch shall be available system wide as a BACnet object.
- G. Controller shall be capable of BACnet communication. BACnet Conformance:
 - 1. Standard BACnet object types supported shall include as a minimum: Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program and Schedule object types. All necessary tools shall be supplied for working with proprietary information.
- H. Schedules: Each ASC shall support a minimum of 10 BACnet schedule objects.
- I. Logging Capabilities: Each controller shall support a minimum of 100 trend logs. Sample time interval shall be adjustable at the operator's workstation. Controller shall periodically upload trended data to system server for long term archiving if desired. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
- J. Alarm Generation: Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures. Alarm logs shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications. Controller must be able to handle up to 200 alarm setups stored as BACnet event enrollment objects -system destination and actions individually configurable.

2.6 UNITARY SYSTEM CONTROLLERS (USC)

- A. All devices required for single loop control shall be terminated on a single controller. (for example, cooling coil control valve control. The temperature sensor and the valve control signal.)
- B. The EMCS Contractor shall provide all Unitary System Controllers. USCs shall be fully programmable or applications specific controllers with pre-packaged operating sequences maintained in Flash RAM.
- C. The USC shall be a node on the automation network and shall control its own communications so that the failure of any one node, shall not inhibit communications on the network between the remaining nodes. USCs shall be totally independent of other network nodes for their monitoring and control functions.
- D. Provide each USC with a battery back-up for the protection of volatile memory for a minimum of 72 hours. Batteries shall be rated for a seven-year life.
- E. All associated applications programs shall reside at the USC. The USC shall not require communication to any other panel for normal operating sequences other than time scheduled base commands.
- F. Control shall be based on algorithms, i.e. proportional plus integral plus derivative (PID), proportional plus integral (PI), or proportional to comply with the sequences of operation PID algorithms shall maintain the system operation within +/- 2% of setpoint.
- G. The USC shall be configured with sufficient input/output capacity to achieve the required control points to meet the sequence of operations.

2.7 VAV TERMINAL UNIT CONTROLLER (TUC)

- A. All devices required for single loop control shall be terminated on a single controller. (for example, terminal unit air valve control. The flow sensor and the actuator control signal.)
- B. The EMCS Contractor shall provide all controllers required for all variable air volume (VAV) terminal units. The number and location of terminal units and airflow rates shall be as indicated on the mechanical drawings.
- C. The TUC shall be capable of monitoring and controlling the following parameters for VAV terminal units per the sequences of operation and input/output summary: space temperature; primary air flow rate; damper modulation; heating coil stage control, heating valve control, heating SCR control (as applicable); fan on/off control; supply air sensor; occupancy sensor; carbon dioxide sensor or humidity sensor.
- D. Furnish primary damper actuators, for factory mounting, meeting the following requirements: direct shaft mounting; adequate torque, to properly operate the damper from fully open to fully closed without binding; locking "V" groove or similar means to prevent slippage between actuator and shaft.
- E. The EMCS Contractor shall field install the following components for each terminal unit: space temperature sensor; supply air temperature sensor; occupancy sensor, and carbon dioxide sensor as indicated on the Mechanical Drawings.
- F. The EMCS Contractor shall furnish to the terminal unit manufacturer the following components for factory installation and wiring for each terminal unit: VAV controller with integral differential pressure transducer and damper actuator.
- G. The terminal unit manufacturer may provide the following components for each terminal unit for interface and mounting of the TUC: primary air dampers; enclosure to house the TUC and associated components including suitable mounting brackets shall be NEMA 1 rating and located outside the terminal unit; multi-point averaging type flow sensor at the primary air inlet to the terminal unit; 24 VAC control transformer; 24 VAC fan control relay interface; 24 VAC heater control relay interface (up to two stages); 24 volt SCR heater input as scheduled (0-10 Vdc or 4-20 mA).
- H. Any items required for proper operation but not provided by TU vendor, shall be provided under this section.

2.8 AIR HANDLING UNIT CONTROLLER

- A. All devices required for single loop control shall be terminated on a single controller. (for example, AHU static pressure control. The differential pressure sensor and the VFD ramp signal.)
- B. The EMCS Contractor shall provide controllers required for chilled/hot water and DX/electric heat air handling units and fan coil units. Provide an enclosure to house the controller and associated components including suitable mounting brackets shall be NEMA 1 rated and located outside the FCUs.
- C. The controller shall be capable of monitoring and controlling the following parameters per the sequences of operation and input/output summary; space temperature; space relative humidity sensor; cooling/heating stage control or modulating valve control; fan on/off control and status; supply air sensor; occupancy sensor; carbon dioxide sensor; VFD control and monitoring.

2.9 EMCS CONTROLLER LEVEL NETWORK

- A. EMCS Automation Level Network shall consist of BACnet MS/TP (76.8 Kbps minimum). Data transfer rate and data throughput as required to meet the alarm annunciation requirements.

2.10 SOFTWARE OVERVIEW

- A. **Dynamic Colored Floor plans:** Dynamic colored floor plans that compare actual space conditions to setpoints shall be provided on all floorplan graphics displayed on the front-end. Floorplan enlargements shall also use the thermographs to display space conditions. Zones within the set point range shall appear transparent white. As the space gets warmer the zone color shall gradually modulate from transparent white to transparent red to identify a hot zone. As the space conditions get cooler the zone color shall gradually modulate from transparent white to transparent blue to identify a cold zone. Each zone shall indicate the current actual zone temperature within the zone. The floor plans shall use a dynamic scheduling icon to indicate schedule occupancy for each zone and provide direct one-click access to that zones unique schedule. Provide a designated icon or symbol indicating that the zone is in the occupied/unoccupied condition. From the floorplan graphic, the operator shall be able to click on any zone and go directly to the graphic for the piece of equipment controlling that zone. All dynamic floor plans shall be visible via web interface as well as on the LAN. The authorized system operator shall be able to change the zone or system identifier (or name) on the graphic and that change shall be distributed to other associated graphics and to the equipment controller.
- B. **Pop up Trends:** Provide trend logs that automatically pop up when the operator mouse clicks on the point from the graphic. Provide pop up trends for all dampers, control valves, temperature sensors, carbon dioxide sensors, humidity sensors, airflows, static pressures, flow meters, VFD speeds, etc. The EMCS contractor shall set up all trends for the owner. The pop-up trend shall include a trend tool that allows the operator to modify the trend time scale and sample interval for up to 10 sample values. The trends shall be graphical on the computer screen but shall provide an output as an .xls, .csv, .pdf, HTML, or text file.
- C. **Interactive Maps:** Implement JAVA SCRIPT API 3.0 or newer, such as Google Interactive maps depicting the facility location to indicate the site plan. This is not a static image and must be completely interactive.
- D. **Custom User HTML applications:** The EMCS shall utilize HTML applications as an extra feature. At minimum, provide 7-day forecast, weather radar, traffic map and hurricane tracker. All of these features shall be imbedded into the EMCS system.
- E. **Provided a web-based EMCS platform;** contractor shall provide an Open License software. Licenses that are not open are not acceptable. There shall be no per seat or per user licensing fee charged to the owner by the contractor.
- F. **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 shall be BACnet Objects.
- G. **User access shall include 50 assigned operators** that shall include five levels of access within the web system. Each operator log-in shall have an expiration date to allow for temporary access to the system. The operator's access description shall include his e-mail address and cell/phone numbers. The operator access can be limited from 5 minutes to permanent access. The user shall be limited to eight bad login attempts before being locked out of the system.

- H. Global modification: Provide the capability for global modification of user definable parameters of all points shall be provided. Global modification is defined as the mass adjustment of user definable parameters across a defined group, area, facility, campus, or network. Parameters shall include, but not be limited to temperature set point (VAV boxes, AHU Discharge, VAV AHU Static Pressure Setpoints etc.), equipment start/stop, equipment status, valve output signal, VFD speed control signal, and damper position signal. User shall be able to lock the definable parameter to a set value, or adjust a set point to an operator adjustable value. This function shall be accomplished through the standard graphical user interface/workstation and is to be selectively applicable by the user to all controllers on the network, all controllers in a specific facility or all controllers in a specific zone within a specific facility.
- I. The system operator shall be able to override the output signal to the valves, dampers, variable frequency drives, etc. with the use of the PC mouse click on the device. The system override shall include a Hand-Off-Auto (HOA) capability. If the output is commanded to the hand position the operator shall designate an output value of 0-100% in 1% increments. The hand override position shall be permanent or expire after a designated time period and revert to the auto position. The color-graphic shall indicate the device that has been overridden by a color change of the output value.
- J. For non-emergency in-warranty events the system operator may submit a Service Request directly from the floor plan or system graphic. The web interface shall include the EMCS suppliers contact information including phone numbers and e-mail address. The service request will be logged into the EMCS suppliers service department. A non-response by the assigned technician shall elevate the request to the next highest manager or supervisor until the system operator receives an response that their request has been received and is scheduled for a resolution. All requests for service shall be maintained in the customer's database for future reference. The service request capability may be extended after the expiration of the warranty as part of a service agreement.
- K. The web-based system shall be accessible from Tablet PCs and provide the same functionality that is available from personal computers connected through the LAN or WAN to the system operator. The tablet PCs as a minimum shall include an Apple iPad and Google Android based tablet PC. Operation shall include touch screen capability and use of the tablet keyboard screen. The operator shall be able to view color-graphics, system trends, override setpoints, change time schedules, and override damper and valve positions.

2.11 ENERGY SAVING PROGRAMS

- A. Demand Limiting: Demand limiting programming and sequence shall include, but not be limited to the following:
 - 1. Monitor total power consumption for each power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.
 - 2. Integrate with lighting controls to reduce lighting power to an operator set maximum demand level.
 - 3. Provide a means from the graphical user interface for the system operator to manually initiate or disable the demand limiting sequence.
 - 4. Provide programming that will allow a demand response signal from an approved entity (electrical service provider) to remotely initiate or disable the demand limiting sequence.
 - 5. Provide programming that will initiate demand limiting according to a schedule.
 - 6. When demand limiting is initiated, the EMCS shall:

- a. Increase the space cooling temperature setpoint by 4 degrees F (adj), above the current operating setpoint. The rate of change for the temperature setpoint increase shall be operator adjustable.
 - b. Decrease the space heating temperature setpoint by 4 degrees F (adj), below the current operating setpoint. The rate of change for the temperature setpoint decrease shall be operator adjustable.
 - c. Automatically reduce lighting power on the circuits indicated on construction documents.
7. When demand limiting is disabled, the EMCS shall reset temperature setpoints and lighting power levels back to original operating setpoints.
8. Demand limiting shall be confined to "non-critical" zones. For purposes of planning, assume all zones are "non-critical" unless otherwise noted on the construction documents. All zones shall have the option to be added or removed from the demand limiting program, by the system operator.
9. The EMCS shall include a graphic "page" that shows all adjusted setpoints (original setpoints and demand limited setpoints) and the power meters being monitored to confirm the programming is operational and effective at shedding the associated loads.
- B. Duty Cycling: Periodically stop and start loads, based on space temperature, and according to various on/off patterns.
- C. Automatic Time Scheduling: Self-contained programs for automatic start/stop/scheduling of building loads. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary schedules.
- D. Optimal Start/Stop: Perform optimized start/stop as function of outside conditions, inside conditions, or both. Optimization shall be adaptive and self-tuning, adjusting to changing conditions by modifying occupancy period based upon the desired temperature at beginning and end of the occupancy period. Base optimization on occupancy schedules, outside air temperature, seasonal requirements, and interior room temperature. Employ adaptive model prediction for how long building takes to warm up or cool down under different conditions.
- E. Night-Setback Program: Reduce heating space temperature setpoint or raise cooling space temperature setpoint during unoccupied hours in conjunction with scheduled start/stop and optimum start/stop programs.
- F. Setpoint Reset: Setpoints for control of variable load systems shall be reset based on load demand, as described in the Sequence of Operations.
- G. Calculated Points: Define calculations and totals computed from monitored points (analog/digital points), constants, or other calculated points.
- H. Event Initiated Programming: Any data point capable of initiating event, causing series of controls in a sequence.
- I. Holiday Scheduling
- J. Direct Digital Control: Furnish software so operator is capable of customizing control strategies and sequences of operation by defining appropriate control loop algorithms and choosing optimum loop parameters.

- K. Trend logging shall be provided for all points per the input/output summary where there is a change in the analog or binary signal. Each controller shall be capable of storing trend values and then automatically transfer data to the NAC or the NS hard disk. Trend data shall be updated continuously per the operator assigned interval at intervals as low as one minute. Collect samples at intervals specified in minutes, hours, days, or month. Output trend logs as line-graphs or bar graphs. Binary points (input and output) shall only be logged upon a change of value (COV). Display trend samples on workstation in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time versus data.

2.12 FIELD INSTRUMENTATION

- A. Temperature Sensors: All temperature sensors shall be thermistor type, factory-calibrated to within 0.5 °F, interchangeable with housing appropriate for application. Sensors shall have a temperature curve rated for the application. Sensor wiring terminations shall be in a galvanized box.
1. Outside air temperature sensors shall be installed in weather proof enclosure with ventilated sun-shield.
 2. Duct mounted temperature sensors shall be averaging type for supply air, mixed air and low temperature applications for air handling units. Duct probe temperature sensor shall be acceptable for terminal units.
 3. Space temperature sensors shall contain a backlit LCD digital display and user function keys along with temperature sensor, setpoint adjustment and after-hours override use. Override time may be set in one-hour increments.
 4. Thermowell temperature sensors shall be stainless steel probe of length that is equivalent to a minimum of 50% of the pipe diameter. End-to-end accuracy shall be ± 0.5 deg. F. Connection box shall be moisture/water proof with conduit fitting. Furnish the stainless steel thermowell to the mechanical contractor for installation. A thermal conducting grease shall be installed in the thermowell to provide uniform temperature sensing.
 5. Provide flat plate stainless steel space temperature sensors with no local setpoint adjustment as indicated on the drawings.
- B. Carbon Dioxide Sensors: The sensor shall be capable of monitoring carbon dioxide concentration with an accuracy of ± 30 parts per million (PPM). The sensor shall produce a linear 0-10 VDC or 4-20 mA signal over the range of 0 to 2000 PPM. The sensor shall measure using non-dispersed infrared (NDIR) technology to measure carbon dioxide gas and shall be:
1. Wall mounted carbon dioxide sensors shall be Veris CWE series or equivalent.
 2. Duct mounted carbon dioxide sensor shall be Veris CWD series or equivalent.
 3. The EMCS contractor shall utilize the required calibration devices to properly commission and calibrate the sensors per the manufacturer's requirements.
- C. Relative Humidity Sensors: relative humidity sensors shall be a two-wire type, 4-20 mA output proportional to the relative humidity range of 0-100%. The accuracy of the sensors shall be $\pm 2\%$ over a range of 10-90% RH.
1. Outdoor relative humidity sensors: provide non-corroding outdoor shield to minimize wind effects and solar heating. Install wall-mount weather proof enclosure with conduit fitting. Sensor shall be Veris HO series, or equivalent.
 2. Wall-mounted relative humidity sensor: sensor shall be installed in a wall-mounted enclosure with white cover. Sensor shall be Veris HEW series or equivalent.
 3. Duct-mounted relative humidity sensor: sensor shall be provided with a moisture resistant enclosure with conduit fitting. The probe length shall be 8" minimum. Sensor shall be Veris HED series or equivalent.

D. Pressure Transducers:

1. Air pressure transducer: The pressure transducer shall have an input range compatible with the medium being measured. The proportional output signal shall be 0-10 VDC or 4-20 mA. The accuracy shall be +/- 0.25% FS. Transducer shall be SETRA Model 264 or equivalent. Air pressure sensors and all associated tubing, hardware, and accessories shall be provided as appropriate for the application.
 - a. Duct mounted pressure sensor shall be stainless steel and provided with mounting flange and hardware. The sensor probe length shall be appropriate for the associated duct dimensions.
 - b. Wall mounted space pressure sensor shall include stainless steel wall plate, pressure pick up filter, and mounting hardware.
 - c. Ceiling mounted space pressure sensor shall be paintable, low-profile type, with pressure pick up filter, integral surge dampener, and adhesive ring for ceiling mount.
 - d. Outdoor pressure sensor shall include an outdoor rated sensor, 50 ft. of vinyl tubing, mounting bracket and hardware. A surge dampener shall also be provided for all outdoor pressure sensor applications to absorb pressure fluctuations.
- E. Freezestat: Provide freezestats for all chilled water air handling systems that receive more than 10% untreated outside air. Freezestats shall provide vapor tension elements, which shall serpentine the inlet face on all coils. Provide additional sensors, wired in series, to provide one linear foot per square foot of coil surface area. Freezestat shall be manually reset at the switch. Interlock to the associated fan so that fan will shut down when HOA switch is in hand or auto position. Provide time delay relays with a 0-10 minute time delay relay duration to minimize nuisance freezestat trips. Time delay relay shall be adjustable at the associated control panel.
- F. Air differential pressure switch: For fan shutdown, provide air differential pressure switches for all fans controlled by a variable frequency drive (VFD) to shut down the associated fan in the event of sensing high differential pressure. Air differential pressure switches shall have an adjustable setpoint with a range of 0-10 inches w.g. with manual reset at the switch unless otherwise indicated to be automatic reset or required by the application to be automatic reset. Provide ¼ inch copper tubing with compression fittings to mount to the side of the duct. Sensor shall be DWYER Series 1900 or equivalent.
- G. Momentary control relays: Provide momentary control relays as indicated. Relays shall have coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application. Contact ratings shall be 10 amp. Provide complete isolation between the control circuit and the digital output. Relays shall be located in the UC or other local enclosures and have pin-type terminals. Relays shall have LED indication of status.
- H. Current sensing relay: Current sensing relays shall be rated for the applicable load. The output relay shall have an accessible trip adjustment over its complete operating range. Enclosure shall have an LED to indicate relay status.
- I. Photocell: Ambient light level shall be by a photocell in a non-corroding in a weatherproof housing with sun shield suitable for exterior installation. The control signal output shall be 4-20 ma or binary contact closure as specified in the sequences of operation. Mount the photocell on the north side of the building on the roof. The sensor reading shall be 0-750 foot-candles.
- J. Occupancy Sensors

1. Occupancy sensors shall be dual-technology, ceiling mounted type. Sensors shall be capable of detecting presence in the control area by via Doppler shifts in transmitted ultrasound and passive infrared (PIR) heat changes. Sensor shall utilize Dual Sensing Verification Principle for coordination between ultrasonic and PIR technologies. Detection verification of both technologies must occur in order to activate lighting systems. Sensor shall have a retrigger feature in which detection by either technology shall retrigger the lighting system on within 5 seconds of being switched off. The sensor shall operate at 24 VDC/VAC. WattStopper DT-300 or approved equal.
2. Sensors shall have a time delay that is adjustable with configuration software or shall have a fixed time delay of 5 to 30 minutes, set by a DIP switch. Sensors shall feature a walk-through mode, where lights turn off 3 minutes after the area is initially occupied if no motion is detected after the first 30 seconds.
3. The sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options. The sensor shall have an LED indicator that remains active at all times in order to verify detection within the area to be controlled.

2.13 HVAC VENTILATION SHUTDOWN SWITCH

- A. The HVAC ventilation shutdown switch shall be a mushroom type switch, STI Series 2000 Stopper Station that complies with the following:
 1. Color shall be coordinated with the Owner prior to ordering.
 2. Latches when depressed.
 3. Twist to reset.
 4. Indoor/Outdoor flush type clear plastic cover.
 5. Switch label shall read "HVAC VENTILATION SHUTDOWN" or other label approved by the Owner. Coordinate final label text with the Owner prior to ordering.
- B. Coordinate final location of shutdown switch with the Mechanical Drawings, the Architect, and the Owner prior to installation.

2.14 NATURAL GAS FLOW METERS

- A. Inline Thermal Mass Flow Meters shall be provided for natural gas sub-metering applications where indicated on mechanical drawings or in control diagrams in piping larger than 3/4". Natural gas flow meters shall be separate from the natural gas meter provided by the utility company. The flow meter shall have a 316L stainless steel insertion probe, built-in flow conditioner, flanged or NPT connections to match adjoining piping system, and weather-tight NEMA 4X electronics enclosure with interface and display; +/- 2.0 % accuracy of actual reading from 100 to 500 SFPM and +/- 1.0 % accuracy of actual reading from 500 to 7,000 SFPM; pulse and analog outputs proportional to flow rate and native BACnet MS/TP. The unit of measurement output from the meter shall be field selectable. The flow meter shall be installed with a minimum straight pipe run upstream and downstream of the flow meter as indicated in the manufacturer's installation manual. Refer to meter manufacturer's installation manual for additional requirements. Meters shall be furnished by Division 23 and installed by Division 22. Meter shall be ONICON F-5500 series or pre-approved substitution.

2.15 AIRFLOW MEASURING STATIONS (AFMS)

- A. Duct mounted airflow measuring stations with combination airflow and air temperature measurement devices shall have the following features:
 - 1. Multi-point sensors in one or more probe assemblies with a maximum of one to sixteen sensor nodes per location, and a single remotely mounted microprocessor-based transmitter for each measurement location. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Each sensing point shall independently determine the airflow rate and temperature at each node, which shall be equally weighted in calculations by the transmitter prior to output as the cross-sectional average. Each ducted sensor probe shall have an integral, U.L. Listed, plenum rated cable. Each independent temperature sensor shall have a calibrated accuracy of $\pm 0.15^{\circ}\text{F}$ (0.08°C) over the entire operating temperature range of -20°F to 160°F (-28.9°C to 71°C) and shall be calibrated at 3 temperatures against standards that are traceable to NIST. Acceptable manufacturer shall be EBTRON, Inc. GTx116-PC.
 - 2. Each transmitter shall have a display capable of simultaneously displaying both airflow and temperature. Airflow rate shall be field configurable to be displayed as velocity or volumetric rates, selectable as IP or SI units. Each transmitter shall operate on 24 VAC and be fused and protected from over voltage, over current and power surges.
 - 3. Each independent airflow sensor shall have a laboratory accuracy of $\pm 2\%$ of Reading over the entire calibrated airflow range of 0 to 5,000 fpm (25.4 m/s) and shall be wind tunnel calibrated at 16 points against air velocity standards that are traceable to NIST.

2.16 DAMPERS

- A. Provide motorized volume control and shutoff dampers as detailed in 23 33 00 - Ductwork Accessories.

2.17 DAMPER ACTUATORS

- A. Outside and exhaust air damper actuators shall be mechanical spring return. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
- B. Outside and return air modulating actuators shall utilize analog (proportional) control 0-10 VDC. Actuators shall be driven in both the open and closed directions.
- C. Electric damper actuators shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.
- D. Single section dampers shall have one electronic actuator direct shaft mounted.
- E. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section.
- F. Damper actuators shall be BELIMO or equivalent.

2.18 CONTROL VALVES

- A. Furnish all valves controlled by the EMCS as shown on the Mechanical Drawings. Furnish all automated isolation valves as shown on the Mechanical Drawings. Control valves shall be factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. EMCS contractor to size control valve with a maximum of 3 psi pressure drop. 2-position isolation valves shall be full-line size.

1. Equal Percentage control characteristic shall be provided for all water coil control valves.
- B. Pressure Independent Characterized Control Ball Valves $\frac{1}{2}$ " to 6", for two-way modulating applications shall have equal percentage characteristics and control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSI across the valve. The pressure independent control valve shall be provided and delivered from a single manufacturer as a complete assembly. The actuator shall be integrally mounted to the valve at the factory with a single screw on a direct coupled DIN mounting-base. All valve actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow and/or temperature control. Programming using actuator mounted switches or multi-turn actuators are not acceptable. The control valves shall be sized for the scheduled flow and not pressure drop. Calibrated Balancing Valves and Automatic Flow Limiting Valves shall be prohibited from use at coil circuit piping where pressure independent control valves are installed. Contractor shall provide a section of straight pipe five times the pipe diameter with respect to the nominal valve size upstream of the control valve assembly where utilizing integral flow sensor to guarantee sensor accuracy.
 1. NPS $\frac{3}{4}$ " and Smaller: Belimo PIQCV or equal. Forged brass body rated at no less than 360 PSI, stainless steel ball and blowout-proof stem, characterizing disc integral to ball, PTFE ball seat, dual EPDM lubricated O-rings, and female NPT union ends. Close off pressure rating of 100 psi. Integral pressure regulator located upstream of ball to maintain a constant pressure differential. Replaceable cartridge type regulators are not permitted.
 2. NPS 1" through 2": Belimo ePIV or equal. Forged brass, nickel-plated body rated at no less than 360 PSI, stainless steel ball and blowout-proof stem, PTFE ball seat, dual EPDM lubricated O-rings, stainless steel or TEFZEL characterizing disc, and female NPT union ends. Close off pressure rating of 200 psi. Valve shall be integrated with an electronic (ultra-sonic or electromagnetic) flow sensor (accuracy +/- 2%) providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psi.
 3. NPS 2-1/2" through 6": Belimo ePIV or equal. GG25 cast iron body according to ANSI 125, Class B, stainless steel ball and blowout-proof stem, PTFE ball seat, with a dual EPDM lubricated O-rings and a stainless steel flow characterizing disc. End connection pattern to match ANSI 125 flange. Close off pressure rating of 100 psi. Valve shall be integrated with an electronic (ultra-sonic or electromagnetic) flow sensor (accuracy +/- 2%) providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psi.
- C. Characterized Control Ball Valves (CCV) for $\frac{1}{2}$ " to 2": for 3-way modulating applications shall have equal percentage characteristics. Manufacturer shall be Belimo or approved equal. Balancing valves shall be provided in all coil circuits that utilize 3-way control valves.
 1. Valve housing shall consist of forged brass rated at no less than 400 psi at 250 °F. Three-way valves shall have EPDM O-rings behind ball seals to allow for a minimum close-off pressure of 40 psi with an actuator that provides 35 in-lbs torque for $\frac{1}{2}$ to 2 in. sizes. Three-way valves shall be installed in a "tee" configuration with actuator perpendicular to the shaft. Confirm mixing or diverting application for correct valve selection.

- D. Globe Valves 2-1/2" to 6": for 3-way modulating applications shall have equal percentage characteristics. Manufacturer shall be Belimo G7 series or approved equal. Balancing valves shall be provided in all coil circuits that utilize 3-way control valves.
 - 1. Valve housing shall consist of cast iron rated at no less than 125 psi at 300 °F. Valve shall have stainless steel stem, plug and seat. Three-way valves shall be installed in a "tee" configuration with actuator perpendicular to the shaft. Confirm mixing or diverting application for correct valve selection.
- E. Butterfly valves: For chiller and cooling tower isolation control valves, butterfly control valves may be provided.
 - 1. Butterfly Isolation valves shall be line-size. Design velocity shall be less than 12 feet per second when used with standard EPDM seats. Butterfly valves shall have ductile iron body, 304 stainless steel disc and EPDM seat. The valve body close-off pressure rating shall be 150 psi over a range of -20 °F to 250 °F. The flange shall be ANSI 125/250. Provide Belimo Series F6 and F7 or Bray Series 3L.
- F. Actuators for characterized control valves and globe valves: Provide electric actuators for all control valves that are furnished as part of the EMCS contract. Two-way and three-way control valve actuators shall meet, at minimum, the following requirements:
 - 1. Motor driven type with gear assembly made of hardened steel. Actuator shall have an input voltage of 24 VAC. Provide visual mechanical position indication.
 - 2. Actuators installed within the interior of the building envelope shall be provided with NEMA-2 rated housings.
 - 3. Actuators installed exterior to the building envelope shall be provided with NEMA-4 rated housings or a weather shield. All penetrations through exterior actuator housings shall be provided with fittings that prevent water ingress.
 - 4. Valves shall be sized to meet the shut-off requirements when operating at the maximum system differential pressure and with the installed system pump operating at shut-off head. Actuators shall control against system maximum working pressures.
 - 5. Normal and failure positions shall be as indicated in the operating sequences. Provide spring return action per the sequences.
 - 6. Manual declutch lever to enable manual operation of the valve. It shall be possible for an operator to manually modulate valves located in mechanical rooms in the event of loss of power.
 - 7. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for butterfly valve actuators.
 - 8. All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
 - 9. Electric actuators shall be Belimo, compatible with the valves furnished.
- G. Butterfly Valve Industrial Actuators
 - 1. Enclosure shall be NEMA 4 (weatherproof) enclosure and will have an industrial quality coating.

2. Actuator shall have a motor rated for continuous duty. The motor shall be fractional horsepower; permanent split capacitor type designed to operate on a 120 VAC, 1 phase, 60 Hz supply. Two adjustable cam actuated end travel limit switches shall be provided to control direction of travel. A self-resetting thermal switch shall be imbedded in the motor for overload protection.
3. Reduction gearing shall be designed to withstand the actual motor stall torque. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
4. Actuator shall have a 6 ft wiring harness provided for ease in field wiring (above 1500 in-lbs). Two adjustable SPDT cam-actuated auxiliary switches, rated at 250 VAC shall be provided for indication of open and closed position. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
5. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator and when in manual operation electrical power to the actuator will be permanently interrupted. The hand wheel will not rotate while the actuator is electrically driven.
6. The actuator shall be analog, floating, or two position as called out in the control sequence of operation. All analog valves shall be positive positioning, and respond to a 2-10 VDC, 4-20 mA, or adjustable signal as required. Analog actuators shall have a digital control card allowing any voltage input for control and any DC voltage feedback signal for position indication.
7. Butterfly valve actuators shall be Belimo or Bray furnished with specified butterfly valves.

2.19 PANELS AND ENCLOSURES

- A. Provide panels and enclosures for all components of the EMCS, which are susceptible to physical or environmental damage.
- B. Interior panels and enclosures shall meet be NEMA 1 rated painted steel panels with locking door.
- C. Exterior mounted panels and enclosures shall be NEMA 4 painted steel panels with locking door.
- D. Panels for USCs shall be mounted on the outside of all unit ventilators and fan coil units with three feet of wall clearance in front of them and no higher than 7 feet to the bottom of the panel.

2.20 LABELING AND WARNING NOTICES

- A. Provide labeling for all control panels and enclosures.
- B. Provide labeling of all control wires and input/output points at the controller and at the control device; the label at each end of the wire shall be the same Labels shall be machine generated, typed and clearly legible with a maximum of 17 characters. Hand written labels or labels written on the control wire jacket will not be acceptable. Each label shall be unique to its function and shall reference the applicable system. For example "AHU-1 SAT" will indicate the supply air temperature sensor for AHU-1. Improper labeling shall be removed and shall require re-commissioning of the control device and controller to document correct functionality.
- C. Provide high voltage warning notices at all equipment controlled by the EMCS and at all associated motor starters when used by equipment controller.

2.21 TUBING AND PIPING

- A. Provide tubing and piping as required for the field instrumentation.

- B. Tubing within equipment rooms, vertical risers, and penetrations to ductwork shall be either copper pipe or shall be plastic tubing within conduit. Tubing for all water-based instrumentation shall be copper pipe. Identify the type of tubing proposed in the shop drawing submittal.
- C. Provide suitable bulk head fittings for duct and panel penetrations.
- D. Tubing in plenum rated areas may be plastic tubing. Polyethylene tubing shall meet, at minimum, the following requirements: flame retardant; crack resistant; 300 psi burst pressure.

2.22 CONDUIT AND FITTINGS

- A. Provide all conduits, raceways and fittings for the EMCS monitoring, communication and control cabling. All work shall meet all applicable codes.
- B. Conduit, where required, shall meet, the requirements specified within Division 26.
- C. EMCS monitoring and control cable shall not share conduit with cable carrying voltages in excess of 90 VAC.

2.23 CABLING

- A. Provide all cables for the EMCS. Cable shall meet, at minimum, the following requirements:
 - 1. Minimum 98% conductivity stranded copper.
 - 2. Proper impedance for the application as recommended by the EMCS component manufacturer.
 - 3. Monitoring and control cable shall be #18 AWG or larger, dependent on the application. Analog input and output cabling shall be shielded.
 - 4. Management Level Network cable shall be CAT 6, 24 gauge unshielded.
 - 5. Automation Level Network cable shall be #24 AWG shielded.
 - 6. Shield shall be grounded at the CCP, UC, or control panel. Ground at one end only to avoid ground loops.
 - 7. Identification of each end at the termination point. Identification should be indicated on and correspond to the record drawings.
- B. 120 VAC power wiring shall be of #12 AWG solid conductor or larger as required.

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION

- A. The EMCS supplier shall provide a pre-construction coordination meeting with the affected trades to ensure a cooperative efficient process of installation. The invited trades shall include the general contractor, mechanical contractor, electrical contractor, test and balance contractor, commissioning provider, owner's representative, consulting engineer and others with a direct interest in the coordination of the affected systems. The EMCS contractor shall provide an outline of the meeting agenda highlighting the construction schedule, coordination with mechanical and electrical trades. Provide a sign-in sheet and submit it through the attendees along with a summary of the meeting notes for future reference.

3.2 INSPECTION DURING INSTALLATION

- A. Provide a technician to assist the Engineer or Owner's Representative with inspections made during the installation period that are required to review the progress and quality of ongoing work. The engineer/owner's representative shall generate field observation reports on the findings of the inspection. The engineer or owner's representative shall advise the EMCS contractor during the inspection of any concerns noted with respect to the installation and shall repeat the concerns in writing as soon as possible after the inspection is completed. The EMCS contractor shall take corrective action to meet the requirements of the specifications. Upon correction, the EMCS contractor shall submit written documentation through the contractors to the engineer.

3.3 INSTALLATION OF COMPONENTS

- A. Provide all interlock and control wiring. All wiring shall be installed in a neat and professional manner in accordance with specification Division 26 and all national, state and local electrical codes.
- B. All wiring shall be installed as continuous lengths with no splices permitted between termination points.
- C. Provide wire and wiring techniques recommended by equipment manufacturers. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the Owner's Representative prior to rough-in. Provide auxiliary pilot duty relays on motor starters as required for control function.
- D. Maximum pulling, tension, and bend radius for wiring and cable installation, as specified by the manufacturer, shall not be exceeded during installation.
- E. Electrical Contractor shall provide 120 or 277 volt power at a junction box within 48" of the controller. The BAS Contractor shall coordinate with the Electrical Contractor to identify locations of power requirements prior to the installation of the controls.
- F. Conduit for control wiring shall be provided whenever one of the following conditions exists:
 - 1. Conduit is indicated on the drawings or specifically required by the specifications.
 - 2. Cabling runs through inaccessible areas such as within partitions/walls, above closed in ceilings, under floor; within trenches and underground; on the exterior of the building; exposed on the surface of the building; when encased in concrete or other material that makes the cable inaccessible or when located such that access to the cable is not readily obtained.
 - 3. Cable within mechanical, telecommunications and electrical equipment rooms and control rooms.
 - 4. Conduit shall be installed, inside wall from sensor box to above the wall, for all wall mounted temperature, humidity and CO2 sensors.
- G. Size of conduit shall be in accordance with the manufacturer's recommendations, specifications of Division 26, and NEC requirements.
- H. Secure conduit with conduit clamps fastened to the structure and spaced according to Division 26 and code requirements. Conduit shall not be hung on flexible duct straps or tie rods. Conduit shall not be run on or attached to ductwork.
- I. Control wiring located above accessible ceilings may be plenum rated cable. Plenum rated cable shall be neatly bundled and routed parallel or perpendicular to building surfaces.

- J. Where plenum rated cable is installed without conduit, it shall be supported from or secured to the building structure. Cables shall be supported independently by cable hooks and shall not be supported by or secured to ductwork, electrical conduits, piping, or ceiling suspension systems. Multiple cables are to be dressed every 5 ft. to 7 ft. Cables shall be supported at a maximum of 10 ft. intervals with a maximum cable sag of 6" between supports.
- K. Control wiring located in underground conduits shall be provided with direct-burial-rated insulation.
- L. When communication bus enters or exits a building, a surge suppressor shall be installed. The surge suppressor shall be installed according to the controls manufacturer's instructions.
- M. Provide sleeves for all cable and conduit passing through walls, partitions, structural components, floors and roof. Maintain fire rating at all penetrations through fire rated construction.
- N. All communication wiring shall be labeled to indicate origination and destination data.
- O. All sensor wiring shall be labeled to indicate the origination (at the device) and destination of data (at the control panel). The description shall indicate the type and location of the control device such as "AHU-1 SA temp" or "VAV 1-1 space temp".
- P. Wall temp sensors at 48" above the finished floor to comply with ADA requirements and to match the height of the light switches. Mount humidity sensor at equal height to wall temperature sensor.
- Q. Outdoor pressure sensors shall be installed a minimum of five feet above the roof surface and shall be free of immediate obstructions and sources of turbulence that could affect pressure readings. Sensors shall be attached to the top of roof mounted equipment or provided with stand-alone vertical support if no roof mounted equipment is available. Sensor tubing shall be routed into the building through a sealed weathertight penetration. Provide a heat trap loop in the sensor tubing immediately below the roof.

3.4 VERIFICATION REQUIREMENTS

- A. Verification shall be provided by the EMCS contractor to demonstrate and confirm that the installed system complies with the specifications and the control sequences of operation herein specified. upon completion of the verification process the EMCS contractor shall demonstrate to the engineer or owner's representative the functionality of the control system devices are in compliance with the contract documents.
- B. Technicians provided by the EMCS contractor shall be factory trained and qualified in the operation of the provided control system. The EMCS contractor shall provide, if requested, the factory training certificates of the individuals providing the verification services on this project.
- C. Verification tools, applicable to the system provided, shall be utilized by the factory-trained technicians for proper verification of system operation and functionality. Temperature verification sensors shall be NIST certified within the last 12 months. Meters such as Fluke 52 series or better shall be utilized. Use of non-certified meters may require the system to be re-verified with certified meters at no cost to the owner.
- D. Documentation of the verification process shall be provided per the project general conditions in electronic PDF format as required. Documentation shall include the following forms:
 - 1. Project System Verification Forms for each controller provided on the project to verify the proper function of each controller, control device and system component provided.

2. Panel Verification Forms for each control panel to document the proper installation and function of each control panel provided.
3. Sequence of Operation Verification Forms for each piece of controlled equipment to confirm compliance of the control system with the specified sequences of operation.
4. Not providing proper documentation for each control devices, panel, or system, upon request by the engineer or owner's representative, may require the EMCS contractor to re-verify the applicable systems at no additional cost to the owner.
- E. After completion of the verification, the EMCS contractor shall be able to demonstrate the sequence of operations for each system to the engineer and the owner's representative.
- F. Equipment checkout sheets are to be produced by this contractor showing checkboxes and compliance with the following procedures for each piece of equipment and turned over to the owner and/or mechanical engineer.

3.5 COLORGRAPHICS

- A. The colorgraphics shall be provided for the EMCS system prior to system acceptance and owner training.
- B. The colorgraphics provided shall include the following as a template. Provide forward and backward links on the graphic.
 1. Site plan with link to overall building plan including detached buildings. The site plan shall be referenced to an automatically updated aerial view or map view of the area such as Google Maps or Bing Maps. Provide link to proceed to the overall building floor plan.
 2. The overall building plan shall indicate space temperature conditions referenced by the color of the zone. Specific details of the zone temperatures and equipment are not required. Provide a link to the floor plan wings, upper floors and remote buildings.
 3. The floor plan colorgraphics shall indicate the space temperatures by color references. Additional information shall indicate the space temperature, the occupancy of the zone, air handling units, VAV terminals and ductwork with diffusers. A link at each terminal unit or AHU shall automatically connect the system operator to the equipment colorgraphic.
 4. The colorgraphics for the equipment shall as a minimum be equal to the points from the input/output summary or control schematic. Primary control devices as required by the sequences of operation shall also be provided.
 5. Control points from equipment that are integrated into the EMCS via BACnet shall be provided to convey the operating conditions of the attached equipment. Coordination of the integration points shall be accomplished during the submittal phase. The EMCS contractor shall provide a list of all integrated points on their submittal.

3.6 ENERGY MONITORING PROGRAMMING AND GRAPHICS

- A. The EMCS shall be programmed to include a dedicated graphics page for energy monitoring.
- B. The kW and KWH data acquired from each power meter shall be categorized within the EMCS by the following end-uses.
 1. Total HVAC system loads
 2. Interior lighting loads
 3. Exterior lighting loads
 4. Plug loads

- 5. Process loads
- 6. Building operations and other miscellaneous loads
- C. The EMCS shall provide a graphic representation to show instantaneous real-time energy consumption data and shall provide hourly, daily, monthly, and yearly energy consumption data. Where multiple meters are used to measure an end-use category, the graphic representation for that end-use category shall include data from the individual meters as well as a total for the associated category. The graphic representation shall also include time and date of the highest peak demand for the current month and year as well as prior months and years for stored data. Demand thresholds may be set to adjust and shed loads in order to reduce peak consumption.
- D. All meter data collected shall be stored for a minimum of 36 months and shall have the ability to be trended by building operation and management personnel on an hourly, daily, monthly, and yearly basis using the previous 36 months of stored data.

3.7 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- A. Startup testing documentation: Prepare the checklist documenting startup testing of each input and output device, with technician's initials and date certifying each device has been tested and calibrated prior to acceptance testing. This document shall indicate proof that the following functions have been commissioned and shall be included in the as-built documentation: short to ground check, configuration of trends, confirmation that color-graphics are accurately representing actual systems, point to point checkout, all damper and valve actuators respond to input change, control modules are addressed and have functional descriptors, specified interlocks are functional, calibration report of all sensors, discrete outputs respond to time schedule or manual enable command.
- B. Demonstration. Prior to acceptance, demonstrate the following performance tests to demonstrate system operation and compliance with specifications.
 - 1. Engineer, owner's representative and mechanical contractor shall be invited to observe and review system demonstration. Provide attendees at least 10 days notice.
 - 2. Demonstration shall follow process approved as part of the submittal and shall include complete checklists and forms for each system as part of system demonstration.
 - 3. Demonstrate actual field operation of each sequence of operation as specified. Demonstrate calibration and response of any input and output points requested by engineer or owner's representative.
 - 4. Demonstrate complete operation of operator interface including review of color-graphics, time schedules, trend logs, alarm notification, functionality of tablet PC operation.
 - a. PID loop response. Supply graphical trend data output showing each PID loop's response to a set point change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be selectable from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show set point, actuator position, and controlled variable values.
 - b. Demand limiting. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand limiting setpoint, and status of set points and other affected equipment parameters.

- c. Trend logs for each system. Trend data shall indicate set points, operating points, valve positions, and other data as specified. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.
 - 1) Once seven (7) days of trending data has been collected, the trend logs shall be exported to pdf format and submitted to the engineer, owner and commissioning provider for review. Trends shall be set up for the following points at a minimum as applicable:
 - (a) Pumping systems
 - (1) Start/stop
 - (2) Speed command
 - (3) Differential pressure set point
 - (4) Differential pressure (system)
 - (b) Packaged air handling units
 - (1) Start/stop
 - (2) Discharge air temperature
 - (3) Outdoor air damper position
 - (4) Space temperature set point
 - (5) Space temperature
 - (6) Outside air temperature
 - (c) Zones: 100% of temperature zones in 15-minute intervals
 - (1) Space temperature set point
 - (2) Space temperature
 - (3) Carbon dioxide concentration
 - (d) Exhaust fans
 - (1) Start/stop
 - (2) Status
 - (e) Outside air conditions
 - (1) Outdoor air temperature
 - (2) Outdoor air humidity
 - 5. Alarms and Interlocks. Check each alarm with an appropriate signal at a value that will trip the alarm. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction. Alarm verification shall include temperatures exceeding alarm threshold (high and low), fan failure safety, duct high static pressure switch, freezestat, and smoke detector shutdown.
 - 6. Tests that fail to demonstrate proper system operation to the engineer shall be repeated after contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.
- C. Owner Acceptance.
- 1. After tests described in this specification are performed to the satisfaction of both engineer and owner's representative, the engineer shall accept the control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond EMCS contractor's control. Engineer shall 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 by the engineer.

3.8 DEMONSTRATION AND OWNER TRAINING

- A. Furnish basic operator training for multiple persons on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 16 hours: 8 hours instructor time for onsite training and 8 hours of hands on class environment training. Training sessions may be provided in 4-hour increments as approved by the owner's representative.
 - 1. Change/modify temperature setpoints.
 - 2. Change/modify time of day, holiday and override schedules.
 - 3. Display, create, and modify trends of system points.
 - 4. Update room numbers on the color-graphics.
- B. Demonstrate complete and operating system to Owner. Provide written documentation listing the attendees of the specified training with sign-in sheet and training time and date.

3.9 SEQUENCE OF OPERATIONS

- A. Refer to the Mechanical Drawings for project control schematics and sequence of operations.

END OF SECTION

SECTION 23 21 13
ABOVE GROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 WORK INCLUDED

- A. Pipe and pipe fittings.
- B. Flanges, unions, dielectric connections, and couplings.
- C. Valves.
- D. Condensate drain piping.

1.3 RELATED WORK

- A. Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping
- B. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC
- C. Section 23 05 48 - Vibration Controls for HVAC Piping and Equipment
- D. Section 23 05 53 - Identification for HVAC Piping and Equipment
- E. Section 23 07 19 - HVAC Piping Insulation

1.4 REFERENCES

- A. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300.
- C. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings: DWV.
- D. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings—DWV.
- E. ASME B31.1 - Power Piping.
- F. ASME B31.3 - Process Piping.
- G. ASME B31.9 - Building Services Piping.
- H. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
- I. ASSE 1079 - Performance Requirements for Dielectric Pipe Unions.
- J. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings.
- K. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- L. ASTM B32 - Standard Specification for Solder Metal.
- M. ASTM B306 - Standard Specification for Copper Drainage Tube (DWV).
- N. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
- O. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
- P. ISO 9001 - Quality Management Systems — Requirements.
- Q. ANSI/AWWA C110 - Ductile-Iron and Gray-Iron Fittings 3 in. through 48 in., for Water and Other Liquids.
- R. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- S. ASTM B32 - Solder Metal.

1.5 QUALITY ASSURANCE

- A. Foreign made pipes and fittings will not be acceptable.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Welding Materials and Procedures: Conform to ASME BPVC-IX and applicable state labor regulations.
- D. Welder's Certification: In accordance with ASME BPVC-IX.

1.6 SUBMITTALS

- A. Submit product data under provisions of Division One.
- B. Include data on pipe materials, pipe fittings, valves, and accessories.
- C. Include welder's certification of compliance with ASME BPVC-IX.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division One.
- B. Store and protect products under provisions of Division One.
- C. Deliver and store valves in shipping containers with labeling in place.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, proper storage and dunnage, completing sections of the work, and isolating parts of completed system. Tape will not be allowed as an acceptable end cover.

PART 2 - PRODUCTS

2.1 EQUIPMENT DRAINS AND OVERFLOWS

- A. Steel Pipe: ASTM A53/A53M, Schedule 40, galvanized.
 - 1. Fittings: Galvanized cast iron, or ASTM A47/A47M, ASME B16.3, malleable iron.
 - 2. Joints: Threaded, or grooved mechanical couplings.
- B. Copper Drainage Tubing: ASTM B306, DWV.
 - 1. Fittings: ASME B16.23 cast copper alloy solder joint DWV fittings or ASME B16.29 wrought copper alloy solder joint DWV fittings.
 - 2. Joints: Soldered joints made in accordance with ASTM B828 using ASTM B32 Alloy Grade Sn50/Pb50 solder.

2.2 FLANGES, UNIONS, DIELECTRIC CONNECTIONS, AND COUPLINGS

- A. Pipe Size 2 Inches and Under: Provide 150 psi malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.
- B. Pipe Size Over 2 Inches: Provide 150 psi forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping; 1/16 inch thick preformed neoprene bonded gasket.
- C. Dielectric connections for pipe sizes 2 inches and under: Provide dielectric unions, rated at 180°F at 250 psi in compliance with ASSE 1079.
- D. Dielectric connections for pipe sizes larger than 2 inches: Provide dielectric flanged pipe fittings, rated to 180°F at 175 psi in compliance with ASME B16.1.
- E. Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to welding, threading or flanged methods. All grooved components shall be of one manufacturer, and conform to local code approval and/or is listed by ASME B31.1, ASME B31.3, ASME B31.9, ASME, UL/ULC, FM, IAPMO or BOCA. Grooved end manufacturer to be ISO 9001 certified. Grooved couplings shall meet the requirements of ASTM F1476. Manufacturer shall be Victaulic, Anvil Gruvlok, or Shurjoint. Can be utilized only in mechanical rooms or cooling tower areas.

2.3 ACCEPTABLE MANUFACTURERS - VALVES

- A. Milwaukee
- B. Crane
- C. Nibco
- D. Apollo
- E. Bray
- F. Kitz

2.4 ACCEPTABLE MANUFACTURERS - VALVES (GROOVED ONLY)

- A. Victaulic
- B. Anvil Gruvlok
- C. Shurjoint

2.5 GATE VALVES

- A. Up to 2 Inches: Bronze body, bronze trim, rising stem, handwheel, inside screw, single wedge or disc, threaded ends.
- B. Over 2 Inches: Iron body, bronze trim, rising stem, handwheel, OS&Y, single wedge, flanged ends.

2.6 GLOBE VALVES

- A. Up to 2 Inches: Bronze body, bronze trim, rising stem and handwheel, inside screw, renewable stainless steel disc, threaded ends, with back seating capacity.
- B. Over 2 Inches: Iron body, bronze trim, rising stem, hand wheel, OS&Y, plug-type disc, flanged ends, renewable seat and disc.

2.7 BALL VALVES

- A. Up to 2 Inches: Bronze two-piece body, 600 PSI full port, stainless steel ball and stem, teflon seats and stuffing box ring, lever handle, and balancing stops, threaded ends.
- B. Over 2 Inches: Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, or gear drive hand wheel for sizes 10 inches (250 mm) and over, flanged.
- C. Ball valves installed in insulated lines shall have stem extensions compatible with up to 2" of insulation. Extensions shall be non-metallic equal to Nibco "nib-seal".

2.8 PLUG COCKS

- A. Up to 2 Inches: Bronze body, bronze tapered plug, non-lubricated, teflon packing, threaded ends, with one wrench operator for every ten plug cocks.
- B. Over 2 Inches: Cast iron body and plug, pressure lubricated, teflon packing, flanged ends, with wrench operator with set screw.

2.9 BUTTERFLY VALVES

- A. Iron body, aluminum bronze or stainless steel disc, resilient replaceable seat for service to 180 degrees F lug or grooved ends, extended neck, infinite position lever handle with memory stop. Valve shall be rated at full working pressure with downstream flange removed in either direction.

2.10 SWING CHECK VALVES

- A. Up to 2 Inches: Bronze 45 degree swing disc, threaded ends.
- B. Over 2 Inches Iron body, bronze trim, 45 degree swing disc, renewable disc and seat, flanged or grooved ends.

2.11 SPRING LOADED CHECK VALVES

- A. Iron body, bronze trim, stainless steel spring, aluminum bronze disc, threaded, grooved, wafer or flanged ends.

2.12 RELIEF VALVES

- A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean, and treat systems.
- E. Provide extended necks for all vents, thermometer wells, pressure gauge wells, pet cocks and pete's plugs.

3.2 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
- B. Install piping to conserve building space, and not interfere with use of space and other work.
- C. Group piping whenever practical at common elevations.
- D. Branch tap connections to piping mains shall be from the top of the pipe.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping.
- F. Provide clearance for installation of insulation, and access to valves and fittings.
- G. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Division 08.
- H. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
- I. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- J. Prepare pipe, fittings, supports, and accessories for finish painting. Refer to Division 09.
- K. Install valves with stems upright or horizontal, not inverted.
- L. All grooved components (couplings, fittings, valves, gaskets, and specialties) shall be of one manufacturer.
- M. Grooved manufacturer shall provide on-site training for contractor's field personnel by a factory trained representative in the proper use of grooving tools, application of groove, and the product installation. Factory trained representative shall periodically visit the job site and inspect installation. Contractor shall remove and replace any improperly installed products.

3.3 APPLICATION

- A. Install unions downstream of valves, and at equipment or apparatus connections.
- B. Provide non-conducting dielectric connections wherever joining dissimilar metals.
- C. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.

- D. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- E. Install plug valves for throttling, bypass, or manual flow control services.
- F. Provide spring loaded check valves on discharge of condenser and chilled water pumps.
- G. Use plug cocks for throttling service. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.
- H. Use only butterfly valves in condenser water systems for throttling and isolation service.
- I. Use lug end butterfly valves to isolate equipment.
- J. Provide chain operated butterfly valve for installations at 12 feet or higher.
- K. Provide 3/4-inch ball (drain) valves equal to Nibco T-585-70-HC at main shut-off valves, low points of piping, bases of vertical risers, and at equipment and pipe to nearest drain.
- L. Provide automatic air vents at all high points and air pockets in the system. Where automatic air vents are installed above a ceiling or in other concealed locations, provide vent tubing to nearest drain.
- M. Provide manual air vents as indicated on details and drawings.

3.4 CONDENSATE DRAIN PIPING

- A. Drain piping from each unit shall be extended to the nearest floor drain or condensate drainage system. Drains shall be of the size indicated but not less than the full size of the drain pan connections.
- B. Use plugged tees in lieu of elbows.
- C. Slope all drain lines 1/8" per foot, minimum.
- D. Provide auxiliary drain pan on all AHU's above ceiling with auxiliary drain line routed to discharge in visually prominent area. Discharge location shall be coordinated with Architect.

3.5 PIPE FABRICATION AND INSTALLATION

- A. All pipes shall be cut accurately to measurements established at the site and shall be worked into place without springing or forcing.
- B. Piping layout and installation shall be made in the most advantageous manner possible with respect to headroom, valve access, opening and equipment clearance, and clearance from other work. Particular attention shall be given to piping in the vicinity of equipment; layout shall be made in such manner as to preserve maximum access to the various equipment parts for maintenance.
- C. All changes in directions shall be made with fittings; field bending and mitering of pipe is prohibited.
- D. Air vents and air chambers shall be installed as hereinafter specified.

3.6 OFFSETS AND FITTINGS

- A. Due to the small scale of the Drawings, it is not possible to indicate all offsets, fittings, etc. which may be required. The Contractor shall carefully investigate structural and finish conditions affecting the Work, and shall take such steps as may be required to meet such conditions at no additional cost to the Owner.
- B. All piping shall be installed close to walls, ceilings and columns, (consistent with the proper space for covering, removal of pipe and special clearances), so as to occupy the minimum of space, and all offsets, fittings, etc., required shall be provided at no additional cost to the Owner.

3.7 SECURING AND SUPPORTING

- A. All piping shall be adequately supported to line and grade, with due provisions for expansion and contraction.
- B. Piping shall be supported on approved clevis type, split ring, or trapeze type hangers properly connected to the structural members of the building.
- C. All insulated piping shall be fitted with suitable steel protection saddles.
- D. Perforated bar hangers, straps, wire or chains will not be permitted.

3.8 ISOLATION VALVES

- A. All piping systems shall be provided with line size shut-off valves located at risers, at branch connections to mains, and at other locations as indicated and required.

3.9 TESTING OF PIPING SYSTEMS

- A. During the progress of the Work and upon completion, tests shall be made as specified herein and as required by Authorities Having Jurisdiction, including Inspectors, Owner or Engineer. The Engineer or duly authorized Construction Inspector shall be notified in writing at least 2 working days prior to each test or other Specification requirement which requires action on the part of the Construction Inspector.
- B. Tests shall be conducted as part of this Work and shall include all necessary instruments, equipment, apparatus, and service as required to perform the tests with qualified personnel. Submit proposed test procedures, recording forms, and test equipment for approval prior to the execution of testing.
- C. Tests shall be performed before piping of various systems have been covered or furred-in. For insulated piping systems, testing shall be accomplished prior to the application of any insulation.
- D. All piping systems shall be tested and proved absolutely tight for a period of not less than 24 hours at a pressure of 150 psi(g) or 150% of design pressure, whichever is greater. Tests shall be witnessed by the Engineer or an authorized representative and pronounced satisfactory before pressure is removed or any water drawn off.
- E. Leaks, damage or defects discovered or resulting from test shall be repaired or replaced to a like new condition. Leaking pipe joints, or defective pipe, shall be removed and replaced with acceptable materials. Test shall be repeated after repairs are completed and shall continue until such time as the entire test period expires without the discovery of any leaks, damage, or defects.
- F. Wherever conditions permit, each piping system shall thereafter be subjected to its normal operating pressure and temperature for a period of no less than five 5 days. During that period, it shall be kept under the most careful observation. The piping systems must demonstrate the propriety of their installation by remaining absolutely tight during this period.

END OF SECTION

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for Owner's use.

1.3 REFERENCES

- A. AHRI 710 - Performance Rating of Liquid-Line Driers.
- B. AHRI 730 (I-P) - Flow Capacity Rating of Suction Line Filters and Suction Line Filter Driers.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants.
- D. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants.
- E. ASHRAE Std 147 - Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems.
- F. ASME A13.1 - Scheme for the Identification of Piping Systems.
- G. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- H. ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- I. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
- J. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- K. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
- L. AWS B2.2/B2.2M - Specification for Brazing Procedure and Performance Qualification.

1.4 SUBMITTALS

- A. Shop Drawings: Indicate layout of refrigeration piping system, including equipment, critical dimensions, and sizes.
- B. Piping: Submit data on pipe materials, fittings, and accessories.
- C. Valves: Submit manufacturers catalog information with valve data and ratings for each service.
- D. Refrigerant Specialties: Submit manufacturers catalog information including capacity, component sizes, rough-in requirements, and service sizes.
- E. Welding Certificates: Submit per AWS B2.2/B2.2M and ASME BPVC-IX.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide for the systems as shown. Submit shop drawings of piping systems showing all traps, pipe sizes, and accessories; drawing to be marked "Approved" and signed by a representative of the Application Engineering Department of the condensing unit manufacturer. Pipe sizes shall be as recommended by unit manufacturer. Refer to piping schematic on Drawings.

2.2 MATERIAL

- A. PIPE: Type ACR copper tubing, hard-drawn, per ASTM B280.
- B. FITTINGS: Wrought copper per ASME B16.22.
- C. JOINTS: Brazed joints with Sil-Fos filler metal per AWS A5.8M/A5.8.

2.3 ACCESSORIES

- A. All accessories shall be UL listed and rated in accordance with AHRI 710.
- B. On systems 7-1/2 tons and larger, each separate refrigerant circuit shall have a separate filter drier rated in accordance with AHRI 730 (I-P). Each filter drier shall have a replaceable core and a three valve bypass. The filter drier shall be full line size and installed in the refrigerant liquid line. The filter shall have a minimum 4-3/4 inches diameter shell with removable flange and gasket. Flange shall be tapped for 1/4 inch FPT access valve. Size filter-drier for maximum 2.0 psi pressure drop at evaporator operating temperature. Similar to Mueller Refrigeration model Drymaster micro-guard refillable filter series SD-485 through SD19217 or Sporlan catch-all.
- C. On systems less than 7-1/2 tons, the filter drier shall be the sealed type; sizes as above. One drier per refrigerant circuit.
- D. Liquid-Moisture Indicator shall be full line size, installed in liquid refrigerant line. Indicator shall be rated for the applicable refrigerant, system pressure and temperature; manufactured by Mueller Refrigeration or Sporlan.
- E. Thermostatic expansion valve shall have adjustable super heat and be as manufactured by Sporlan.
- F. Shut-off valves shall be bi-directional ball valves with welded body, brass ball with dual Teflon seals and integral relief port. Valves shall be rated for the applicable refrigerant, system pressure and temperature. Valves shall be manufactured by Mueller Refrigeration or Sporlan.

2.4 REFRIGERANT AND OIL

- A. Contractor shall leave the refrigeration system with a full charge of refrigerant and oil and shall be responsible for the maintenance of a full charge of refrigerant and oil in the systems for a period of one year from date of Substantial Completion.
- B. Should any leaks in the refrigeration system occur during the guarantee period, the Contractor shall eliminate such leaks and recharge system to a full charge of refrigerant and oil at no cost to the Owner.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All equipment and piping shall be installed in accordance with the manufacturer's recommendations and printed installation instructions.

- B. All items required for a complete and proper installation are not necessarily indicated on the Drawings or in the Specifications. Provide all items required as per manufacturer's requirements.
- C. Refrigerant piping shall be installed in accordance with ASHRAE Std 15 and ASHRAE Std 34.
- D. Arrange refrigerant piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required.
- E. Braze joints per AWS B2.2/B2.2M and AWS A5.8M/A5.8 requirements.
- F. Pipe shall be cut square, reamed and chamfered, and shall be free from burrs and obstruction. Pipe ends shall have full-bore openings and shall not be undercut.
- G. Refrigerant piping located in areas other than the room or space where the refrigerating equipment is located shall be identified with pipe markers that meet labeling requirements of ASME A13.1. Markers shall be manufactured by W.H. Brady Company or approved equal. The pipe identification shall be located at intervals not exceeding 20 feet on the refrigerant piping or pipe insulation. The minimum height of the identification lettering shall be 1/2". The pipe identification shall indicate the refrigerant designation and safety group classification of the refrigerant used in the piping system. For Group A2L and B2L refrigerants, the identification shall also include the following statement: "WARNING – Risk of Fire. Flammable Refrigerant." For Group A2, A3, B2, and B3 refrigerants, the identification shall also include the following statement: "DANGER – Risk of Fire or Explosion. Flammable Refrigerant." For any Group B refrigerant, the identification shall also include the following statement: "DANGER – Toxic Refrigerant".
- H. Refrigerant piping routed indoors shall be installed at a minimum of 7'-3" above finished floor when located above an area affording passage of occupants.
- I. Refrigerant piping located indoors shall be located within building elements such as a ceiling or wall space or within a protective enclosure unless installed a minimum of 7'-3" above finished floor, within 6'-0" of the associated equipment or within a refrigerant machinery room.
- J. Provide shield plates for refrigerant pipes containing Group A2, A3, B2L, B2, and B3 refrigerants that are located in concealed locations where piping is installed in studs, joists, rafters or similar member spaces, and are located less than 1-1/2 inches from the nearest edge of the member. Shield plates shall be constructed of steel, have a minimum thickness of 16 gage, and shall extend two inches beyond the edge of the piping on each side.
- K. Refrigerant pipe and joints installed in the field shall be exposed for visual inspection and testing prior to being covered or enclosed.

3.2 FIELD QUALITY CONTROL

- A. Test piping and refrigeration system in accordance with ASME B31.5, ASHRAE Std 147, and this section.
- B. The refrigerant piping system shall be tested as a whole or separate tests shall be conducted for the low-pressure side and high-pressure side of the piping system.
 - 1. Pressure Test:
 - a. Pressure test shall be performed using dry nitrogen.
 - b. The means used to pressurize the refrigerant piping system shall have on its outlet side a test pressure measuring device and either a pressure-limiting device or a pressure-reducing device. The test pressure measuring device shall have an accuracy of +/- 3% or less of the test pressure and shall have a resolution of 5% or less of the test pressure.

- c. The system shall be pressurized for a period of not less than 60 minutes. Additional test gas shall not be added to the system after the start of the test.
 - d. Test pressure shall be at least 110% of the system design pressure.
 - e. Test pressure shall not exceed 130% of the design pressure of any component in the system.
 - f. The system shall not show loss of pressure on the test measuring device throughout the entirety of the test.
- 2. Evacuation and Leak Test:
 - a. Evacuate moisture completely by applying a commercial vacuum pump. Moisture indicator shall indicate a completely moisture-free condition at time of final inspection.
 - b. The vacuum pump shall run until the system indicates a vacuum of 500 microns.
 - c. After achieving a vacuum, the system shall be isolated from the vacuum pump. The system pressure shall not rise for a minimum of 24 hours.
 - d. The system shall be flushed with the operating refrigerant and the vacuum pump connected and rerun to repeat the evacuation. Evaluation shall be performed under supervision of the Engineer.
- C. Repair any and all leaks and retest as required.

END OF SECTION

SECTION 23 31 13 METAL DUCTWORK

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Low pressure ductwork.
- B. Casings.
- C. Exposed ductwork located indoors.
- D. Duct leakage testing.
- E. Duct system protection.
- F. Duct system cleaning.

1.2 RELATED SECTIONS

- A. Division 9 - Finishes: Weld priming, weather resistant, paint or coating.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC
- C. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC
- D. Section 23 05 93 - Testing, Adjusting, And Balancing
- E. Section 23 07 13 - Duct Insulation
- F. Section 23 33 00 - Ductwork Accessories
- G. Section 23 37 13 - Air Distribution Devices

1.3 REFERENCES

- A. ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- C. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- D. NADCA ACR - The NADCA Standard for Assessment, Cleaning, and Restoration of HVAC Systems.
- E. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- F. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.
- G. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual.
- H. ASHRAE (FUND) ASHRAE Handbook - Fundamentals; Chapter 21 - Duct Design.
- I. ASHRAE (HVACS) ASHRAE Handbook - HVAC Systems and Equipment; Chapter 19 - Duct Construction.
- J. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- K. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- L. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- M. ICC (IECC) - International Energy Conservation Code.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.

1.5 GENERAL DESCRIPTION

- A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

1.6 SUBMITTALS

- A. Submit shop drawings, duct fabrication standards and product data under provisions of Division One.
- B. Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration prior to start of work.
- C. The contract documents are schematic in nature and are to be used only for design intent. The contractor shall prepare sheet metal shop drawings, fully detailed and drawn to scale, indicating all structural conditions, all plumbing pipe and light fixture coordination, and all offsets and transitions as required to permit the duct to fit in the space allocated and built. All duct revisions required as a result of the contractor not preparing fully detailed shop drawings will be performed at no additional cost.

1.7 DEFINITIONS

- A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain indicated clear size inside lining. Where offsets or transitions are required, the duct shall be the equivalent size based on constant friction rate.
- B. Low Pressure: Low pressure ductwork shall be rated for an operating pressure of 2". Low pressure ductwork shall be defined as all return, exhaust, and outside air ducts, all supply ductwork associated with constant volume air handling units with a scheduled external static pressure of less than 2", and all supply ductwork downstream of terminal units in variable volume systems.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings, use sheet metal end caps on any lined duct exposed to the weather.
- B. Storage: Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

- A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discolorations, and other imperfections, including those which would impair painting.
- B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A653/A653M.
- C. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A480/A480M; Type 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.
- D. Aluminum Sheet: Where indicated, provide aluminum sheet complying with ASTM B209, Alloy 3003, Temper H14.

2.2 MISCELLANEOUS DUCTWORK MATERIALS

- A. General: Non-combustible and conforming to UL 181, Class 1 air duct materials.
- B. Flexible Ducts: Flexmaster U.S.A., Inc. Type 5M, Thermaflex MKE, ATCO #036 or approved equal.
 - 1. Flexible ducts shall be corrosive resistant galvanized steel formed and mechanically locked to inner fabric with minimum 1-1/2" thick, R-6 insulation. Flexible duct shall be rated up to at least 10 in.w.g. positive pressure and shall have reinforced metalized outer jacket to comply with UL 181, Class 1 air duct.
- C. Sealants: Hard-Cast "iron grip" or approved equal, non-hardening, water resistant, fire resistive and shall not be a solvent curing product. Sealants shall be compatible with mating materials, liquid used alone or with tape or heavy mastic.
- D. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
 - 1. For exposed stainless steel ductwork, provide matching stainless steel support materials.
 - 2. For aluminum ductwork, provide aluminum support materials.

2.3 LOW PRESSURE DUCTWORK

- A. Fabricate and support in accordance with latest SMACNA (DCS) Standards and ASHRAE handbooks, except as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by approved shop drawings. Obtain engineer's approval prior to using round duct in lieu of rectangular duct.
- C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil-turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
- D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.
- E. Use crimp joints with bead for joining round duct sizes 6 inch smaller with crimp in direction of airflow.
- F. Use double nuts and lock washers on threaded rod supports.

2.4 EXPOSED DUCTWORK LOCATED INDOORS

- A. Where ductwork is indicated to be exposed to view in occupied spaces, provide round or flat oval, double wall galvanized steel construction with spiral lockseam with perforated inner liner, United McGill Corporation model Acousti-k27 or approved equal.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Obtain manufacturer's inspection and acceptance of fabrication and installation of ductwork at beginning of installation.

- B. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- C. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- D. Connect diffusers or troffer boots to low pressure ducts with 5 feet maximum, 4 feet minimum, length of flexible duct. Hold in place with strap or clamp.
- E. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- F. The interior surface of all ductwork shall be smooth. No sheet metal parts, tabs, angles, or anything else may project into the ducts for any reason, except as specified to be so. All seams and joints shall be external.
- G. All ductwork located outdoors shall be "crowned" to prevent water from ponding. Ref: Insulation for additional requirements.
- H. Where ducts pass through non-rated floors, provide structural angles for duct support. Where ducts pass through non-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches. Where ducts pass through rated interior partitions, rated exterior walls, or rated floors, install fire dampers or smoke dampers as required. Provide sleeves for dampers not provided with factory sleeve. Refer to Section 23 33 00 - Ductwork Accessories for fire and smoke damper requirements.
- I. All angles shall be carried around all four sides of the duct or group of ducts. Angles shall overlap corners and be welded or riveted.
- J. All ductwork shall be fabricated in a manner to prevent the seams or joints being cut for the installation of grilles, registers, or ceiling outlets.
- K. All duct hangers shall be attached to building structure. Cutting slots in roof or floor decking for hanger straps to be cast in concrete is not acceptable.

3.2 INSTALLATION OF FLEXIBLE DUCTS

- A. Maximum Length: For any duct run using flexible ductwork, do not exceed 5'-0" extended length.
- B. Installation: Install in accordance with Section III of SMACNA (DCS).

3.3 DUCTWORK APPLICATION SCHEDULE

- A. Ductwork materials shall be provided to comply with the following:

AIR SYSTEM	MATERIAL
Low Pressure Supply	Galvanized Steel, Aluminum
Buried Supply or Return	Concrete, Glass Fiber Reinforced Plastic
Medium and High Pressure Supply	Galvanized Steel
Return and Relief	Galvanized Steel, Aluminum
General Exhaust	Galvanized Steel, Aluminum
Grease Exhaust	Carbon Steel, Stainless Steel
Domestic Range Hood Exhaust	Galvanized Steel
Dishwasher/Ductwork Serving Type II Hoods	Stainless Steel

Shower/Locker Room/Dryer Vent/Paint Hood Exhaust	Stainless Steel
Fume Hood Exhaust	Stainless Steel
Corrosive Pool Environments	Aluminum
Welding Exhaust	Galvanized Steel
Outside Air Intake	Galvanized Steel
Combustion Air	Galvanized Steel
Emergency Generator Ventilation	Carbon Steel

3.4 DUCTWORK HANGERS AND SUPPORTS

- A. All ductwork shall be properly suspended or supported from the building structure. Hangers shall be galvanized steel straps or hot-dipped galvanized rod with threads pointed after installation. Strap hanger shall be attached to the bottom of the ductwork, provide a minimum of two screws one at the bottom and one in the side of each strap on metal ductwork. The spacing, size and installation of hangers shall be in accordance with the recommendations of the latest SMACNA edition.
- B. Wire shall not be used for permanent support or attachment components.
- C. All duct risers shall be supported by angles or channels secured to the sides of the ducts at each floor with sheet metal screws or rivets. The floor supports may also be secured to ducts by rods, angles or flat bar to the duct joint or reinforcing. Structural steel supports for duct risers shall be provided under this Division.

3.5 AIR DUCT LEAKAGE: (FROM SMACNA DUCT STANDARDS LATEST EDITION) TEST ALL DUCTWORK (DESIGNED TO HANDLE OVER 1,000 CFM) AS FOLLOWS:

- A. Test apparatus
 - 1. A source of high pressure air-a portable rotary blower or a tank type vacuum cleaner.
 - 2. A flow measuring device consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated with its own calibration curve. Pressure and flow readings shall be taken with U-tube manometers.
- B. Test Procedures
 - 1. Test for audible leaks as follows:
 - 2. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
 - a. Start the blower with its control damper closed.
 - b. Gradually open the inlet damper until the duct pressure reaches 1.5 times the standard designed duct operating pressure.
 - c. Survey all joints for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
 - 3. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:
 - a. Start blower and open damper until pressure in duct reaches 50% in excess of designed duct operating pressure.
 - b. Read the pressure differential across the orifice on manometer No. 2. If there is no leakage, the pressure differential will be zero.
 - c. Total allowable leakage shall not exceed one (1) percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

- d. Even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak which, must be corrected.
- 4. Testing Report
 - a. Contractor shall provide a testing report for each air system to the engineer. The report shall indicate the completion of testing and compliance with testing specification.
 - b. All duct testing reports shall be included in the final close out documents.

3.6 DUCT SYSTEM PROTECTION

- A. Provide temporary closures at the ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation; provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.
- B. Provide temporary construction filters on air handling equipment and/or return air ductwork during construction to protect ductwork and equipment from dust.
- C. Any ductwork stored on site with observable dirt or debris inside shall be cleaned by a third party.
- D. If the air handling system has been operated without temporary construction filters or if the integrity of the temporary closures has been compromised, the contractor shall have the duct system cleaned per the following section.

3.7 DUCT SYSTEM CLEANING

- A. For renovation projects and HVAC retrofit applications wherein existing duct systems are scheduled to be re-used, or where required by the Duct System Protection section above, the contractor shall have the existing duct systems cleaned in accordance with the current published standards of ASHRAE, NADCA ACR and as indicated below.
- B. Duct system cleaning method used shall incorporate the use of vacuum collection devices that are operated continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned through a predetermined opening. The vacuum collection device must be of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment is assured.
- C. All vacuum devices exhausting air inside the building shall be equipped with HEPA filters (minimum efficiency), including hand-held vacuums and wet-vacuums.
- D. All vacuum devices exhausting air outside the facility shall be equipped with Particulate Collection including adequate filtration to contain debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any outdoor environmental standards, codes or regulations.
- E. Fibrous glass thermal or acoustical insulation elements present in any equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment, while the HVAC system is under constant negative pressure, and not permitted to get wet in accordance with applicable NADCA and NAIMA standards and recommendations.
- F. Duct cleaning method used shall not damage the integrity of the ductwork, nor damage porous surface materials such as liners inside the ductwork or system components.
- G. Replace the fiberglass material if there is any evidence of damage, deterioration, delamination, friable material, mold or fungus growth, or moisture such that fibrous glass materials cannot be restored by cleaning or resurfacing with an acceptable insulation repair coating.

- H. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
- I. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.
- J. Cleaning Report: Contractor shall provide a report to the Owner indicating the completion of duct cleaning per specification and areas of the duct system found to be damaged and/or in need of repair.

3.8 DUCT JOINTS AND SEAMS

- A. All ductwork shall be constructed to Seal Class A, as referenced in SMACNA (DCS).
- B. All non-welded joints and seams shall be sealed. This includes but is not limited to:
 - 1. Transverse joints.
 - 2. Longitudinal seams.
 - 3. Duct wall penetrations.
 - 4. Spin-ins, taps, and other branch connections.
 - 5. Access doors, access panels, and duct connections to equipment.
- C. Openings for rotating shafts shall be sealed with bushings.

END OF SECTION

SECTION 23 33 00
DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Volume control dampers.
- B. Shutoff Dampers.
- C. Round Duct Taps.
- D. Conical Duct Taps.
- E. Back draft dampers.
- F. Air turning devices.
- G. Flexible duct connections.
- H. Duct access doors.
- I. Duct test holes.

1.2 RELATED WORK

- A. Section 23 02 00 - Basic Materials and Methods for HVAC
- B. Section 23 05 48 - Vibration Controls for HVAC Piping and Equipment
- C. Section 23 31 13 - Metal Ductwork

1.3 REFERENCES

- A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating.
- B. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- C. ICC (IECC) - International Energy Conservation Code.
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- E. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- F. UL 33 - Safety Heat Responsive Links for Fire-Protection Service.
- G. UL 555 - Standard for Fire Dampers.

1.4 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Division One.
- B. Provide shop drawings for shop fabricated assemblies indicated, including volume control dampers duct access doors duct test holes. Provide product data for hardware used.
- C. Submit manufacturer's installation instructions under provisions of Division 1, for fire dampers and combination fire and smoke dampers.

PART 2 - PRODUCTS

2.1 VOLUME CONTROL DAMPERS

- A. Fabricate in accordance with SMACNA (DCS), and as indicated.
- B. Fabricate splitter dampers of material same gauge as duct to 24 inches size in either direction, and two gauges heavier for sizes over 24 inches.
- C. Fabricate splitter dampers of double thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with minimum 1/2 inch diameter rod in self aligning, universal joint, action flanged bushing, with set screw.
- D. Fabricate single blade dampers for duct sizes to 9-1/2 x 24 inch.
- E. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12 x 72 inch.

1. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
 2. On outside air, return air, and all other dampers required to be low leakage type, provide galvanized blades and frames, seven inches wide maximum, with replaceable vinyl, EPDM, silicone rubber seals on blade edges and stainless steel side seals. Provide blades in a double sheet corrugated type construction for extra strength. Provide hat channel shape frames for strength and blade linkage enclosure to keep linkage out of the air stream. Construction leakage not to exceed 1/2%, based on 2,000 fpm and 4 inch static pressure.
- F. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.
- G. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Where rod lengths exceed 30 inches provide regulator at both ends.
- H. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.2 SHUTOFF DAMPERS

- A. Fabricate in accordance with SMACNA (DCS), and as indicated.
- B. Provide Class I multi-blade damper of parallel blade pattern for all ductwork systems which penetrate the building thermal envelope in accordance with ICC (IECC) and ASHRAE Std 90.1 I-P.
1. Damper shall be constructed of one-piece 16 ga. roll-formed galvanized steel hat-shaped channel frame. Blades shall be 14 ga. roll-formed galvanized steel, airfoil type. Blade edge seals shall be neoprene gaskets mechanically locked to blade edge. Bearings shall be 304 stainless steel, oil-impregnated and self-lubricating sleeve type, turning in extruded holes in damper frame.
- C. Shutoff dampers shall have an air leakage rate not greater than 4 cfm/ft² of damper surface area at 1.0 in.w.g. and shall be labeled by an approved agency when tested in accordance with AMCA 500-D for such purpose.

2.3 ROUND DUCT TAPS

- A. Taps to trunk duct for round flexible duct shall be spin-in fitting with locking quadrant butterfly damper, model no. FLD-B03 by Flexmaster or approved equal.

2.4 CONICAL DUCT TAPS

- A. Taps to trunk duct for primary air inlet to all VAV terminal units shall be conical fitting, model no. CB by Flexmaster or approved equal.

2.5 ACCEPTABLE MANUFACTURERS - FIRE DAMPERS AND COMBINATION FIRE AND SMOKE DAMPERS

- A. Greenheck.
- B. Louvers and Dampers Inc.
- C. Ruskin.
- D. Nailor Industries.
- E. Pottorff.

2.6 FIRE DAMPERS

- A. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- B. Provide curtain type dampers of galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream. Provide factory sleeve for each damper.

- C. Fabricate multiple blade fire dampers per UL with 16 gauge minimum galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
- D. Fusible links, UL 33, shall separate at 165 degrees F. Provide adjustable link straps for combination fire/balancing dampers.

2.7 ACCEPTABLE MANUFACTURERS - BACKDRAFT DAMPERS

- A. Greenheck.
- B. American Warming and Vent.
- C. Louvers and Dampers Inc.
- D. Ruskin.
- E. Pottorff.
- F. Substitutions: Under provisions of Division One.

2.8 BACKDRAFT DAMPERS

- A. Gravity back draft dampers, size 18 x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturers standard construction.
- B. Fabricate multi-blade, parallel action gravity balanced back draft dampers of 16 gauge galvanized steel, or extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.
- C. Gravity backdraft dampers shall have an air leakage not greater than 20 cfm/ft² where not less than 24 inches in either dimension and 40 cfm/ft² where less than 24 inches in either dimension. The rate of air leakage shall be determined at 1.0 in.w.g. when tested in accordance with AMCA 500-D for such purpose.

2.9 ACCEPTABLE MANUFACTURERS - AIR TURNING DEVICES

- A. Young Regulator.
- B. Titus.
- C. Tuttle and Bailey.
- D. Substitutions: Under provisions of Division One.

2.10 AIR TURNING DEVICES

- A. On duct sizes less than 12 x 12, multi-blade device with blades aligned in short dimension; steel or aluminum construction; with individually adjustable blades, mounting straps.
- B. Multi-blade device with radius blades attached to pivoting frame and bracket, steel or aluminum construction, with worm drive mechanism with 18 inch long removable key operator.

2.11 ACCEPTABLE MANUFACTURERS - FLEXIBLE DUCT CONNECTIONS

- A. Metaledge.
- B. Ventglass.
- C. Substitutions: Under provisions of Division One.

2.12 FLEXIBLE DUCT CONNECTIONS TO AIR MOVING EQUIPMENT

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.

- B. UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 20 oz. per sq. yd., approximately 6 inches wide, crimped into metal edging strip.

2.13 ACCEPTABLE MANUFACTURERS - DUCT ACCESS DOORS

- A. Greenheck.
- B. American Warming and Vent.
- C. Ruskin.
- D. Titus.
- E. Substitutions: Under provisions of Division One.

2.14 DUCT ACCESS DOORS

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.
- B. Review locations prior to fabrication.
- C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover. Insulation shall be replaceable without field cutting or patching.
- D. Access doors smaller than 12 inches square may be secured with sash locks.
- E. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.
- F. Access doors with sheet metal screw fasteners are not acceptable.

2.15 DUCT TEST HOLES

- A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- B. Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions.
- B. Balancing Dampers
 - 1. Provide at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and as required for air balancing. Use splitter dampers only where indicated.
 - 2. All regulators mounted on externally insulated ductwork shall have 16 gauge elevated platforms at least 1/8 inch higher than the thickness of the insulation. Damper shaft shall have Ventlock No. 607 bearing mounted on ductwork within elevated platform. If duct is inaccessible the operating handle shall be extended and the regulator installed on the face of the wall or ceiling. Where regulators are exposed in finished parts of the building, they shall be flush type, Ventlock No. 666. All regulators shall be manufactured by Ventlock, or approved equal.
 - 3. All dampers in lined ductwork shall have bushing to prevent damper damage to liner.
- C. Provide fire dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

- D. Demonstrate re-setting of fire dampers to authorities having jurisdiction and Owner's representative.
- E. Provide gravity backdraft dampers or motorized shutoff dampers in accessible location nearest to exterior wall/roof penetrations and where indicated for all outdoor air intake and exhaust systems to automatically shut when the associated systems or spaces served are not in use.
- F. Provide flexible duct connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Provide at least one inch slack at all flexible duct connections.
- G. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated.
- H. Provide duct access doors for inspection and maintenance of all fire dampers, smoke dampers, and combination fire/smoke dampers. Provide minimum 12 x 12 inch size access opening where duct size permits. All duct sizes that cannot accommodate a minimum 12 x 12 inch access opening shall be provided with a removable duct section to permit inspection and maintenance of the damper and its operating parts. Removable duct sections shall match the pressure class of the associated duct system, maintain 100 percent of the duct free area, and utilize gaskets and clamp type draw latches to allow removal and reinstallation without the use of tools.
- I. Provide duct test holes where indicated and required for testing and balancing purposes.

END OF SECTION

SECTION 23 34 00
HVAC FANS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 WORK INCLUDED

- A. Centrifugal roof ventilators
- B. Ceiling and inline ventilators
- C. Utility fans

1.3 RELATED SECTIONS

- A. Section 23 02 00 - Basic Materials and Methods for HVAC
- B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
- C. Section 23 05 48 - Vibration Controls for HVAC Piping and Equipment
- D. Section 23 05 93 - Testing, Adjusting, And Balancing
- E. Section 23 09 63 - Energy Management and Control System (EMCS)
- F. Section 23 33 00 - Ductwork Accessories

1.4 REFERENCES

- A. AMCA 204 - Balance Quality and Vibration Levels for Fans.
- B. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
- C. AMCA 211 - Certified Ratings Program Product Rating Manual for Fan Air Performance.
- D. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
- E. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- F. AMCA 311 - Certified Ratings Program Product Rating Manual for Fan Sound Performance.
- G. ASCE 7-16 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures.
- H. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- I. ASTM E330/E330M - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.
- J. FLA (FBC-B) - Florida Building Code: Building (8th Edition).
- K. ICC (IBC) - International Building Code.
- L. ICC (IECC) - International Energy Conservation Code.
- M. Miami (APD) - Approved Products Directory; Miami-Dade County.
- N. NFPA 70 - National Electrical Code.
- O. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- P. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- Q. UL 705 - Power Ventilators.

1.5 QUALITY ASSURANCE

- A. UL Compliance: Fans shall be designed, manufactured, and tested in accordance with UL 705.
- B. UL Compliance: Fans and components shall be UL listed and labeled.
- C. Nationally Recognized Testing Laboratory Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.
- D. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- E. Electrical Component Standard: Components and installation shall comply with NFPA 70.
- F. Sound Power Level Ratings: Comply with AMCA 301. Test fans in accordance with AMCA 300. Fans shall be licensed to bear the AMCA 300 Seal.
- G. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA 210.
- H. Motors for fans that are not less than 1/12 hp (0.082 kW) and less than 1 hp (0.746 kW) shall be electronically commutated motors per ICC (IECC) and ASHRAE Std 90.1 I-P.
- I. High Wind models shall be analyzed and stamped by a state license P.E. to the ASCE 7-16 Standard which meets the ICC (IBC), FLA (FBC-B), and Miami (APD) codes.
- J. Each High Wind model is subject to be certified by a Nationally Recognized Testing Laboratory to ASTM E330/E330M.

1.6 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
- B. Product data for selected models, including specialties, accessories, and the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound power ratings.
 - 3. Motor ratings and electrical characteristics plus motor and fan accessories.
 - 4. Materials, gages and finishes, include color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Full color paint samples.
- C. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.
- D. Coordination drawings, in accordance with Division 23, Section "Basic Materials and Methods", for roof penetration requirements and for reflected ceiling plans drawn accurately to scale and coordinating penetrations and units mounted above ceiling. Show the following:
 - 1. Roof framing and support members relative to duct penetrations.
 - 2. Ceiling suspension members.
 - 3. Method of attaching hangers to building structure.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.
- E. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer installed wiring and field installed wiring.
- F. Product certificates, signed by manufacturer, certifying that their products comply with specified requirements.

- G. Maintenance data for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 23, Section "Basic Materials and Methods".
- H. Provide delegated design submittal for equipment anchorage as required in specification 23 02 00 – Part 1.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Fans shall be stored and handled in accordance with the unit manufacturer's instructions.
- B. Lift and support units with the manufacturer's designated lifting or supporting points.
- C. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.
- D. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.9 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes and corrections.
 - 6. On site demonstration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Greenheck Fan Corporation
- B. Loren Cook Company
- C. Pennbarry
- D. ACME
- E. Twin City Fan and Blower

2.2 GENERAL DESCRIPTION

- A. Provide fans that are factory fabricated and assembled, factory tested, and factory finished with indicated capacities and characteristics.
- B. Fans and Shafts shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
- C. Provide factory baked-enamel finish coat after assembly. Color for roof mounted fans shall be chosen by Architect during the submittal process.

2.3 CENTRIFUGAL ROOF VENTILATORS

- A. Fan shall be a spun aluminum, centrifugal, roof mounted, direct driven or belt driven as indicated.

- B. Fan shall be UL 705 listed. Fan shall bear the AMCA certified ratings seal for sound and air performance.
- C. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure.
- D. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. A discharge baffle conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections.
- E. The motor, bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. Unit shall bear an engraved aluminum nameplate and shall be shipped in transit tested packaging.
- F. Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA 204, balance quality and vibration levels for fans.
- G. Motor shall be heavy duty type with permanently lubricated sealed ball bearings.
- H. Bearings shall be designed and individually tested specifically for use in air handling applications. Construction shall be heavy duty re-greaseable ball type in a cast iron housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.
- I. Accessories: The following accessories are required.
 - 1. Disconnect Switch: Non-fusible type, with thermal overload protection, mounted inside fan housing, factory-wired through an internal aluminum conduit.
 - 2. Bird Screens: Removable ½ inch mesh, 16 gauge, aluminum or brass wire.
 - 3. Dampers: Gravity backdraft damper or motorized shutoff damper mounted in accessible location. Refer to 23 33 00 - Ductwork Accessories.
 - 4. Roof Curbs: Prefabricated, minimum 12 inch high, heavy-gauge, galvanized steel; mitered and welded corners; 2 inch thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks; and 2 inch wood nailer. Curb heights shall be increased as required to maintain a minimum height of 8 inches above adjacent roofing surface. Size as required to suit roof opening and fan base. Roof curb shall match roof slope so that the curb is level.

2.4 CEILING AND INLINE VENTILATORS

- A. Ceiling and inline ventilators shall be direct drive or belt drive as indicated, centrifugal blower type. Fan wheel shall be constructed of galvanized steel and shall be dynamically balanced. The housing shall be constructed of minimum 20 gauge corrosion resistant galvanized steel and acoustically insulated for quiet operation. Blower and motor assembly shall be easily removable from the housing without disturbing the ductwork. The motor shall be permanently lubricated with built-in thermal overload protection and shall be factory tested prior to shipment. The ceiling ventilators shall be furnished standard with a powder-painted white steel grille.
- B. Ventilators shall be certified and licensed to bear the AMCA Seal for Air and Sound Performance. Ventilator performance shall be based on tests and procedures performed in accordance with AMCA 211 and comply with the requirements of the AMCA Certified Ratings Program. Fan sound power level ratings shall be based on tests and procedures performed in accordance with AMCA 311 and comply with the requirements of the AMCA Certified Ratings Program. Ventilators shall be UL listed and CSA certified.

- C. Accessories: The following accessories are required.
 - 1. Dampers:
 - a. Aluminum backdraft damper.
 - b. Motor-operated volume control damper.
 - c. L listed ceiling radiation damper for ceiling fans comply with NFPA 90A rated for 3 hours
 - 2. Disconnect Switch: Nonfusible type with thermal overload protection.
 - 3. Speed Controls: Fan mounted, solid state speed controller.

2.5 UTILITY FANS

- A. Fans shall be of the direct driven or belt driven utility fan type as indicated with a single width, single inlet housing in AMCA arrangement 10.
- B. The housing shall be constructed of minimum 14 gauge steel with continuously welded or lock formed seams permitting no air leakage. The housing shall be field rotatable to any of the eight standard discharge positions. Housing and bearing supports shall be constructed of minimum 10 gauge welded steel members to prevent vibration and rigidly support the shaft and bearings. Side access inspection port shall be provided for access to the motor compartments.
- C. The fan wheel shall be of the forward curved type C, non-overloading backward inclined, centrifugal fan type and constructed of heavy gauge steel.
- D. Wheels shall be statically and dynamically balanced. The wheel cone and fan inlet cone shall be carefully matched for maximum performance and operating efficiency.
- E. Motors shall be permanently lubricated, heavy duty, ball bearing type carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. The fan shaft shall be ground and polished solid steel mounted in heavy duty, permanently sealed, pillow block ball bearings. Bearings shall be selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. The motor pulley shall be adjustable for final system balancing.
- F. Fan performance shall be based on tests conducted in accordance with AMCA 210. Fans shall be licensed to bear the AMCA Certified Ratings Seal for air performance.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Refer to specification 23 02 00 – Part 1 for anchorage requirements for roof mounted equipment.
- C. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.
- D. Refer to 23 05 48 - Vibration Controls for HVAC Piping and Equipment for additional installation requirements.
- E. Flexible duct connections and shutoff dampers are prohibited from being installed in duct systems conveying grease laden exhaust air per NFPA 96 requirements.

END OF SECTION

SECTION 23 34 39
HIGH-VOLUME, LOW-SPEED PROPELLER FANS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes
 - 1. Powerfoil X4.0
 - 2. Basic 6
 - 3. Essence
- B. Summary of Work
 - 1. Provide the ceiling-mounted, circulation fans with the models scheduled and with the capacities indicated. The fan shall be furnished with standard mounting hardware and variable speed control to provide cooling and destratification.
 - 2. Installation of the fan, miscellaneous or structural metal work (if required), field electrical wiring, cable, conduit, fuses and disconnect switches, other than those addressed in the installation scope of work, shall be provided by others.

1.2 RELATED SECTIONS

- A. Section 21 00 00 - Fire Protection
- B. Section 23 02 00 - Basic Materials and Methods for HVAC
- C. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
- D. Section 23 05 53 - Identification for HVAC Piping and Equipment
- E. Section 26 02 00 - Basic Materials and Methods for Electrical
- F. Section 28 46 00 - Fire Alarm and Smoke Detection System

1.3 REFERENCES

- A. 10 CFR 430, Appendix U to Subpart B - Uniform Test Method for Measuring the Energy Consumption of Ceiling Fans.
- B. AMCA 211 - Certified Ratings Program Product Rating Manual for Fan Air Performance.
- C. AMCA 230 - Laboratory Methods Of Testing Air Circulating Fans For Rating And Certification.
- D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
- E. CSA C22.2 No. 113 - Fans and Ventilators.
- F. ISO 9001 - Quality Management Systems — Requirements.
- G. NFPA 13 - Standard for the Installation of Sprinkler Systems.
- H. NFPA 70 - National Electrical Code.
- I. NFPA 72 - National Fire Alarm and Signaling Code.
- J. UL 507 - Electric Fans.
- K. ROHS - Restriction of Hazardous Substances
- L. NEMA - National Electrical Manufacturers Association

1.4 QUALITY ASSURANCE

- A. Certifications
 - 1. The fan assembly, as a system, shall be Intertek/ETL-certified and built pursuant to the guidelines set forth by UL 507 and CSA standard 22.2 No. 113.
 - 2. The fan shall be compliant with NFPA 13, NFPA 72 and NFPA 70.
 - 3. Controllers shall comply with National Electrical Code (NEC) and Underwriters Laboratory (UL) standards and shall be labeled where required by code.

4. Fans shall be tested to meet the minimum efficiency requirements of 10 CFR 430, Appendix U to Subpart B.
 5. Performance ratings shall conform to AMCA 211. Fans shall be tested and labeled in accordance with AMCA 230 for performance ratings.
- B. Manufacturer Qualifications
1. The fan and any accessories shall be supplied by a company that has a minimum of ten (10) years of product experience.
 2. ISO 9001 - certified

1.5 SUBMITTALS

- A. Shop Drawings: Drawings detailing product dimensions, weight, and attachment methods.
- B. Product Data: Specification sheets on the ceiling-mounted fan, specifying electrical and installation requirements, features and benefits, and controller information.
- C. Revit Files: File provided for Contractor's coordination drawings.
- D. Installation Guide: The manufacturer shall furnish a copy of all operating and maintenance instructions for the fan. All data is subject to change without notice.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver product in original, undamaged packaging with identification labels intact. The fan shall be new, free from defects, and factory tested.
- B. The fan and its components must be stored in a safe, dry location until installation.

1.7 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 1. Purpose of equipment.
 2. Principle of how the equipment works.
 3. Important parts and assemblies.
 4. How the equipment achieves its purpose and necessary operating conditions.
 5. Most likely failure modes, causes and corrections.
 6. On site demonstration.

1.8 WARRANTY

- A. The manufacturer shall replace any products or components defective in material or workmanship for the customer free of charge including transportation charges in accordance to the following schedule:
 1. HVLS fans scheduled as Powerfoil X4.0 Fans:
 - a. Mechanical - 15 years
 - b. Electrical - 7 years
 - c. Labor - 1 year
 2. HVLS fans scheduled as Basic 6 Fans:
 - a. Mechanical - 7 years
 - b. Electrical - 3 years
 - c. Labor - 1 year
 3. HVLS fans scheduled as Essence Fans:
 - a. Mechanical - 10 years
 - b. Electrical - 5 years

- c. Labor - 1 year

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Big Ass Fans
- B. Entrematic
- C. Macroair

2.2 HIGH VOLUME, LOW SPEED FANS - BIG ASS FANS POWERFOIL X4.0

- A. Complete Unit
 - 1. Regulatory Requirements:
 - a. The entire fan assembly (with or without light kit) shall be Intertek/ETL-certified and built pursuant to the construction guidelines set forth by UL 507 and CSA C22.2 No. 113.
 - b. The BAFCon controller shall be compliant with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) The device may not cause harmful interference, and (2) The device must accept any interference received, including interference that may cause undesirable operation.
 - 2. Sustainability Characteristics:
 - a. The fan shall be designed to move an effective amount of air for cooling and destratification in a variety of applications (including industrial and agricultural) over an extended life. The fan components shall be designed specifically for high volume, low speed fans to ensure lower operational noise. Sound levels from the fan operating at maximum speed measured in a laboratory setting shall not exceed 55 dBA. Actual results of sound measurements in the field may vary due to sound reflective surfaces and environmental conditions.
 - b. The BAFCon controller shall be designed to control Big Ass Fans and lighting systems from a secure, centralized location. The system shall be designed specifically for high volume, low speed Big Ass Fans to ensure maximum control. The system shall include optional SmartSense functionality to maximize energy savings. SmartSense shall provide the capability to automatically control the speed of Big Ass Fans using information from user-determined settings and built-in temperature and humidity sensors.
 - 3. Good workmanship shall be evident in all aspects of construction. Field balancing of the airfoils shall not be necessary.
- B. Onboard Fan Control
 - 1. The onboard fan controller shall be constructed using a variable frequency drive (VFD) that is pre-wired to the motor and factory-programmed to minimize the starting and braking torques for smooth and efficient operation. The onboard controller shall be prewired to the motor using a short run of flexible conduit with a dedicated ground conductor to minimize electromagnetic interference (EMI) and radio frequency interference (RFI). A 15-ft incoming power cord shall be pre-wired to the controller with one of the following plugs: NEMA L6-20P Twist-Lock Plug, NEMA L6-30P Twist-Lock Plug, NEMA L15-20P Twist Lock Plug, NEMA L16-20P Twist-Lock Plug.
 - 2. As an option, the architect or owner may upgrade to the "harsh environment package," which includes a seal for the weather-resistant onboard VFD enclosure and a motor with IP55 NEMA classification.
 - 3. For fans with single-phase input, conversion to three-phase output takes place at the VFD.

C. Airfoil System

1. The fan shall be equipped with eight (8) Powerfoil airfoils of precision extruded aluminum alloy. The airfoils shall be connected by means of two (2) high strength locking bolts per airfoil. The airfoils shall be connected to the hub and interlocked with zinc plated steel retainers.
2. The fan shall be equipped with eight (8) Powerfoil winglets (standard) or eight (8) Powerfoil Plus winglets (optional) on the ends of the airfoils and eight (8) AirFences® positioned on the airfoils at the optimum location for performance. Both the winglets and AirFences shall be molded of a polypropylene blend. The standard color of the winglet and AirFence shall be "Safety Yellow." Color shall be as scheduled and shall be coordinated with the architect and owner prior to ordering.
3. Airfoil Restraint System
 - a. All 20- to 24-ft diameter fans shall be equipped with a patented airfoil restraint system to provide redundant safety between the ends of the airfoils and the fan hub. The airfoil restraint system shall be available as an option on smaller diameter fans.
 - b. The airfoil restraint system shall be comprised of durable, lightweight nylon safety straps that shall extend from winglets through the airfoils and secure to the fan hub with 12-gauge stamped steel safety clips.
 - c. The straps shall be made of 1 in. wide heavy-duty nylon webbing rated for 825 lb. The loops at the ends of the straps shall be secured in a double-stitch pattern for reinforced durability.
 - d. The straps shall be precisely matched to each fan's diameter, eliminating the need for a tensioning mechanism and reducing opportunity for noise.
 - e. The straps shall run along the inside of the airfoils for an uninterrupted look.
 - f. Safety clips are preattached to each winglet at the factory to comprise the outer anchor points and provide tension, while clips on the opposite end secure to threaded inserts incorporated in the fan hub.

D. Motor

1. The fan motor shall be an AC induction type inverter rated at 1725 RPM, 200-240/400-480 VAC, 50/60 Hz, three-phase.
2. The motor shall be totally enclosed, fan cooled (TEFC) with an IP44 NEMA classification. A NEMA 56C standard frame shall be provided for ease of service. The motor shall be manufactured with a double baked Class F insulation and be capable of continuous operation in 32°F to 122°F ambient conditions.
3. The motor shall have a C-face attachment that shall enable technicians to detach the motor for easy field service. The C-face motor adapter shall be designed to work with the NitroSeal™ gearbox.
4. As an option, the architect or owner may upgrade to the "harsh environment package," which includes a motor with an IP55 NEMA classification. As part of the "harsh environment package," the onboard VFD enclosure is sealed for weather-resistant operation.

E. Gearbox

1. The fan gearbox shall be a NitroSeal™ Drive designed specifically for the Powerfoil X series. The gearbox shall include a high-efficiency, hermetically sealed, nitrogen-filled, offset helical gear reducer with two-stage gearing, a hollow output shaft, cast iron housing, double lip seals, high quality SKF Explorer Series bearings with crowned cages for optimal lubrication flow, and precision machined gearing to maintain backlash less than 11 arc-minutes over the life of the unit. Lubrication shall be high-grade, low-foaming synthetic oil with extreme pressure additives and a wide temperature range, and shall be lubricated for the life of the product (no oil changes required).
 2. The gearbox shall be equipped with a hollow shaft threaded to accept a ¾" NPT fitting in which wiring, piping, etc., can be routed to below the fan. A standard junction box can be affixed to this hollow shaft to allow for installing optional features such as lights or cameras. The inclusion of the hollow shaft shall be specified at the time of order.
- F. Mounting Post
1. The fan shall be equipped with a mounting post that provides a structural connection between the fan assembly and extension tube. The mounting post shall be formed from A36 steel, contain no critical welds, and be powder coated for corrosion resistance and appearance.
- G. Mounting System
1. The fan mounting system shall be designed for quick and secure installation on a variety of structural supports. The design of the upper mount shall provide two axes of rotation. This design shall allow for adjustments to be made after the mount is installed to the mounting structure to ensure the fan will hang level from the structure.
 2. The upper mount shall be of ASTM A-36 steel, welded construction, at least 3/16" thick, and powder coated for appearance and corrosion resistance. No mounting hardware or parts substitutions, including cast aluminum, are acceptable.
 3. All mounting bolts shall be SAE Grade 8 or equivalent.
- H. Hub
1. The fan hub shall be 19" in diameter and shall be made of precision cut aluminum for high strength and light weight. The hub shall consist of two (2) aluminum plates, eight (8) aluminum spars, and one (1) aluminum spacer fastened with a pin and collar rivet system. The overall design shall provide a flexible assembly such that force loads experienced by the hub assembly shall be distributed over a large area to reduce the fatigue experienced at the attachment point for the fan blade.
 2. The hub shall be secured to the output shaft of the gearbox by means of (10) high strength bolts. The hub shall incorporate five (5) safety retaining clips made of 1/4" thick steel that shall restrain the hub/airfoil assembly.
- I. Safety Cables
1. The fan shall be equipped with an upper safety cable that provides an additional means of securing the fan assembly to the building structure. The upper safety cable shall have a diameter of 3/8".
 2. The fan shall be equipped with two lower safety cables pre-attached to the fan hub that shall provide an additional means of securing the fan to the extension tube. The lower safety cables shall have a diameter of 1/4".
 3. The safety cables shall be fabricated out of 7 x 19 galvanized steel cable. The end loops shall be secured with swaged Nicopress® sleeves, pre-loaded and tested to 3,200 lbf.
 4. Field construction of safety cables is not permitted.
- J. Digital Variable Speed Wall Controller

1. The fan shall be equipped with a digital variable speed wall controller. The controller user interface shall be a wall-mounted, touch interface.
 2. The controller shall be mounted to a standard rectangular or square outlet box.
 3. A 150-ft CAT5 cable shall be provided for connecting the controller to the fan's VFD and to provide power to the controller.
 4. The controller mounting location shall meet the requirements of OSHA standard 29 CFR 1910.303(g) for accessibility minimum clearances.
 5. The controller shall have an IP65 rating.
 6. The controller shall provide fan start/stop, speed, and direction control functions.
 7. The controller shall provide diagnostic and fault history information for the connected fan, as well as the ability to configure fan parameters with the assistance of Big Ass Fans Customer Service.
 8. The controller interface shall be able to be secured with a passcode to prevent unauthorized access to fan controls and settings.
 9. The controller shall operate out of the box without setup and upon connection to CAT5 cable.
- K. BAFCon Controller (Optional)
1. The fan shall have the option of operating with the BAFCon controller.
 2. The digital controller user interface shall be a wall-mounted touchscreen with a 5-inch display and an 800 (RGB) x 480 pixel resolution.
 3. The digital controller shall be mounted to a standard rectangular or square outlet box.
 4. A 150-ft CAT5 cable shall be provided for connecting the digital controller to the fan's VFD, allowing for seamless communication between BAFCon and the VFD. The cable shall provide power to the digital controller.
 5. The digital controller shall not require a 120 V power supply at the controller mounting location.
 6. The digital controller mounting location shall meet the requirements of OSHA standard 29 CFR 1910.303(g) for accessibility minimum clearances.
 7. The digital controller shall support up to eight Powerfoil D fans controlled as a group or individually.
 8. The digital controller shall provide fan start/stop, speed, and direction control functions.
 9. The digital controller shall provide diagnostic and fault history information for each connected fan as well as the ability to configure fan parameters with the assistance of Big Ass Fans Customer Service.
 10. The digital controller shall include optional SmartSense functionality to maximize energy savings. SmartSense shall provide the capability to automatically control the speed of Big Ass Fans using information from user-determined settings and built-in temperature and humidity sensors.
 11. The digital controller interface shall be able to be secured with user and admin passcodes to prevent unauthorized access to fan controls and settings.
 12. The digital controller shall include Bluetooth® functionality for receiving firmware updates from a mobile app. The app shall be supported by iOS® and Android™ mobile devices. The digital controller's Bluetooth functionality can be disabled if not needed or permitted.
13. BAFCon Multi-Fan Accessory Kit (Optional)
- a. If multiple fans will be installed, the BAFCon Multi-Fan Accessory Kit shall be available.

- b. The kit shall include a two-screw RJ45 terminal block, a ¼ Watt, 120 Ohm termination resistor, RJ45 pass through splitters, and split-gland cord grips for connecting multiple fans to the controller.
 - c. The accessory kit shall include a two-screw RJ45 terminal block, a ¼ Watt, 120 Ohm termination resistor, RJ45 pass through splitters, and split-gland cord grips for daisy chaining multiple fans to the controller.
- L. Fire Alarm Control Panel Integration
 - 1. Includes a 10-30 VDC pilot relay for seamless fire control panel integration. The pilot relay can be wired Normally Open or Normally Closed in the field.
- M. Guy Wires
 - 1. Included for installations with extension tubes 4 ft or longer to limit the potential for lateral movement.

2.3 HIGH VOLUME, LOW SPEED FANS - BIG ASS FANS BASIC 6

- A. Complete Unit
 - 1. Regulatory Requirements: The entire fan assembly shall be Intertek/ETL-certified and built pursuant to the construction guidelines set forth by UL 507 and CSA C22.2 No. 113.
 - 2. Sustainability Characteristics: The fan shall be designed to move an effective amount of air for cooling and destratification in industrial applications over an extended life. The fan components shall be designed specifically for high volume, low speed fans to ensure lower operational noise. Sound levels from the fan operating at maximum speed measured in a laboratory setting shall not exceed 55 dBA. Actual results of sound measurements in the field may vary due to sound reflective surfaces and environmental conditions.
 - 3. Good workmanship shall be evident in all aspects of construction. Field balancing of the airfoils shall not be necessary.
- B. Airfoil System
 - 1. The fan shall be equipped with six (6) Powerfoil airfoils of precision extruded aluminum alloy. The airfoils shall be connected by means of two (2) high strength locking bolts per airfoil. The airfoils shall be connected to the hub and interlocked with zinc plated steel retainers.
 - 2. The fan shall be equipped with six (6) Powerfoil winglets on the ends of the airfoils. The winglets shall be molded of a polypropylene blend. The standard color of the winglet shall be "Safety Yellow." Color shall be as scheduled and shall be coordinated with the architect and owner prior to ordering.
- C. Motor
 - 1. The fan motor shall be an AC induction type inverter rated at 1725 RPM, 200-240/460-480 VAC, 60 Hz, three-phase.
 - 2. The motor shall be totally enclosed, fan cooled (TEFC) with an IP56. A B5 standard frame shall be provided for ease of service. The motor shall be manufactured with a double baked Class F insulation and be capable of continuous operation in 5degreesF to 104 degreesF ambient conditions.
- D. Gearbox
 - 1. The gearbox shall be a helical gear reducer, precision finished from hardened steel for low noise and long service life with double lip seals to retain oil and prevent contamination. The gearbox shall be lubricated for life. The gear reducer shall have a standard backlash of less than 25 arc minutes and be equipped with a 17-4 stainless steel shaft of 1-1/4" diameter.
- E. Motor Frame

1. The motor frame and mount shall be constructed of steel and powder coated for corrosion resistance and appearance.
- F. Mounting System
 1. The fan mounting system shall be designed for quick and secure installation on a variety of structural supports. The design of the upper mount shall provide two axes of rotation. This design shall allow for adjustments to be made after the mount is installed to the mounting structure to ensure the fan will hang level from the structure.
 2. The upper mount shall be of ASTM A36/A36M steel, welded construction, at least 3/16" thick, and powder coated for appearance and corrosion resistance. No mounting hardware or parts substitutions, including cast aluminum, are acceptable.
 3. All mounting bolts shall be SAE Grade 8 or equivalent.
- G. Hub
 1. The fan hub shall be 19" in diameter and shall be made of precision cut aluminum for high strength and light weight. The hub shall consist of two (2) aluminum plates, six (6) aluminum spars, and one (1) aluminum spacer fastened with a pin and collar rivet system. The overall design shall provide a flexible assembly such that force loads experienced by the hub assembly shall be distributed over a large area to reduce the fatigue experienced at the attachment point for the fan blade.
 2. The hub shall be secured to the output shaft of the gearbox by means of a steel coupling interface. The hub shall incorporate three (3) safety retaining clips made of 1/4" thick steel that shall restrain the hub/airfoil assembly.
- H. Safety Cables
 1. The fan shall be equipped with an upper safety cable that provides an additional means of securing the fan assembly to the building structure. The upper safety cable shall have a diameter of 3/8".
 2. The fan shall be equipped with two lower safety cables pre-attached to the fan hub that shall provide an additional means of securing the fan to the extension tube. The lower safety cables shall have a diameter of 1/4".
 3. The safety cables shall be fabricated out of 7 x 19 galvanized steel cable. The end loops shall be secured with swaged Nicopress® sleeves, pre-loaded and tested to 3,200 lbf.
 4. Field construction of safety cables is not permitted.
- I. Variable Frequency Drive
 1. The Variable Frequency Drive (VFD) shall be a NEMA 4X VFD that is factory programmed to minimize starting and braking torques. The VFD shall have touchpad controls and an LED display for controlling the fan's direction, operation, speed, and programming. The VFD may be equipped with an EMI/RFI filter to limit interference with other electronic equipment and a rotary switch disconnect for lock-out/tag-out requirements.
 2. Onboard Variable Frequency Drive: The VFD may be mounted on the fan motor frame. A wall-mounted remote keypad equipped with touchpad controls and an LED display shall be provided for such installations, allowing access to all VFD functions.
 3. Wall-Mounted Variable Frequency Drive: The VFD may be wall-mounted for ease of access.
- J. Fire Control Panel Integration
 1. Includes a 10-30 VDC pilot relay for seamless fire control panel integration. The pilot relay can be wired Normally Open or Normally Closed in the field.
- K. Guy Wires

1. Included for installations with extension tubes 4 ft or longer to limit the potential for lateral movement.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Fan location must have a typical bar joist or existing I-beam structure from which to mount the fan. Additional mounting options may be available.
- B. Mounting structure must be able to support weight and operational torque of fan. Consult structural engineer if necessary.
- C. Fan location must be free from obstacles such as lights, cables, or other building components.
- D. Check fan location for proper electrical requirements. Consult installation guide for appropriate circuit requirements.
- E. Each fan requires dedicated branch circuit protection.
- F. Before the BAFCon controller is installed, the fan system shall be installed by a factory-certified installer according to the instructions in the fan Installation Guide.
- G. Install a rectangular or square outlet box at the BAFCon controller mounting location.
- H. If the BAFCon controller will be mounted more than 250 ft from the fan or if multiple fans will be daisy chained, ensure the optional BAFCon Accessory Kit is included. The accessory kit shall be installed by a factory- certified installer according to the instructions included with the kit.

3.2 INSTALLATION

- A. The fan and BAFCon controller shall be installed by a factory-certified installer according to the manufacturer's Installation Guide, which includes acceptable structural dimensions and proper sizing and placement of angle iron for bar joist applications. Contractor shall consult a structural engineer for installation methods outside the manufacturer's recommendation and a certification, in the form of a stamped print or letter, submitted prior to installation.
- B. Minimum Distances
 1. Airfoils must be installed at a minimum distance above the floor as recommended by the fan manufacturer.
 2. Installation area must be free of obstructions such as lights, cables, sprinklers or other building structures with the airfoils at least 2 ft clear of all obstructions.
 3. The structure the fan is attached to shall be capable of supporting the operational torque load indicated by the fan manufacturer.
- C. The fan shall not be located where it will be continuously subjected to wind gusts or in close proximity to the outputs of HVAC systems or radiant heaters.
- D. In buildings equipped with sprinklers, including ESFR sprinklers, fan installation shall comply with all of the following:
 1. The maximum fan diameter shall be 24 ft.
 2. The HVLS fan shall be centered approximately between four adjacent sprinklers.
 3. The vertical clearance from the HVLS fan to the sprinkler deflector shall be a minimum of 3 ft.
 4. All HVLS fans shall be interlocked to shut down immediately upon receiving a waterflow signal from the alarm system in accordance with the requirements of NFPA 72.

- E. Mount the BAFCon controller to a flat, readily accessible surface that is free from vibration and away from foreign objects and moving equipment. The controller mounting location must meet the requirements of OSHA standard 29 CFR 1910.303(g) for accessibility minimum clearances.
- F. If the SmartSense feature will be used, the BAFCon controller must not be mounted adjacent to or above a radiant heat source, near HVAC ventilation intakes/exhausts, on a poorly insulated exterior wall, or in a different temperature/humidity environment than the fans it will control. Additional mounting guidelines can be found in the Installation Guide.

END OF SECTION

SECTION 23 37 13
AIR DISTRIBUTION DEVICES

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Ceiling air diffusers.
- B. Wall registers and grilles.
- C. Louvers.
- D. Other air devices indicated on drawings and schedules.

1.2 RELATED SECTIONS

- A. Section 08 91 00 - Louvers
- B. Section 23 02 00 - Basic Materials and Methods for HVAC
- C. Section 23 05 93 - Testing, Adjusting, And Balancing
- D. Section 23 07 13 - Duct Insulation
- E. Section 23 31 13 - Metal Ductwork
- F. Section 23 33 00 - Ductwork Accessories

1.3 REFERENCES

- A. AHRI 880 (I-P) - Performance Rating of Air Terminals.
- B. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating.
- C. AMCA 540 - Test Method for Louvers Impacted by Wind Borne Debris.
- D. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers.
- E. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets.
- F. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
- G. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- H. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
- I. ASTM D870 - Standard Practice for Testing Water Resistance of Coatings Using Water Immersion.
- J. ASTM D2794 - Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
- K. ICC (IBC) - International Building Code.
- L. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air distribution devices of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Codes and Standards:
 - 1. AHRI Compliance: Test and rate air distribution devices in accordance with AHRI 880 (I-P).
 - 2. ASHRAE Compliance: Test and rate air distribution devices in accordance with ASHRAE Std 70.
 - 3. AMCA Compliance: Test and rate louvers in accordance with AMCA 500-L.
 - 4. AMCA 540 - Test Methods for Louvers Impacted by Wind Borne Debris with Enhanced Protection Approval.
 - 5. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers.
 - 6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.

7. NFPA Compliance: Install air distribution devices in accordance with NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
8. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
9. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
10. IBC - International Building Code.
11. IMC - International Mechanical Code.
12. UMC - Uniform Mechanical Code.

1.5 DEFINITIONS

- A. Hurricane-prone regions:
 1. The U.S. Atlantic Ocean and Gulf of Mexico coasts where the ultimate design wind speed for Risk Category II Buildings is greater than 115 mph;
 2. Hawaii, Puerto Rico, Guam, Virgin Islands and American Samoa.
- B. Wind-borne debris region: Areas within hurricane-prone regions located:
 1. Within 1 mile of the coastal mean high water line where the ultimate design wind speed is 130 mph or greater; or
 2. In areas where the ultimate design wind speed is 140 mph or greater. For Risk Category II buildings and structures and Risk Category III building and structures, except health care facilities, the wind-borne debris region shall be based on Figure 1609.3(1). For Risk Category IV buildings and structures and Risk Category III health care facilities, the wind-borne debris region shall be based on Figure 1609.3(2).
- C. Ultimate design wind speed - The ultimate design wind speed for the determination of the wind loads shall be determined by Figures 1609.3(1), 1609.3(2) and 1609.3(3) of ICC (IBC).

1.6 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for the following:
 1. Air Distribution Devices
 - a. Schedule of air distribution devices indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
 - b. Data sheet for each type of air distribution devices, and accessory furnished; indicating construction, finish, and mounting details.
 - c. Performance data for each type of air distribution devices furnished, including aspiration ability, temperature and velocity traverses; throw and drop; and noise criteria ratings. Indicate selections on data.
 2. Louvers
 - a. Manufacturer's product data including performance data.
 - b. Preparation instructions and recommendations.
 - c. Storage and handling requirements and recommendations.
 - d. Installation methods.
- B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air distribution device and louver, indicating materials, construction, dimensions, accessories, and installation details.
- C. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver air distribution devices wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
- B. Store air distribution devices and louvers in original cartons and protect from weather and construction work traffic in accordance with manufacturer's instructions. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.
- C. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.8 WARRANTY

- A. Warrant the installation of the work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from defective or nonconforming workmanship.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS - AIR DEVICES

- A. Titus Company
- B. Metalaire Industries, Inc.
- C. Nailor Industries
- D. Krueger
- E. Price

2.2 AIR DEVICES

- A. Unless otherwise indicated, provide manufacturer's standard air devices when shown of size, shape, capacity, type and accessories indicated on drawings and schedules, constructed of materials and components as indicated and as required for complete installation and proper air distribution.
- B. Provide air devices that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.
- C. Unless noted otherwise on drawings, the finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250-hour ASTM D870 Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50 inch-pound force applied.
- D. Provide air device with border styles that are compatible with adjacent ceiling or wall system, and that are specially manufactured to fit into the wall construction or ceiling module with accurate fit and adequate support. Refer to architectural construction drawings and specifications for types of wall construction and ceiling systems.
- E. Provide integral volume damper with roll formed steel blades where indicated on drawings or schedules. Dampers shall be opposed blade design with a screwdriver slot or a concealed lever operator for adjustment through the face of the air device.
- F. Air devices designated for fire rated systems shall be pre-assembled with UL classified radiation damper and thermal blanket. Fire rated air devices shall be shipped completely assembled, one assembly per carton; each assembly shall be enclosed in plastic shrink wrap with installation instructions.

2.3 ACCEPTABLE MANUFACTURERS - LOUVERS

- A. Ruskin Manufacturing Company
- B. Greenheck Company
- C. Louvers and Dampers, Inc.
- D. Pottorff
- E. Arrow

2.4 LOUVERS

- A. Louvers not located in hurricane-prone regions or wind-borne debris regions shall meet the requirements of AMCA 500-L for Laboratory Methods of Testing Louvers for Rating and be drainable stationary type louvers.
- B. Louvers located in hurricane-prone regions shall meet the requirements of AMCA 550 for High Velocity Wind Driven Rain without the use of a control damper.
- C. Louvers located in wind-borne debris regions within 30 feet of grade shall meet the requirements of AMCA 540 for Large Missile Impact.
- D. Provide louvers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- E. Provide louvers that have minimum free area and maximum pressure drop as indicated on drawings.
- F. Provide louvers with frame and sill styles that are compatible with adjacent substrate, and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to architectural construction drawings and specifications for types of substrate.
- G. Coordinate with Architect for finish and color.
- H. Louver Screens: On inside face of exterior louvers, provide 1/2" square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All interior surfaces of all air devices shall be painted flat black.
- B. See floor plans for type, neck size and CFM of air for all air distribution devices.
- C. Install all air distribution devices as detailed on plans and in accordance with manufacturer's recommendations.
- D. The backside of all air devices shall be insulated with taped and sealed external duct wrap to match the insulation thickness and R-value of the ductwork connecting to the air device. Refer to 23 07 13 - Duct Insulation.
- E. Inspect areas to receive louvers. Notify the Architect of conditions that would adversely affect the installation or subsequent utilization of the louvers. Do not proceed with installation until unsatisfactory conditions are corrected.
- F. If opening preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- G. Install louvers at locations indicated on the drawings and in accordance with manufacturer's instructions.
- H. Install louvers plumb, level, in plane of wall, and in alignment with adjacent work.
- I. Touch-up, repair or replace any damaged products prior to substantial completion.

END OF SECTION

SECTION 23 37 23
HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 WORK INCLUDED

- A. Hooded gravity ventilators.

1.3 RELATED SECTIONS

- A. Section 23 02 00 - Basic Materials and Methods for HVAC
- B. Section 23 05 93 - Testing, Adjusting, And Balancing
- C. Section 23 33 00 - Ductwork Accessories

1.4 REFERENCES

- A. ASCE 7-10 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures.
- B. ASCE 7-16 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures.
- C. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- D. ASTM E330/E330M - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.
- E. FLA (FBC-B) - Florida Building Code: Building (8th Edition).
- F. ICC (IBC) - International Building Code.
- G. ICC (IECC) - International Energy Conservation Code.
- H. ISO 9001 - Quality Management Systems — Requirements.
- I. Miami (APD) - Approved Products Directory; Miami-Dade County.
- J. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.5 QUALITY ASSURANCE

- A. Approved ISO 9001 compliant manufacturer listed in this section with minimum 10 years' experience in manufacture of similar products in successful use in similar applications.
- B. Nationally Recognized Testing Laboratory Compliance (NRTL): Components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.
- C. High Wind models shall be analyzed and stamped by a state license P.E. to the ASCE 7-16 Standard which meets the ICC (IBC), FLA (FBC-B) and Miami (APD) codes.
- D. Each High Wind model is subject to be certified by a Nationally Recognized Testing Laboratory to ASTM E330/E330M.
- E. Shutoff dampers shall be provided as required by ASHRAE Std 90.1 I-P and ICC (IECC).

1.6 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
- B. Product data for selected models, including specialties, accessories, and the following:
 - 1. Dimensional drawings and product data on each ventilator.
 - 2. Materials, gages and finishes, include color charts.
 - 3. Dampers, including housings, linkages, and operators.
 - 4. Full color paint samples.
- C. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.
- D. Coordination drawings, in accordance with Division 23, Section "Basic Materials and Methods", for roof penetration requirements and for reflected ceiling plans drawn accurately to scale and coordinating penetrations and units mounted above ceiling. Show the following:
 - 1. Roof framing and support members relative to duct penetrations.
 - 2. Ceiling suspension members.
 - 3. Method of attaching hangers to building structure.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.
- E. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer installed wiring and field installed wiring.
- F. Product certificates, signed by manufacturer, certifying that their products comply with specified requirements.
- G. Maintenance data for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 23, Section "Basic Materials and Methods".
- H. Provide delegated design submittal for equipment anchorage as required in specification 23 02 00 – Part 1.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Fans shall be stored and handled in accordance with the unit manufacturer's instructions.
- B. Lift and support units with the manufacturer's designated lifting or supporting points.
- C. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.
- D. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.8 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes and corrections.
 - 6. On site demonstration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Greenheck Fan Corporation
- B. Loren Cook Company
- C. Pennbarry
- D. ACME
- E. Twin City Fan and Blower

2.2 HOODED GRAVITY VENTILATORS

- A. Hooded gravity ventilators shall be aluminum construction unless noted otherwise.
- B. Hood shall be constructed of precision formed, arched panels with interlocking seams.
- C. Vertical end panels shall be fully locked into hood end panels.
- D. The aluminum base shall have continuously welded curb cap corners for maximum leak protection.
- E. Internal reinforcement and bracing shall be provided as required.
- F. Accessories: The following accessories are required.
 - 1. Bird Screens: Removable ½ inch mesh, 16 gauge, aluminum wire.
 - 2. Dampers: Gravity backdraft damper or motorized shutoff damper mounted in accessible location. Refer to 23 33 00 - Ductwork Accessories.
 - 3. Roof Curbs: Prefabricated, minimum 12 inch high, heavy-gauge, galvanized steel; mitered and welded corners; 2 inch thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks; and 2 inch wood nailer. Curb height shall be increased as required to maintain a minimum height of 8 inches above adjacent roofing surface. Size as required to suit roof opening and ventilator base. Roof curb shall match roof slope so that the curb is level.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Refer to specification 23 02 00 – Part 1 for anchorage requirements for roof mounted equipment.
- C. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer's requirements.
- D. Ensure roof openings are square, accurately aligned, correctly located, and in tolerance prior to installation.
- E. Install the roof curb as required by the job conditions and as recommended by the manufacturer and install proper flashing and counterflashing. See details on the Drawings.
- F. Set ventilators in place, taking care to protect the adjacent roofing, and make all ductwork connections.
- G. Ventilator installation shall comply with NFPA 90A requirements.

END OF SECTION

**SECTION 23 41 00
AIR FILTERS**

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC are included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

1.3 REFERENCES

- A. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
- B. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality.

PART 2 - PRODUCTS

2.1 FILTERS

- A. Air filters shall be high efficiency ASHRAE pleated panels consisting of synthetic media, welded wire media support grid, and beverage board enclosing frame, AAF PREpleat M13, 2-inch thick or approved equal.
- B. APPROVED MANUFACTURERS
 - 1. American Air Filter.
 - 2. Camfil.
 - 3. Airguard Industries, Inc.
 - 4. Cambridge.
 - 5. Filtration Group

2.2 LOW VELOCITY FILTER SECTION

- A. Filters shall be of the throwaway cartridge type in 2-inch frames. When installing multiple filters into slide-in frames tape adjacent filters together with duct tape to prevent bypassing of air around the filter. Media shall be rated at 500 feet per minute.
- B. Filtering media shall be formed of non-woven reinforced synthetic type filtering media bonded to 96% open area media support grid folded into a non-creased radial pleat design. The filter pack shall be bonded to the enclosing frame to prevent air bypass. Minimum Efficiency Reporting Value of MERV 13 when evaluated under the guidelines of ASHRAE Std 52.2. Initial resistance shall not exceed 0.30 inches water gauge at 500 fpm face velocity.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Filters shall be provided upstream of all cooling coils or other devices with wetted surfaces through which air is supplied to occupiable spaces per ASHRAE Std 62.1.

- B. Install differential pressure switch to activate "Filter Dirty" light when pressure difference across filters reaches 0.5 inches w.g. (adjustable). Locate "filter dirty" lights in mechanical rooms with identifying label.
- C. Refer to Section 23 02 00 for additional filter information.

END OF SECTION

SECTION 23 55 00
FUEL FIRED UNIT HEATERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Infrared heaters.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 23 09 63 - Energy Management and Control System (EMCS): Installation of thermostats and other controls components.
- B. Section 26 29 26 - Miscellaneous Electrical Controls and Wiring: Installation and wiring of thermostats and other controls components.

1.3 RELATED SECTIONS

- A. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
- B. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping.23 05 48 - Vibration Controls for HVAC Piping and Equipment
- C. Section 23 07 13 - Duct Insulation

1.4 REFERENCES

- A. ANSI Z223.1 - National Fuel Gas Code.
- B. NFPA 31 - Standard for the Installation of Oil Burning Equipment.
- C. NFPA 54 - National Fuel Gas Code.
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- E. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- F. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.
- G. ANSI/NEMA MG 1 - Motors and Generators.

1.5 SUBMITTALS

- A. Submit under provisions of Division 1.
- B. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- C. Product Data: Provide manufacturer's literature and data indicating rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- D. Manufacturer's Installation Instructions: Indicate rigging, assembly, and installation instructions.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation data under provisions of Division 1.
- B. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listing.

1.7 WARRANTY

- A. Provide (1) one year warranty under provisions of Division 1.
- B. Warranty: Include coverage for (5) five year, non-prorated warranty for heat exchangers and draft diverters.

PART 2 - PRODUCTS

2.1 INFRARED HEATERS

- A. Manufacturers:
 - 1. Reznor
 - 2. Detroit Radiant Products Company
 - 3. Solaranics, Inc.
 - 4. Space-Ray/SunStar, Gas-Fired Products, Inc.
- B. Units: Self- contained, packaged, factory assembled, pre-wired unit consisting of cabinet, heat exchanger, burner, reflector, controls.
- C. Refer to Schedule. Gas heating capacities are sea level ratings.
- D. Cabinet: Galvanized steel with baked enamel finish.
- E. Ceramic Emitter: Assembly of high temperature ceramic tiles with stainless steel housing and reflector.
- F. Gas Burner: Atmospheric type with adjustable combustion air supply, combination gas valve and pressure regulator incorporating manual shut- off, pilot valve, automatic 100 percent shut- off and thermo- couple pilot safety device, electronic pilot ignition.
- G. Gas Burner Safety Controls: Thermo- couple sensor prevents opening of solenoid gas valve until pilot flame is proven and stops gas flow on ignition failure.
- H. Room Thermostat: Low voltage, to control burner operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that space is ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available.
- C. Verify that proper fuel supply is available for connection.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install to NFPA 90A and NFPA 90B.
- C. Install gas fired units to ANSI Z223.1 (NFPA 54).
- D. Install oil fired units to NFPA 31.
- E. Provide flue gas venting from equipment vent connection to the outdoors, tested and UL listed, for use with building heating equipment in compliance with NFPA 211. Flue vent category and material shall be provided in accordance with the equipment manufacturer's installation instructions.
- F. Install heaters with vibration isolation. Refer to Section 23 05 48.

END OF SECTION

SECTION 23 62 13
AIR COOLED CONDENSING UNITS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC is included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for Owner's use.

1.3 REFERENCES

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- B. AHRI 340/360 (I-P) - Standard for Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants.
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- E. ICC (IECC) - International Energy Conservation Code.
- F. NFPA 70 - National Electrical Code.

1.4 QUALITY ASSURANCE

- A. Unit shall be factory tested, shall be UL-labeled and rated in accordance with AHRI 340/360 (I-P).
- B. Unit construction shall comply with ASHRAE Std 15.
- C. Unit wiring shall comply with NFPA 70.
- D. Unit shall meet or exceed minimum efficiency requirements in accordance with ICC (IECC) and ASHRAE Std 90.1 I-P.

1.5 SUBMITTALS

- A. Submit Shop drawings and product data under provisions of Division One.
- B. Shop drawings shall indicate components, dimensions, weights, required service clearances, and location and sizes of field connections. Indicate equipment, piping and connections and accessories required for complete system.
- C. Product data shall include rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
- D. Submit manufacturer's installation instructions.
- E. For roof mounted units provide delegated design submittal for equipment anchorage as required in specification 23 02 00 - Part 1.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation data.

- B. Include start-up instructions, maintenance data, controls, and accessories. Include trouble-shooting guide.
- C. Submit maintenance data.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to site. Comply with manufacturer's installation instructions for rigging, unloading and transporting units.
- B. Accept products on site and inspect for damage.
- C. Protect units from physical damage. Factory shipping covers and skids shall be kept in place until installation. Store in a clean dry place and protect from weather and construction traffic.

1.8 WARRANTY

- A. Provide the entire condensing unit with parts and labor warranty by the equipment manufacturer for one year from start-up or 18 months from date received on site.
- B. Provide all components of the refrigeration circuit with parts and labor warranty by the equipment manufacturer for five years.

1.9 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes and corrections.
 - 6. On site demonstration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Daikin
- B. Trane
- C. York
- D. Carrier
- E. Aeon
- F. Lennox

2.2 AIR-COOLED CONDENSING UNITS

- A. Air-cooled condensing unit shall be designed for use with split system having a remote direct-expansion (DX) cooling coil mounted in evaporator fan unit and rated in accordance with either AHRI 210/240 or AHRI 340/360 (I-P). Capacity shall be as called for on the Drawings when matched to the appropriate evaporator coil.
- B. Condensing unit shall consist of high-efficiency hermetic compressor, air-cooled condenser with quiet fan, factory wired controls, R-454B or R-32 refrigerant and refrigeration circuit and valves.
- C. Cabinet shall be heavy-gauge galvanized steel with bonding primer and baked-enamel finish coat. The entire cabinet shall be protected from rust.

- D. Compressor shall be protected from excessive current and temperatures and shall be provided with a thermostatically controlled crankcase heater to operate only when needed for protection of the compressor. Compressor shall be mounted on resilient rubber isolators. Compressor shall be located in compartment isolated from condenser fan and coil. Provide a high-capacity dryer in the system to remove moisture and dirt.
- E. Condenser fan shall be directly connected to a weather-protected, quiet, high-efficiency motor. Fan guard shall be provided and shall be protected from rust by PVC finish. Condenser coil shall be aluminum fin with copper tube.
- F. Connections for refrigerant suction and liquid lines shall be extended outside the cabinet and provided with service valves with gauge connections.
- G. Power connections shall be made to the connectors located inside the electrical connection box.
- H. Standard operating and safety controls shall include high-pressure switch, low pressure switch, compressor overload service, and solid-state timed-off control.

2.3 AUXILIARY EQUIPMENT

- A. Auxiliary equipment shall consist of refrigerant lines prepared for the unit involved. These lines shall be cleaned, dried, and pressurized at the factory.
- B. Low ambient kit to allow operation at outside temperature below 35 deg. F (2 deg. C) shall be provided.
- C. Expansion valve shall be provided with the evaporator coil.
- D. Provide thermostat to match the requirements of the job. Thermostat shall provide subbase with Heat-Cool-Off and Fan On-Auto switch. See section on controls for other related requirements.
- E. Provide polyethylene structural base designed for that service, and intended to support the unit and eliminate vibration transmission.
- F. Provide hard-start kit with unit.
- G. Provide integral metal hail guards for condenser coils. Hail guards shall cover all exposed faces of the condenser coil.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All HVAC equipment shall be installed as per manufacturer's printed installation instructions.
- B. Refer to specification 23 02 00 - Part 1 for anchorage requirements for roof mounted equipment.
- C. All items required for a complete and proper installation are not necessarily indicated on the Drawings or in the Specifications. Provide all items required as per manufacturer's requirements.
- D. Install the condensing unit on proper foundation as shown on the Drawings, and in location that will not restrict the air entry or discharge from the unit.
- E. Install refrigerant lines as recommended by the manufacturer, taking care not to lose the refrigerant charge contained in the lines, or allow air to enter the lines or equipment. Locate the lines in such a way as to not obstruct access to the condensing unit or other equipment. Lines located underground or under concrete shall be installed in a PVC sleeve for protection.
- F. Provide electrical connections as required by the applicable codes. Provide control wiring required. All power wiring and control wiring shall be in conduit and located so as not to obstruct access to the unit or other equipment.

3.2 TESTING

- A. Operate the condensing unit and the system to assure that unit is operating properly and without excessive noise and vibration.
- B. Read and record the power draw and the refrigeration suction and liquid pressures as required by Section 23 05 93 - Testing, Adjusting, And Balancing.

END OF SECTION

SECTION 23 82 19
FAN COIL UNIT

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.2 SCOPE

- A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

1.3 REFERENCES

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- B. AHRI 260 (I-P) - Sound Rating of Ducted Air Moving and Conditioning Equipment.
- C. AHRI 340/360 (I-P) - Standard for Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
- D. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
- E. AHRI 430 (I-P) - Performance Rating of Central Station Air-Handling Units.
- F. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- G. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
- H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- I. ICC (IECC) - International Energy Conservation Code.
- J. NFPA 70 - National Electrical Code.
- K. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- L. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- M. SCAQMD 1168 - Adhesive and Sealant Applications.
- N. UL 508 - Industrial Control Equipment.
- O. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- P. UL 1995 - Heating and Cooling Equipment.

1.4 QUALITY ASSURANCE

- A. Installer's Qualifications: Firm with at least 5 years of successful installation experience on projects with mechanical installations similar to that required for this project.
- B. All insulation shall be listed and labeled to have a composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) flame spread index of not more than 25 and smoke-developed index of not more than 50 when tested in accordance with ASTM E84, UL 723 and NFPA 90A.
 - 1. Exception: Outdoor mechanical insulation may have a flame spread index of 75 and smoke-developed index of 150.
- C. Duct and plenum insulation shall comply with minimum R-value requirements of ICC (IECC) and ASHRAE Std 90.1 I-P unless greater values are indicated otherwise in the contract documents.

- D. Adhesive and other material shall comply with NFPA 90A and NFPA 90B. All adhesives and sealants used on interior of building shall comply with VOC limits prescribed by SCAQMD 1168.
- E. Unit fan(s) shall comply with the maximum allowable fan motor horsepower per ICC (IECC) and ASHRAE Std 90.1 I-P.
- F. Unit shall meet or exceed minimum efficiency ratings in accordance with ICC (IECC) and ASHRAE Std 90.1 I-P per testing standards prescribed by AHRI 210/240 or AHRI 340/360 (I-P).
- G. Units shall be tested and certified with AHRI 430 (I-P) and AHRI 260 (I-P).
- H. All coils shall be constructed to meet the requirements of AHRI 410.

1.5 WARRANTY

- A. Provide entire unit with parts and labor warranty by the equipment manufacturer for one year from start-up or 18 months from date received on site.
- B. For units with DX coils, provide all components of the refrigeration circuit with parts and labor warranty by the equipment manufacturer for five years.

1.6 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes and corrections.
 - 6. On site demonstration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Daikin
- B. Trane
- C. JCI/York
- D. AAON
- E. Carrier

2.2 GENERAL

- A. Fan coil units shall be factory built, manufactured as scheduled on Drawings. Contractor shall field verify exact clearances required for fan coil units. Units shall be field located as required and shop drawings shall indicate final location for approval by Architect/Engineer.
- B. Furnish and install fan coil units of the type, capacities, ratings and drive motor horsepower shown on the Drawings.

2.3 CASING

- A. Unit casing shall be constructed of minimum 18-gauge galvanized steel, able to withstand a 125 hour salt spray test per ASTM B117. Unit shall have access panels on each side constructed of minimum 18-gauge galvanized steel.

- B. Unit casing shall be insulated with single wall, 1 inch thick, foil-faced fiberglass insulation with a minimum rating of R-4 and shall be rated for a maximum air velocity of 5,000 feet per minute.
- C. All access panels shall be fully insulated and attached with fasteners. No piping or conduit shall pass through any access panel.
- D. All units shall be provided with hanger rod holes in top and bottom panels for suspension installations.

2.4 DRAIN PAN

- A. All units shall be provided with one-piece stainless steel drain pan with welded corner construction. Drain pan shall be insulated with closed cell foam insulation.
- B. For units installed above a ceiling, in a mechanical mezzanine, or in an attic space, provide secondary drain pan. Drain pan shall be galvanized steel and shall slope at a minimum of 1/8" per foot to drain connection. The drain pan shall extend 3" larger on all sides than unit footprint. The secondary drain pan shall be provided with a condensate overflow switch or separate drain line.

2.5 DIRECT EXPANSION COIL

- A. Direct expansion coils shall be furnished with a brass distributor with solder type connections. Suction and discharge connections shall be on the same end regardless of row depth. Coils shall have intertwined circuits for equal operation on each circuit. Provide the number of distributors equal to the number of refrigerant circuits to the associated condensing unit. Refrigerant piping connections shall be clearly labeled on outside of unit.
- B. Direct expansion coils shall be selected to match the saturated suction temperature and capacity of the associated condensing unit.
- C. Maximum face velocity across cooling coil shall be 500 FPM, unless noted otherwise on equipment schedule.

2.6 ELECTRIC HEATING COIL

- A. The unit manufacturer shall furnish an electric resistance heating assembly with heating capacity, voltage and stages as scheduled. The heater assembly shall be factory wired and installed with over temperature protection.
- B. The heater assembly shall be designed and rated for installation in a blow through configuration.
- C. The heater assembly shall be furnished with an incoming power distribution block capable of accepting at least 125% of the calculated current load.
- D. The heater assembly shall be listed for zero clearance meeting all NFPA 70 requirements and shall be cETL listed in compliance with UL 1995.

2.7 FAN AND MOTOR ASSEMBLY

- A. Units shall be furnished with double inlet, forward curved centrifugal blower that shall be statically and dynamically balanced as an assembly.
- B. Fan and motor assembly shall be in a direct drive, draw-through configuration. Belt drive units are not acceptable.
- C. Fan motors shall be electronically commutated with thermal overload protection and constant torque operation. The motor shall be programmed in the factory to meet the specified airflow value.
- D. Fan motors shall be permanently lubricated and sealed bearings and shall operate on single or three phase power.

- E. Fan motors shall be installed, factory programmed and wired to the control panel. Motor wiring shall be terminated in a junction box external to unit casing.
- F. Fan motors shall be internally isolated from unit casing.

2.8 FILTERS

- A. All units shall be furnished with a flat filter rack with hinged access on both sides designed for a 2" nominal standard sized filter.
- B. Factory shall provide one complete set of spare throwaway filters for each unit.
- C. Refer to 23 41 00 - Air Filters for additional information.

2.9 MIXING PLENUM

- A. Mixing plenum shall be field fabricated and insulated as shown on drawings.

2.10 CONTROLS

- A. The unit fan motor shall be completely factory wired to an external electrical enclosure. An external main incoming power non-fused disconnect switch shall be factory furnished and wired by the unit manufacturer for single point power connection.
- B. Each unit shall include a 24 VAC control circuit transformer, motor control board, motor circuit fusing and terminal strip for connection of field wiring.
- C. The unit shall be factory run tested and end devices shall be factory wired to terminal strip and tested for wiring continuity.
- D. Each unit shall include a low voltage fan speed control device.

2.11 REFRIGERANT LEAK DETECTION

- A. Units provided with DX cooling coils shall be provided with factory installed leak detection system with sufficient quantity of refrigerant detection sensors to detect refrigerant leaks throughout the equipment cabinet.
- B. When the system detects a leak, the unit controller shall automatically initiate mitigation actions to prevent excessive refrigerant concentrations within occupied spaces.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All HVAC equipment shall be installed as per manufacturer's printed installation instructions.
- B. All items required for a complete and proper installation are not necessarily indicated on the Drawings or in the Specifications. Provide all items required as per manufacturer's requirements.
- C. Locations of equipment shown on the drawings are approximate. Locate units so that they may be adequately serviced and maintained.
- D. During construction, provide temporary closures of taped polyethylene on openings to prevent construction dust and debris from entering unit.
- E. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fans have been test run under observation.
- F. Set each unit level and straight.
- G. Remove all shipping blocks and restraints.
- H. Make condensate drain connection. Verify that drain is properly trapped, vented and sloped to condensate termination location as shown on the drawings.
- I. Make duct connections using flexible connectors. Verify that duct is independently and adequately supported.

- J. The secondary drain pan shall be provided with a condensate overflow switch or separate drain line.
 - 1. If a drain line is provided it shall be minimum of 3/4 inch and shall be routed to a visible location approved by the Architect. If this termination point is in a finished ceiling, provide an escutcheon in trim and extend pipe to 1 inch below ceiling and paint to match ceiling color.
 - 2. If a condensate overflow switch is provided, the overflow switch shall include the following features and adhere to the following installation and operation:
 - a. Condensate overflow switch features:
 - 1) UL 508 listing
 - 2) 24 volt power connection
 - 3) Plenum rated casing and wiring when installed in a plenum used for return air
 - b. The condensate overflow switch shall be installed in the secondary drain pan and shall shut down the entire unit when the primary drain line becomes restricted. The switch shall be adjusted as required to ensure that the switch engages prior to the drain pan overflowing. At a minimum, unit shut down shall:
 - 1) De-energize supply fan(s)
 - 2) De-energize heater(s)
 - 3) De-energize refrigeration circuit(s) for units with DX coils
 - 4) Close outside air and economizer dampers
 - 5) Generate an alarm locally at the unit and remotely through the EMCS

3.2 MANUFACTURER START-UP SERVICES

- A. Provide authorized representative of the manufacturer to inspect the assembly and installation of each unit. No start-up, testing or adjusting may be performed until the representative has determined that the unit has been properly installed.
- B. The representative shall start-up, test and adjust units. The representative shall perform operational checks to make certain that all equipment and controls of the systems are operating properly. If defects or improper adjustments are found, they shall be corrected and tested again.
- C. The representative shall prepare and provide a written start-up report to include any measurements taken, test results obtained or corrective actions required.
- D. If unit has packaged controls, the manufacturer's representative shall attend a separate meeting on-site with the EMCS contractor to coordinate and execute programming between the packaged equipment controls and the EMCS.

END OF SECTION

SECTION 23 82 39
ELECTRIC UNIT HEATERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Electric unit heaters.

1.2 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
- B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.
- C. The scope of the work shall include the furnishing and complete installation of the equipment covered by this section, with all auxiliaries, ready for owner's use.

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 23 09 63 - Energy Management and Control System (EMCS): Installation of thermostats and other controls components.
- B. Section 26 29 26 - Miscellaneous Electrical Controls and Wiring: Installation and wiring of thermostats and other controls components.

1.4 RELATED SECTIONS

- A. Section 23 02 00 - Basic Materials and Methods for HVAC
- B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment

1.5 REFERENCES

- A. NFPA 70 - National Electrical Code.
- B. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
- C. UL 1278 - Movable and Wall- or Ceiling-Hung Electric Room Heaters.
- D. UL 1995 - Heating and Cooling Equipment.
- E. UL 2021 - Fixed and Location Dedicated Electric Room Heaters.

1.6 QUALITY ASSURANCE

- A. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL 1995, UL 1278, and UL 2021 as applicable), Intertek (ETL), or other third-party national recognized testing laboratory acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Unit shall be stored and handled per unit manufacturer's recommendations.

1.8 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Division One.
- B. Submit shop drawings indicating components, assembly, dimensions, weights, and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and electronic valves required for complete system.
- C. Submit product data indicating rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.

- D. Manufacturer's Installation Instructions: Indicate rigging, assembly, and installation instructions.

1.9 WARRANTY

- A. Provide manufacturer's warranty one-year parts and labor warranty.

1.10 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes and corrections.
 - 6. On site demonstration.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Q-mark
- B. Reznor
- C. Modine Manufacturing Company
- D. TPI Corporation (Markel, Raywall, Redd-i)

2.2 CABINET

- A. Construct casing of 18 gage steel and threaded pipe connections for hanger rods.
- B. The control enclosure compartment factory installed to the bottom of heater shall be provided with hinged and latched access door that opens from bottom to simplify wiring installation and maintenance.
- C. Provide discharge louvers which are adjustable in both horizontal and vertical directions. Provide baked enamel finish to louvers.

2.3 FAN

- A. Manufacture fan blades from anodized aluminum.
- B. Provide quiet, propeller-blade fan, connected directly to drive motor.
- C. Statically and dynamically balanced fans and equip with substantial fan guard.
- D. Horizontal models with permanently lubricated sleeve bearings.
- E. Vertical models with grease lubricated ball bearings.

2.4 MOTOR

- A. Motors shall be totally enclosed, permanently lubricated, and thermally protected.
- B. Motor shall be factory wired to control enclosure compartment.
- C. Both motor and fan blade shall be factory installed within heater casing on rubber isolators to minimize vibration and noise.

2.5 ELECTRIC HEATING ELEMENTS

- A. Element shall consist of a nickel-chromium resistance wire surrounded with magnesium oxide and sheathed in steel spiral-finned tubes.

B. Elements shall have kilowatt rating as scheduled in drawings.

2.6 THERMAL OVERLOAD PROTECTION

- A. Equip heaters with auto reset thermal overloads that are sealed to prevent moisture to enclosure.
- B. Thermal overload protection shall shut down element and motor if safe operating temperatures are exceeded.

2.7 CONTROLS

- A. Provide heaters with 24-volt transformer and control circuit, NEC required fusing, power-on indicator, thermostat with stainless steel capillary sensor and three position switch factory-installed and wired in the control enclosure compartment to the terminal block for ease of wiring.
- B. Thermostat shall be field adjustable from 40 to 70°F.

2.8 MOUNTING HARDWARE

- A. Provide with universal mounting bracket and all necessary accessory hardware.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that space is ready for installation of units as indicated on shop drawings.
- B. Verify that proper power supply is available.

3.2 INSTALLATION

- A. Install unit heaters in accordance with manufacturer's instructions.
- B. Install unit heaters in accordance with NFPA 70 and NFPA 90B.

END OF SECTION

SECTION 26 02 00
BASIC MATERIALS AND METHODS FOR ELECTRICAL

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all Work herein.
- B. The Contract Drawings indicate the extent and general arrangement of the systems. If any departure from the Contract Drawings are deemed necessary by the Contractor, details of such departures and the reasons therefore, shall be submitted to the Architect for approval as soon as practicable. No such departures shall be made without the prior written approval of the Architect.

1.2 SCOPE OF WORK

- A. The Work included under this Contract consists of the furnishing and installation of all equipment and material necessary and required to form the complete and functioning systems in all of its various phases, all as shown on the accompanying Drawings and/or described in these Specifications. The contractor shall review all pertinent drawings, including those of other contracts prior to commencement of Work.
- B. This Division requires the furnishing and installing of all items Specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, transportation, storage, equipment, utilities, all required permits, licenses and inspections. All work performed under this Section shall be in accordance with the Project Manual, Drawings and Specifications and is subject to the terms and conditions of the Contract.
- C. The approximate locations of Electrical items are indicated on the Drawings. These Drawings are not intended to give complete and accurate details in regard to location of outlets, apparatus, etc. Exact locations are to be determined by actual measurements at the building, and will in all cases be subject to the Review of the Owner or Engineer, who reserves the right to make any reasonable changes in the locations indicated without additional cost to the Owner.
- D. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.
- E. Any discrepancies within the Contract Documents or between the Contract Documents and actual job-site conditions shall be reported to the Owner or Engineer so that they will be resolved prior to bidding. Where this cannot be done at least seven (7) working days prior to bid, the greater or more costly of the discrepancy shall be bid. All labor and materials required to perform the work described shall be included as part of this Contract.
- F. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and fully operating system in cooperation with other trades.

- G. It is the intent of the above "Scope" to give the Contractor a general outline of the extent of the Work involved; however, it is not intended to include each and every item required for the Work. Anything omitted from the "Scope" but shown on the Drawings, or specified later, or necessary for a complete and functioning electrical system shall be considered a part of the overall "Scope".
- H. The Contractor shall rough-in fixtures and equipment furnished by others from rough-in and placement drawings furnished by others. The Contractor shall make final connection to fixtures and equipment furnished by others.
- I. Contractor shall participate in the commissioning process; including but not limited to meeting attendance, completion of checklists and participation in functional testing.

1.3 RELATED SECTIONS

- A. General Conditions
- B. Supplementary Conditions
- C. Division One

1.4 COOPERATION WITH TRADES

- A. Cooperation with trades of adjacent, related, or affected materials or operations shall be considered a part of this work in order to affect timely and accurate placing of work and bring together in proper and correct sequence, the work of such trades.

1.5 REFERENCES

- A. National Electrical Code (NEC)
- B. American Society for Testing and Materials (ASTM)
- C. Underwriter's Laboratories, Inc. (UL)
- D. Insulated Cable Engineer's Association (ICEA).
- E. National Electrical Manufacturer's Association (NEMA).
- F. Institute of Electrical and Electronic's Engineers (IEEE).
- G. American National Standards Institute (ANSI).
- H. National Fire Protection Association (NFPA).
- I. International Energy Conservation Code (IECC).

1.6 COMPLETE FUNCTIONING OF WORK

- A. All work fairly implied as essential to the complete functioning of the electrical systems shown on the Drawings and Specifications shall be completed as part of the work of this Division unless specifically stated otherwise. It is the intention of the Drawings and Specifications to establish the types of the systems, but not set forth each item essential to the functioning of the system. In case of doubt as to the work intended, or in the event of amplification or clarification thereof, the Contractor shall call upon the Architect for supplementary instructions, Drawings, etc.
- B. Contractor shall review all pertinent Drawings and adjust his work to all conditions shown there on. Discrepancies between Plans, Specifications, and actual field conditions shall be brought to the prompt attention of the Architect.
 - 1. Approximate location of transformers, feeders, branch circuits, outlets, lighting and power panels, outlets for special systems, etc., are indicated on the Drawings. However, the Drawings, do not give complete and accurate detailed locations of such outlets, conduit runs, etc., and exact locations must be determined by actual field measurement. Such locations will, at all times, be subject to the approval of the Architect.

2. Communicate with the Architect and secure his approval of any outlet (light fixture, receptacle, switch, etc.) location about which there may be the least question. Outlets obviously placed in a location not suitable to the finished room or without specific approval, shall be removed and relocated when so directed by the Architect. Location of light fixtures shall be coordinated with reflected ceiling plans.
- C. Additional coordination with mechanical contractor may be required to allow adequate clearances of mechanical equipment, fixtures and associated appurtenances. Contractor to notify Architect and Engineer of unresolved clearances, conflicts or equipment locations.

1.7 SCHEMATIC NATURE OF CONTRACT DOCUMENTS

- A. The contract documents are schematic in nature in that they are only to establish scope and a minimum level of quality. They are not to be used as actual working construction drawings. The actual working construction drawings shall be the approved shop drawings.

1.8 CONTRACTOR'S QUALIFICATIONS

- A. An approved contractor for the work under this division shall be:
 1. A specialist in this field and have the personnel, experience, training, and skill, and the organization to provide a practical working system.
 2. Able to furnish evidence of having contracted for and installed not less than 3 systems of comparable size and type that have served their Owners satisfactorily for not less than 3 years.
 3. Perform work by persons qualified to produce workmanship of specified quality. Persons performing electrical work shall be required to be licensed. Onsite supervision, journeyman shall have minimum of journeyman license. Helpers, apprentices shall have minimum of apprentice license.

1.9 DATE OF FINAL ACCEPTANCE

- A. The date of final acceptance shall be the date of owner occupancy, or the date all punch list items have been completed or final payment has been received. Refer to Division One for additional requirements.
- B. The date of final acceptance shall be documented in writing and signed by the architect, owner and contractor.

1.10 DEFINITIONS AND SYMBOLS

- A. General Explanation: A substantial amount of construction and Specification language constitutes definitions for terms found in other Contract Documents, including Drawings which must be recognized as diagrammatic and schematic in nature and not completely descriptive of requirements indicated thereon. Certain terms used in Contract Documents are defined generally in this article, unless defined otherwise in Division 1.
- B. Definitions and explanations of this Section are not necessarily either complete or exclusive, but are general for work to the extent not stated more explicitly in another provision of the Contract Documents.
- C. Indicated: The term "Indicated" is a cross-reference to details, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in Contract Documents. Where such terms as "Shown", "Noted", "Scheduled", "Specified" and "Detailed" are used in lieu of "Indicated", it is for the purpose of helping the reader locate cross-reference material, and no limitation of location is intended except as specifically shown.

- D. Directed: Where not otherwise explained, terms such as "Directed", "Requested", "Accepted", and "Permitted" mean by the Architect or Engineer. However, no such implied meaning will be interpreted to extend the Architect's or Engineer's responsibility into the Contractor's area of construction supervision.
- E. Reviewed: Where used in conjunction with the Engineer's response to submittals, requests for information, applications, inquiries, reports and claims by the Contractor the meaning of the term "Reviewed" will be held to limitations of Architect's and Engineer's responsibilities and duties as specified in the General and Supplemental Conditions. In no case will "Reviewed" by Engineer be interpreted as a release of the Contractor from responsibility to fulfill the terms and requirements of the Contract Documents.
- F. Furnish: Except as otherwise defined in greater detail, the term "Furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.
- G. Install: Except as otherwise defined in greater detail, the term "Install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance.
- H. Provide: Except as otherwise defined in greater detail, the term "Provide" is used to mean "Furnish and Install", complete and ready for intended use, as applicable in each instance.
- I. Installer: Entity (person or firm) engaged by the Contractor or its subcontractor or Subcontractor for performance of a particular unit of work at the project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance. It is a general requirement that such entities (Installers) be expert in the operations they are engaged to perform.
- J. Imperative Language: Used generally in Specifications. Except as otherwise indicated, requirements expressed imperatively are to be performed by the Contractor. For clarity of reading at certain locations, contrasting subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor, or when so noted by other identified installers or entities.
- K. Minimum Quality/Quantity: In every instance, the quality level or quantity shown or specified is intended as minimum quality level or quantity of work to be performed or provided. Except as otherwise specifically indicated, the actual work may either comply exactly with that minimum (within specified tolerances), or may exceed that minimum within reasonable tolerance limits. In complying with requirements, indicated or scheduled numeric values are either minimums or maximums as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to Owner or Engineer via a request for information (RFI) for decision before proceeding.

- L. Abbreviations and Symbols: The language of Specifications and other Contract Documents including Drawings is of an abbreviated type in certain instances, and implies words and meanings which will be appropriately interpreted. Actual word abbreviations of a self-explanatory nature have been included in text of Specifications and Drawings. Specific abbreviations and symbols have been established, principally for lengthy technical terminology and primarily in conjunction with coordination of Specification requirements with notations on Drawings and in Schedules. These are frequently defined in Section at first instance of use or on a Legend and Symbol Drawing. Trade and industry association names and titles of generally recognized industry standards are frequently abbreviated. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicate. Except as otherwise indicated, graphic symbols and abbreviations used on Drawings and in Specifications are those recognized in construction industry for indicated purposes. Where not otherwise noted symbols and abbreviations are defined by the latest ASHRAE Fundamentals Handbook, Chapter 39 "Abbreviations and Symbols", ASME and ASPE published standards.

1.11 DRAWINGS AND SPECIFICATIONS

- A. These Specifications are intended to supplement the Drawings and it will not be the province of the Specifications to mention any part of the Work which the Drawings are competent to fully explain in every particular and such omission is not to relieve the Contractor from carrying out portions indicated on the Drawings only.
- B. Should items be required by these Specifications and not indicated on the Drawings, they are to be supplied even if of such nature that they could have been indicated thereon. In the event of discrepancy between Drawings and Specifications, or within either Drawings or Specifications, the greater or more costly of the discrepancy shall be estimated and the matter referred to the Architect or Engineer for review with a request for information and clarification at least seven (7) working days prior to bid opening date for issuance of an addendum.
- C. The listing of product manufacturers, materials and methods in the various sections of the Specifications, and indicated on the Drawings, is intended to establish a standard of quality only. It is not the intention of the Owner or Engineer to discriminate against any product, material or method that is the equivalent of the standards as indicated and/or specified, nor is it intended to preclude open, competitive bidding. The fact that a specific manufacturer is listed as an acceptable manufacturer should not be interpreted to mean that the manufacturer's standard product will meet the requirements of the project design, Drawings, Specifications and space constraints.
- D. The Architect or Engineer and Owner shall be the sole judge of quality and equivalence of equipment, materials and methods.
- E. Products by other reliable manufacturers, other materials, and other methods, will be accepted as outlined, provided they have equivalent capacity, construction, and performance. However, under no circumstances shall any substitution be made without the written permission of the Architect or Engineer and Owner. Request for prior approval must be made in writing 10 calendar days prior to the bid date without fail.
- F. Wherever a definite product, material or method is specified and there is not a statement that another product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method is the only one that shall be used without prior approval.

- G. Wherever a definite material or manufacturer's product is specified and the Specification states that products of similar design and equivalent construction from the specified list of manufacturers may be substituted, it is the intention of the Owner or Engineer that products of manufacturers that are specified are the only products that will be acceptable and that products of other manufacturers will not be considered for substitution without approval.
- H. Wherever a definite product, material or method is specified and there is a statement that "OR EQUIVALENT" product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method or an "OR EQUIVALENT" product, material or method may be used if it complies with the Specifications and is submitted for review to the Engineer as outline herein.
- I. Where permission to use substituted or alternative equipment on the project is granted by the Owner or Engineer in writing, it shall be the responsibility of the Contractor or Subcontractor involved to verify that the equipment will fit in the space available which includes allowances for all required Code and maintenance clearances, and to coordinate all equipment structural support, plumbing and electrical requirements and provisions with the Mechanical (HVAC) Design Documents and all other trades, including Division 26.
- J. Changes in architectural, structural, electrical, mechanical, and plumbing requirements for the substitution shall be the responsibility of the bidder wishing to make the substitution. This shall include the cost of redesign by the affected designer(s). Any additional cost incurred by affected Subcontractors shall be the responsibility of this bidder and not the Owner.
- K. If any request for a substitution of product, material or method is rejected, the Contractor will automatically be required to furnish the product, material or method named in the Specifications. Repetitive requests for substitutions will not be considered.
- L. The Owner or Engineer will investigate all requests for substitutions when submitted in accordance with the requirements listed above; and if accepted, will issue a letter allowing the substitutions.
- M. Where equipment other than that used in the design as specified or shown on the Drawings is substituted (either from an approved manufacturers list or by submittal review), it shall be the responsibility of the substituting Contractor to coordinate space requirements, building provisions and connection requirements with their respective trade(s) and all other trades; and to pay all additional costs to other trades, the Owner, the Architect or Engineer, if any, due to the substitutions.

1.12 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
- B. Deliver products to the project at such time as the project is ready to receive the equipment, pipe or duct properly protected from incidental damage and weather damage.
- C. Damaged equipment shall be promptly removed from the site and new, undamaged equipment shall be installed in its place promptly with no additional charge to the Owner.

1.13 SUBMITTALS

- A. Coordinate with Division 01 for submittal timetable requirements, unless noted otherwise within thirty (30) days after the Contract is awarded. The Contractor shall submit an electronic copy of a complete set of shop drawings and complete data covering each item of equipment or material. The submittal of each item requiring a submittal must be received by the Architect or Engineer within the above thirty day period. The Architect or Engineer shall not be responsible for any delays or costs incurred due to excessive shop drawing review time for submittals received after the thirty (30) day time limit. The Architect and Engineer will retain a copy of all shop drawings for their files. All literature pertaining to items subject to Shop Drawing submittal shall be submitted at one time. Submittals shall be placed in one electronic file in PDF format and bookmarked for individual specification sections. Individual electronic files of submittals for individual specifications shall not be permitted. Each submittal shall include the following items:
1. A cover sheet with the names and addresses of the Project, Architect, MEP Engineer, General Contractor and the Subcontractor making the submittal. The cover sheet shall also contain the section number covering the item or items submitted and the item nomenclature or description.
 2. An index page with a listing of all data included in the Submittal.
 3. A list of variations page with a listing all variations, including unfurnished or additional required accessories, items or other features, between the submitted equipment and the specified equipment. If there are no variations, then this page shall state "NO VARIATIONS". Where variations affect the work of other Contractors, then the Contractor shall certify on this page that these variations have been fully coordinated with the affected Contractors and that all expenses associated with the variations will be paid by the submitting Contractor. This page will be signed by the submitting Contractor.
 4. Equipment information including manufacturer's name and designation, size, performance and capacity data as applicable. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.
 5. Dimensional data and scaled drawings as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances clearly indicated and labeled at a minimum scale of $1/4" = 1'-0"$, as required to demonstrate that the alternate or substituted product will fit in the space available.
 6. Identification of each item of material or equipment matching that indicated on the Drawings.
 7. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Drawings and Specifications. Any options or special requirements or accessories shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method.
 8. Additional information as required in other Sections of this Division.
 9. Certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Drawings and Specifications, signed and dated in long hand. Submittals that do not comply with the above requirements shall be returned to the Contractor and shall be marked "REVISE AND RESUBMIT".
- B. Refer to Division 1 for additional information on shop drawings and submittals.

- C. Equipment and materials submittals and shop drawings will be reviewed for compliance with design concept only. It will be assumed that the submitting Contractor has verified that all items submitted can be installed in the space allotted. Review of shop drawings and submittals shall not be considered as a verification or guarantee of measurements or building conditions.
- D. Where shop drawings and submittals are marked "REVIEWED", the review of the submittal does not indicate that submittals have been checked in detail nor does it in any way relieve the Contractor from his responsibility to furnish material and perform work as required by the Contract Documents.
- E. Shop drawings shall be reviewed and returned to the Contractor with one of the following categories indicated:
 - 1. REVIEWED: Contractor need take no further submittal action, shall include this submittal in the O&M manual and may order the equipment submitted on.
 - 2. REVIEWED AS NOTED: Contractor shall submit a letter verifying that required exceptions to the submittal have been received and complied with including additional accessories or coordination action as noted, and shall include this submittal and compliance letter in the O&M manual. The contractor may order the equipment submitted on at the time of the returned submittal providing the Contractor complies with the exceptions noted.
 - 3. NOT APPROVED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is not approved, the Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or drawings. Contractor shall not order equipment that is not approved. Repetitive requests for substitutions will not be considered.
 - 4. REVISE AND RESUBMIT: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked revise and resubmit, the Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or provide as noted on previous shop drawings. Contractor shall not order equipment marked revise and resubmit. Repetitive requests for substitutions will not be considered.
 - 5. CONTRACTOR'S CERTIFICATION REQUIRED: Contractor shall resubmit submittal on material, equipment or method of installation. The Contractor's stamp is required stating the submittal meets all conditions of the contract documents. The stamp shall be signed by the General Contractor. The submittal will not be reviewed if the stamp is not placed and signed on all shop drawings.
 - 6. MANUFACTURER NOT AS SPECIFIED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked manufacturer not as specified, the Contractor will automatically be required to furnish the product, material or method named in the specifications. Contractor shall not order equipment where submittal is marked manufacturer not as specified. Repetitive requests for substitutions will not be considered.
- F. Materials and equipment which are purchased or installed without shop drawing review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by the Owner or Engineer for any reason shall be at the expense of the Contractor. The responsible Contractor shall remove the material and equipment noted above and replace with specified equipment or material at his own expense when directed in writing by the Architect or Engineer.
- G. Shop Drawing Submittals shall be complete and checked prior to submission to the Engineer for review.

- H. Provide detailed shop drawings, descriptive literature, table of contents listing all items being submitted at the beginning of each submittal package, physical data and a specification critique for each section indicating "compliance" and/or "variations" for the following items:
 - 1. Switchboards
 - 2. Distribution Panelboards
 - 3. Panelboards
 - 4. Wiring Gutters
 - 5. Heavy Duty Disconnect Switches
 - 6. Lighting Fixtures
 - 7. Lighting Contactors
 - 8. Time Clocks
 - 9. Lighting Control System
 - 10. Photocells
 - 11. Wiring Devices and Plates
 - 12. Conduit and Fittings
 - 13. Wire
 - 14. General Purpose Dry Type Transformers
 - 15. Harmonic Mitigating Type Transformers
 - 16. Emergency Generator
 - 17. Automatic Transfer Switches
 - 18. Sound Reinforcing System
 - 19. Fire Alarm System
 - 20. Surge Protection Devices (SPD)
 - 21. Lightning Protection
- I. Refer to each specification section for additional requirements.

1.14 OPERATION AND MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with Division 1 and in addition to the requirements specified in Division 1, include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.

1.15 COORDINATION DRAWINGS

- A. Prepare coordination drawings to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
 - 1. Indicate the proposed locations of pipe, duct, equipment, and other materials.
 - Include the following:
 - a. Wall and type locations.

- b. Clearances for installing and maintaining insulation.
 - c. Locations of light fixtures and sprinkler heads.
 - d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - e. Equipment connections and support details.
 - f. Exterior wall and foundation penetrations.
 - g. Routing of storm and sanitary sewer piping.
 - h. Fire-rated wall and floor penetrations.
 - i. Sizes and location of required concrete pads and bases.
 - j. Valve stem movement.
 - k. Structural floor, wall and roof opening sizes and details.
- 2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
 - 3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 - 4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.
- B. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.
 - C. By submitting shop drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

1.16 RECORD DRAWINGS

- A. Prepare Record Documents in accordance with the requirements of Division 00 and Division 01, in addition to the requirements specified in Division 26.
- B. The Contractor shall maintain a separate set of clearly and legibly marked Record Drawings on the job site to record all changes and modifications, including, but not limited to the following: work details, alterations to meet site conditions, and changes made by "Change Order" notices. Mark the drawings with colored pencil(s). These shall be available for review by the Owner, Architect or Engineer during the entire construction stage.
- C. The Record Drawings shall be updated concurrently as construction progresses, and in no case less frequently than a daily basis. They shall indicate accurate dimensions for all buried or concealed work, precise locations of all concealed pipe or duct, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents. All dimensions shall include at least two dimensions to permanent structure points.
- D. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified herein to record the locations and invert elevations of underground installations.
- E. If the Contractor does not keep an accurate set of Record Drawings, the pay request may be altered or delayed at the request of the Architect. Delivery of Record Documents is a condition of final acceptance. Record Drawings shall be furnished in addition to Shop Drawings.

- F. The Contractor shall submit an electronic copy of the record documents in PDF format and one (1) full size set of Record Drawing prints to the Architect or Engineer for review prior to scheduling the final inspection at the completion of the work. The drawings shall have the name(s) and seal(s) of the Engineer(s) removed or blanked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS

DATE:

(NAME OF GENERAL CONTRACTOR)

BY: _____

(SIGNATURE)

(NAME OF SUBCONTRACTOR)

BY: _____

(SIGNATURE)

1.17 CERTIFICATIONS AND TEST REPORTS

- A. Submit a detailed schedule for completion and testing of each system indicating scheduled dates for completion of system installation and outlining tests to be performed and schedule date for each test. This detailed completion and test schedule shall be submittal at least 90 days before the projected Project completion date.
- B. Test result reporting forms shall be submitted for review no later than the date of the detailed schedule submitted.
- C. Submit 4 copies of all certifications and test reports to the Architect or Engineer for review adequately in advance of completion of the Work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.
- D. Certifications and test reports to be submitted shall include, but not be limited to those items outlined in Section of Division 26.

1.18 MAINTENANCE MANUALS

- A. Coordinate with Division 1 for maintenance manual requirements, unless noted otherwise bind together in "D ring type" binders by National model no. 79-883 or equal, binders shall be large enough to allow 1/4" of spare capacity. Three (3) sets of all approved shop drawing submittals, fabrication drawings, bulletins, maintenance instructions, operating instructions and parts exploded views and lists for each and every piece of equipment furnished under this Specification. All sections shall be typed and indexed into sections and ed for easy reference and shall utilize the individual specification section numbers shown in the Electrical Specifications as an organization guideline. Bulletins containing information about equipment that is not installed on the project shall be properly marked up or stripped and reassembled. All pertinent information required by the Owner for proper operation and maintenance of equipment supplied by Division 26 shall be clearly and legibly set forth in memoranda that shall, likewise, be bound with bulletins.
- B. Prepare maintenance manuals in accordance with Special Project Conditions, in addition to the requirements specified in Division 26, include the following information for equipment items:
 - 1. Identifying names, name tags designations and locations for all equipment.
 - 2. Fault Current calculations and Coordination Study.
 - 3. Reviewed shop drawing submittals with exceptions noted compliance letter.
 - 4. Fabrication drawings.

5. Equipment and device bulletins and data sheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable, i.e., description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and model numbers of replacement parts.
 6. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 7. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions, servicing instructions and lubrication charts and schedules.
 8. Equipment name plate data.
 9. Wiring diagrams.
 10. Exploded parts views and parts lists for all equipment and devices.
 11. Color coding charts for all painted equipment and conduit.
 12. Location and listing of all spare parts and special keys and tools furnished to the Owner.
 13. Furnish recommended lubrication schedule for all required lubrication points with listing of type and approximate amount of lubricant required.
- C. Refer to Division 1 for additional information on Operating and Maintenance Manuals.
- D. Operating and Maintenance Manuals shall be turned over to the Owner or Engineer a minimum of 14 working days prior to the beginning of the operator training period.

1.19 OPERATOR TRAINING

- A. The Contractor shall furnish the services of factory trained specialists to instruct the Owner's operating personnel. The Owner's operator training shall include 12 hours of onsite training in three 4 hour shifts.
- B. Before proceeding with the instruction of Owner Personnel, prepare a typed outline in triplicate, listing the subjects that will be covered in this instruction, and submit the outline for review by the Owner. At the conclusion of the instruction period obtain the signature of each person being instructed on each copy of the reviewed outline to signify that he has a proper understanding of the operation and maintenance of the systems and resubmit the signed outlines.
- C. Refer to other Division 26 Sections for additional Operator Training requirements.

1.20 SITE VISITATION

- A. Visit the site of the proposed construction in order to fully understand the facilities, difficulties and restriction attending the execution of the work.
- B. Before submitting a bid, it will be necessary for each Contractor whose work is involved to visit the site and ascertain for himself the conditions to be met therein in installing his work and make due provision for same in his bid. It will be assumed that this Contractor in submitting his bid has visited the premises and that his bid covers all work necessary to properly install the equipment shown. Failure on the part of the Contractor to comply with this requirement shall not be considered justification for the omission or faulty installation of any work covered by these Specifications and Drawings.
- C. Understand the existing utilities from which services will be supplied; verify locations of utility services, and determine requirements for connections.
- D. Determine in advance that equipment and materials proposed for installation fit into the confines indicated.

1.21 WARRANTY

- A. The undertaking of the work described in this Division shall be considered equivalent to the issuance, as part of this work, of a specific guarantee extending one year beyond the date of completion of work and acceptance by Owner, against defects in materials and workmanship. Materials, appliances and labor necessary to effect repairs and replacement so as to maintain said work in good functioning order shall be provided as required. Replacements necessitated by normal wear in use or by Owner's abuse are not included under this guarantee.
- B. All normal and extended warranties shall include parts, labor, miscellaneous materials, travel time, incidental expenses, freight/shipping, refrigerant, oils, lubricants, belts, filters and any expenses related to service call required to diagnose warranty problems.

1.22 TRANSFER OF ELECTRONIC FILES

- A. Project documents are not intended or represented to be suitable for reuse by Architect/Owner or others on extensions of this project or on any other project. Any such reuse or modification without written verification or adaptation by Engineer, as appropriate for the specific purpose intended, will be at Architect/Owner's risk and without liability or legal exposure to Engineer or its consultants from all claims, damages, losses and expense, including attorney's fees arising out of or resulting thereof.
- B. Because data stored in electric media format can deteriorate or be modified inadvertently, or otherwise without authorization of the data's creator, the party receiving the electronic files agrees that it will perform acceptance tests or procedures within sixty (60) days of receipt, after which time the receiving party shall be deemed to have accepted the data thus transferred to be acceptable. Any errors detected within the sixty (60) day acceptance period will be corrected by the party delivering the electronic files. Engineer is not responsible for maintaining documents stored in electronic media format after acceptance by the Architect/Owner.
- C. When transferring documents in electronic media format, Engineer makes no representations as to the long-term compatibility, usability or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by Engineer at the beginning of the Project.
- D. Any reuse or modifications will be Contractor's sole risk and without liability or legal exposure to Architect, Engineer or any consultant.
- E. The Texas Board of Architectural Examiners (TBAE) has stated that it is in violation of Texas law for persons other than the Architect of record to revise the Architectural drawings without the Architect's written consent.
 - 1. It is agreed that "MEP" hard copy or computer-generated documents will not be issued to any other party except directly to the Architect/Owner. The contract documents are contractually copyrighted and cannot be used for any other project or purpose except as specifically indicated in AIA B-141 Standard Form of Agreement Between Architect and Owner.
 - 2. If the client, Architect or Owner of the project requires electronic media for "record purposes", then AutoCAD/ Revit documents will be prepared by Engineer on electronic media such as removable memory devices, flash drives or CD's. These documents can also be submitted via file transfer protocols. AutoCAD/ Revit files will be submitted with all title block references intact to permit the end user to only view and plot the drawings. Revisions will not be permitted in this configuration.

3. At the Architect/Owner's request, Engineer will assist the Contractor in the preparation of the submittals and prepare one copy of AutoCAD/ Revit files on electronic media or submit through file transfer protocols. The electronic media will be prepared with all indicia of documents ownership removed. The electronic media will be prepared in a ".rvt" or ".dwg" format to permit the end user to revise the drawings.

PART 2 - PRODUCTS

2.1 SUBSTITUTIONS

- A. The names and manufacturers and model numbers have been used in the Contract documents to establish types of equipment and standards of quality. Where more than one manufacturer is named for a specific item of equipment, only one of the specified manufacturers will be considered for approval. Where only one manufacturer is mentioned with the phrase "or approved equal", Contractor may submit an alternate manufacturer for consideration, provided the following conditions are met:
 1. Submit alternate equipment with complete descriptive data in shop drawing form. Provide sample of equipment upon request for review by Architect. Samples will be returned if requested in writing.
 2. Alternate equipment must be equal from the standpoint of materials, construction and performance.
 3. Alternate submittal must be presented to the Engineer/Architect ten (10) days prior to bid date for approval.
- B. The Architect and Engineer shall be the sole judge of quality and equivalence of equipment, materials and methods.

2.2 PRODUCT LISTING

- A. Products used on this project shall be listed by Underwriters' Laboratories.

2.3 ACCESS DOORS

- A. Wherever access is required in walls or ceilings to concealed junction boxes, pull boxes, equipment, etc., installed under this Division, furnish a hinged access door and frame with flush latch handle to another Division for installation. Doors shall be as follows:
 1. Plaster Surfaces: Milcor Style K.
 2. Ceramic Tile Surfaces: Milcor Style M.
 3. Drywall Surfaces: Milcor Style DW.
 4. Install panels only in locations approved by the Architect.

2.4 EQUIPMENT PADS

- A. Provide 4-inch-high concrete pads for indoor floor mounted equipment. Pads shall conform to the shape of the equipment with a minimum of 6 inch beyond the equipment. Top and sides of pads shall be troweled to a smooth finish, equivalent to the floor. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise.
- B. Provide 6-inch-high concrete pads for all exterior mounted equipment. Pads shall conform to the shape of the equipment with a minimum of 6 inch beyond the equipment. Provide a 4-foot monolithic extension to the pad in front of the equipment for service when mounted on a non-finished area (i.e. landscape, gravel, clay, etc.) Top and sides of pads shall be troweled to a smooth finish. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise.

- C. Provide a minimum 6-inch-high, steel reinforced concrete pad for generators. Pads shall be sized 6" larger than the outside perimeter dimensions. Provide a 4-foot monolithic extension to the pad around the equipment for service when mounted on a non-finished area (i.e. landscape, gravel, clay, etc.). Refer to structural details. Top and sides of pads shall be troweled to a smooth finish. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise. The generator shall be bolted to the concrete pad per the manufacturers details.
- D. Provide steel reinforced concrete pad for utility transformers. Pads shall comply with Utility Company Standards.

2.5 ESCUTCHEONS

- A. Provide heavy chrome or nickel plated plates, of approved pattern, on conduit passing through walls, floors and ceilings in finished areas. Where conduit passes through a sleeve, no point of the conduit shall touch the building construction. Caulk around such conduit with sufficient layers of two hour rated firesafing by Thermafiber 4.0 P.C.F. density, U.S.G. fire test 4/11/78 and seal off openings between conduit and sleeves with non-hardening mastic prior to application of escutcheon plate. Escutcheons shall be Gravel Sure-Lock, or approved equal.

2.6 SPACE LIMITATIONS

- A. Equipment shall be chosen which shall properly fit into the physical space provided and shown on the drawings, allowing ample room for access, servicing, removal and replacement of parts, etc. Adequate space shall be allowed for clearances in accordance with Code requirements. Physical dimensions and arrangement of equipment shall be subject to the approval of the Architect.

2.7 PAINTING

- A. All factory assembled equipment for electrical work, except light fixtures, that normally is delivered with a factory applied finish shall be delivered with a hard surface factory applied finish such as baked-on machinery enamel which will not require additional field painting. The finish shall consist of not less than 2 coats of medium gray color paint USA No. 61 Munsell Notation 8-3G, 6. 10/0.54 enamel. This Contractor shall protect this finish from damage due to construction operations until acceptance of the building. He shall be responsible for satisfactorily restoring any such finishes or replacing equipment that becomes stained or damaged.

2.8 ELECTRICAL SYSTEM IDENTIFICATION

- A. Conduit Systems: Provide adequate marking of major conduit which is exposed or concealed in accessible spaces to distinguish each run as either a power or signal/communication conduit. Except as otherwise indicated, use orange banding with black lettering. Provide self-adhesive or snap-on type plastic markers. Indicate voltage for that raceway. Locate markers at ends of conduit runs, on pull boxes, on junction boxes, near switches and other control devices, near items of equipment served by the conductors, at points where conduit passes through walls or floors, or enters non-accessible construction and at spacings of not more than 50 feet along each run of conduit. Switch-leg conduit and short branches for power connections do not have to be marked, except where conduit is larger than 3/4 inch. Branch circuit conduits, junction boxes and pull boxes shall be marked with a permanent marker indicating panel name and branch circuit numbers.

- B. Underground Cable Identification: Bury a continuous, preprinted, bright colored plastic ribbon cable marker with each underground cable (or group of cables), regardless of whether conductors are in conduit, duct bank, or direct buried. Locate each directly over cables, 6 to 8 inches below finished grade.
- C. Identification of Equipment:
1. All major equipment shall have a manufacturer's label identifying the manufacturer's address, equipment model and serial numbers, equipment size, and other pertinent data. Care shall be taken not to obliterate this nameplate in any way. Provide black back plate with white letters and numbers for normal equipment. Provide red back plate with white letters and numbers for optional emergency equipment. Provide yellow back plate with white letters and numbers for Life safety equipment.
 2. A black-white-black laminated plastic engraved identifying nameplate shall be secured by stainless steel screws to each automatic transfer switch, switchboard, distribution panel, motor control center, motor starter panels and panelboards.
 - a. Identifying nameplates shall have ¼ inch high engraved letters and shall contain the following information:
 - 1) Name
 - 2) Voltage
 - 3) Phase
 - 4) "3" or "4" wire, and
 - 5) Where it is fed from.
 - b. An example of a panelboard nameplate is:
Center Panel – 1HB
480/277 volt, 3 phase, 4 wire
Center Fed from DP2
 - c. An example of an automatic transfer switch nameplate is:
Center ATS #2
480/277 volt, 3 phase, 4 wire, 4 pole
Center Fed from MSB and DPE
 3. Each feeder device in a switchboard, distribution panel, and motor control center device shall have a nameplate showing the load served in ½ inch high engraved letters.
 4. A black-white-black laminated plastic engraved identifying nameplate shall be secured by screws to each transformer, safety switch, disconnect switch, individual motor starter, enclosed circuit breaker, wireway, and terminal cabinet.
 - a. Identifying nameplates shall have 1/4 inch high engraved letters and shall indicate the equipment served.
 - b. An example of a disconnect switch is: AHU-1.
 5. Prohibited Markings: Markings which are intended to identify the manufacturer, vendor, or other source from which the material has been obtained are prohibited for installation within public, tenant, or common areas within the project. Also, prohibited are materials or devices which bear evidence that markings or insignias have been removed. Certification, testing (example, Underwriters' Laboratories, Inc.), and approval labels are exceptions to this requirement.
 6. Warning Signs: Provide warning signs where there is hazardous exposure associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with recognized industry standards for color and design.

7. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical system, provide tags of plasticized card stock, either preprinted or hand printed. Tags shall convey the message, example: "DO NOT OPEN THIS SWITCH WHEN BURNER IS OPERATING."
- D. Identification of Wiring Devices
 1. Contractor shall indicate the circuit serving each wiring device. Provide a typewritten label located on the inside face of the coverplate for all recessed mounted devices and on the outside face of the coverplate on all surface mounted devices.

PART 3 - EXECUTION

3.1 EXCAVATING AND BACKFILLING

- A. Trenching and backfilling and other earthwork operations required to install the facilities specified herein shall conform to the applicable requirements of Division 2 (95% of maximum standard density). Where trenching or excavation is required in improved areas, the backfill shall be compacted to a condition equal to that of adjacent undisturbed earth and the surface of the area restored to the condition existing prior to trenching or excavating operations. Provide a minimum of 3" of sand underneath all conduits. The plans indicate information pertaining to surface and sub-surface obstructions; however, this information is not guaranteed. Should obstructions be encountered whether or not shown, the Contractor shall alter routing of new work, reroute existing lines, remove obstructions where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of new work and leave existing surfaces and structures in a satisfactory and serviceable condition. All work shall comply with OSHA Standards.

3.2 WORKMANSHIP AND CONCEALMENT

- A. The work of this Section shall be performed by workman skilled in their trade. Installation shall be consistent in completeness whether concealed or exposed. Each item of electrical work shall be concealed in walls, chases, under floors and above ceilings except:
 1. Where shown to be exposed.
 2. Where exposure is necessary to the proper function.

3.3 SLEEVES, CUTTING AND PATCHING

- A. This section shall be responsible for placing sleeves for all conduit passing through walls, partitions, sound walls, beams, floors, roof, etc. Sleeves through below-grade walls shall use water-tight fitting manufactured by O-Z/Gedney.
- B. Contractor shall install underground raceways including but not limited to feeders, service laterals, branch circuit and telecommunications. Contractor shall saw cut existing hard surfaces, when required for installation. Contractor shall patch surface to match existing conditions. Contractor shall replace all landscaping material when raceways are installed in these areas. Submit proposed method for patching for review.
- C. All cutting and patching will be done under another Division, but this Section will be responsible for timely performance of this work and layout of holes and setting sleeves.
- D. All un-used sleeves shall be sealed with 2 hour UL approved fire sealant manufactured by "3M" or approved equal.
- E. Refer to 26 05 33 for additional requirements.

3.4 ELECTRICAL GEAR

- A. Install all electrical equipment in accordance with the National Electrical Code and as shown on the drawings.
- B. Lighting contactors, time clocks, fire alarm equipment, security equipment disconnect switches, etc. mounted in mechanical/electrical rooms shall be mounted at a working height not requiring a ladder, when wall space is available. Installation of these devices at greater elevations shall be approved by the Engineer. Contractor shall provide a coordination sketch of each mechanical/electrical room noting locations and mounting heights of all electrical devices (note bottom and top elevations) shown to be installed. Sketches shall be provided to the Engineer for review and the general contractor for coordination with other trades working in these rooms.
- C. Fire retardant back boards secured to drywall studs may be used for contactors, time clocks, fire alarm equipment, security equipment, and disconnect switches 60 amp or smaller. All other wall mounted devices shall be mounted to unistrut. Unistrut shall be securely mounted to the floor and structural ceiling. Toggle bolts or anchor bolts attached to drywall is not acceptable.

3.5 CLEANING

- A. Clean lighting fixtures and equipment.
- B. Touch-up and refinish scratches and marred surfaces on panels, switches, starters, and transformers.

3.6 CORROSIVE AREAS

- A. In areas of a corrosive nature, which include but are not limited to the following: pool equipment rooms, cooling towers and areas subject to salt air, etc., provide NEMA 4 X stainless steel or fiberglass reinforced enclosures for contactors, panel boards, controllers, starters, disconnects and materials used as supporting means (i.e. plastibond unistrut, pipe, fittings). The use of spray on coating may be acceptable in some applications.

3.7 TESTS AND INSPECTIONS

- A. Tests and inspection requirements shall be coordinated with Division I.
- B. Date for final acceptance test shall be sufficiently in advance of completion date of contract to permit alterations or adjustments necessary to achieve proper functioning of equipment prior to contract completion date.
- C. Conduct re-tests as directed by Architect on portions of work or equipment altered or adjusted as determined to be necessary by final acceptance test. No resultant delay or consumption of time as a result of such necessary re-test beyond contract completion date shall relieve Contractor of his responsibility under contract.
- D. Put circuits and equipment into service under normal conditions, collectively and separately, as may be required to determine satisfactory operation. Demonstrate equipment to operate in accordance with requirements of these specifications. Perform tests in the presence of Architect. Furnish instruments and personnel required for tests.
- E. Final Inspection:
 - 1. At the time designated by the Architect, the entire system shall be inspected by the Architect and Engineer. The contractor or his representative shall be present at this inspection.
 - 2. Panelboards, switches, fixtures, etc., shall be cleaned and in operating condition.
 - 3. Certificates and documents required hereinbefore shall be in order and presented to the Architect prior to inspection.

4. Panel covers, junction box covers, etc., shall be removed for visual inspection of the wire, bus bars, etc.
 5. After the inspection, any items which are noted as needing to be changed or corrected in order to comply with these specifications and the drawings shall be accomplished without delay.
- F. The contractor shall provide a thermographic test using an independent testing laboratory using an infrared scanning device. This test shall include but not limited to all switchboards, distribution panelboards, panelboards, automatic transfer switches and other electrical distribution devices. This test shall be conducted to locate high temperature levels. This test shall be conducted between 3 to 8 months after occupancy, but not beyond the one year warranty period. Submit test to the architect and engineer using test reporting forms. All unacceptable conditions shall be corrected prior to the end of the warranty period.

END OF SECTION

**SECTION 26 03 00
DEMOLITION WORK**

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The drawings do not show all demolition work required. The contractor shall make himself familiar with the required scope of work to accomplish the work required by these documents. All demolition work implied or required shall be included in the scope of this contract.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 DEMOLITION WORK

- A. The contractor shall be responsible for loss or damage to the existing facilities caused by him and his workmen, and shall be responsible for repairing such loss or damage. The contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in-service maintenance of all electrical services for the new and existing facilities. The contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary safety protection upon completion of the work.
- B. The contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.
- C. Where existing construction is removed to provide working and extension access to existing utilities, contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall same upon completion of work in the areas affected.
- D. Where partitions, walls, floors, or ceilings of existing construction are being removed, all contractors shall remove and reinstall in locations approved by the Architect all devices required for the operation of the various systems installed in the existing construction.
- E. Outages of services as required by the new installation will be permitted but only at a time approved by the Owner. The contractor shall allow the Owner 2 weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.
- F. The contractor shall modify, remove, and/or relocate all materials and items so indicated on the drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination as directed by the Owner. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition. The contractor may, at his discretion and upon the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

- G. All items which are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved.
- H. When items scheduled for relocation are found to be in damaged condition before work has been started on dismantling, the contractor shall call the attention of the Owner to such items and receive further instructions before removal. Items damaged in repositioning operations are the contractor's responsibility and shall be repaired or replaced by the contractor as approved by the Owner, at no additional cost to the Owner.
- I. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner. Service lines and wiring not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied-off or disconnected in a safe manner acceptable to the Owner. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas or facilities which must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.
- J. During the construction and remodeling, portions of the project shall remain in service. Construction equipment, materials, tools, extension cords, etc., shall be arranged so as to present minimum hazard or interruption to the occupants of the building.
- K. Certain work during the demolition phase of construction may require overtime or nighttime shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner's Representative at least 72 hours in advance.
- L. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch, or replace as required any damage which might occur as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction. Cooperate with the Owner and other trades in scheduling and performance of the work.
- M. Include in the contract price all rerouting of existing conduits, wiring, outlet boxes, fixtures, etc., and the reconnecting of existing fixtures as necessitated by field conditions to allow the installation of the new systems. Furnish all temporary conduit, wiring, boxes, etc., as required to maintain lighting and power service for the existing areas with a minimum of interruption. Remove wire and conduit back to nearest accessible active junction box and extend to existing homeruns as required.
- N. All existing lighting fixtures, switches, outlets, speakers, materials, equipment and appurtenances not included in the remodel or alteration areas are to remain in place and shall remain in service.
- O. Electrical equipment, outlets, speakers, circuits to mechanical and building systems equipment, etc., which are to remain but which are served by conduit and/or circuiting that is disturbed by the remodeling work, shall be reconnected in such a manner as to leave it in proper operating condition.
- P. Existing branch circuit wiring which is to be removed, shall be pulled from the raceways and the empty conduit shall be removed to a point of permanent concealment.
- Q. Existing lighting fixtures shown to be removed and indicated to be reused, shall be cleaned, repaired, relamped and provided with such new accessories as may be needed for the proper installation in their new locations.

- R. New circuiting indicated to be connected to existing panels shall be connected to "spares" and/or "released" breakers as applicable, or new breakers provided where space is available. Contractor shall verify the existing panel load and feeder capacity prior to adding any additional loads.
- S. Within the remodeled or alteration areas where existing ceilings are being removed and new ceiling are installed, all existing lighting fixtures, other ceiling mounted devices and their appurtenances shall be removed and reinstalled into the new ceiling, unless otherwise shown or specified.
- T. Within the remodeled or alteration areas where existing walls are being removed, all existing lighting fixtures, switches, receptacles, other materials and equipment and their appurtenances shall be removed, where required by the remodel work either shown or specified.
- U. Refer to Architectural "Demolition" and "Alteration" plans for actual location of walls, ceilings, etc. being removed and/or remodeled.

END OF SECTION

SECTION 26 05 19
WIRE, CABLE AND RELATED MATERIALS

PART 1 - GENERAL

1.1 SCOPE

- A. Provide 600 volt building wire, cable and connectors and 300 volt wire, cable and connectors.
- B. WORK INCLUDED: Include the following Work in addition to items normally part of this Section.
 - 1. Wiring for lighting, dimming controls and power.
 - 2. Automatic Control Wiring.
 - 3. Connection of equipment shown.
 - 4. Fire Alarm System.
 - 5. Voice Communications and Sound System.
 - 6. Mineral Insulated Cable (MI)
- C. WORK SPECIFIED ELSEWHERE:
 - 1. Heating, ventilating, and air conditioning equipment.
 - 2. Structured cabling system.
 - 3. Coaxial cables

1.2 REFERENCE STANDARDS

- A. UL 4 - Armored Cable
- B. UL 83 - Thermoplastic-Insulated Wires and Cables
- C. UL 1063 - Standard for Machine-Tool Wires and Cables
- D. UL 1569 - Metal-Clad Cables
- E. UL 1685 - Standard for Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables
- F. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire
- G. NFPA 70 - National Electrical Code
- H. All wire cable and connectors shall be UL approved.
- I. NEMA
- J. NEMA Bulletin 119

1.3 ACCEPTABLE MANUFACTURERS

- A. 600 VOLT WIRE AND CABLE
 - 1. Southwire
 - 2. Encore
 - 3. Cerro
 - 4. Atkore
- B. 300 VOLT WIRE AND CABLE
 - 1. Westpenn
 - 2. Beldon
 - 3. Alpha
 - 4. Tappan - Southwire
- C. FLEXIBLE CABLE SYSTEMS
 - 1. AFC Modular Cable Systems
 - 2. Kaf-Tech
- D. CONNECTORS
 - 1. IIsco
 - 2. Cooper

3. AMP - TYCO
4. Burndy
5. Ideal
6. 3M
7. O.Z. Gedney
8. Thomas & Betts
9. Buchanan

1.4 SUBMITTALS

- A. Shop drawings shall include, but not limited to:
 1. Cutsheets of wire, cable and connectors to indicate the performance, fabrication procedures, product variations, and accessories.

1.5 REQUIREMENTS OF REGULATORY AGENCIES WORK IN ACCORDANCE WITH:

- A. National Electrical Code.
- B. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.1 WIRING

- A. All wire shall be new and continuous without weld, splice, or joints throughout its length. It must be uniform in cross-section, free from flaws, scales and other imperfections.
- B. WIRE MATERIAL: Conductors shall be soft drawn, annealed copper. Aluminum wiring is not acceptable unless otherwise noted on drawings.
- C. TYPES:
 1. Provide type "THHN/THWN-2" insulation for all buried feeders and service entrance conductors.
 2. Provide type "THHN/THWN-2" insulation for all branch circuits and above grade feeders.
 3. All wire No. 8 and larger shall be stranded. All wire No. 10 and smaller shall be stranded or solid.
 4. Provide type "XHHW" or other 90 degrees insulation wiring for branch circuit wiring installed through continuous rows of fixture bodies.
 5. All 300-volt cable including but not limited to telephone, fire alarm, data, CATV and security shall be UL listed for use in return air plenums.
 6. All dimming conductors shall be 300 volt, 75 C plenum rated. Dimming conductors shall be solid. Stranded conductors are not acceptable.
- D. CONDUCTOR SIZES
 1. Feeder conductors shall be sized for a maximum of 2% drop in rated voltage at scheduled load.
 2. Branch circuit conductors shall be sized for a maximum 3% drop in the rated voltage to the longest outlet on the circuit.
 3. Minimum wire shall be 12 AWG, unless otherwise shown on Drawings or required by Code.
 4. Minimum wire size for 0-10v dimming controls shall be 18 AWG for conductors not exceeding 300 feet circuit length (one-way) and 16 AWG for those exceeding 300 feet (one-way).
- E. COLOR CODING: No. 6 or larger shall use tape for color coding. No. 8 and smaller wire shall be color coded in accordance with the governing authority requirements or as follows:
120/208 Volt

Neutral: White
Phase A: Black
Phase B: Red
Phase C: Blue
Ground: Green

277/480 Volt

Neutral: Gray
Phase A: Brown
Phase B: Purple
Phase C: Yellow
Ground: Green

120/240 Volt

Neutral: White
Phase A: Black
Phase B: Orange
Phase C: Blue
Ground: Green

0-10 Volt dimming conductors

Purple (source)
Pink (common)

2.2 METAL CLAD CABLE - TYPE MC (600 VOLT)

- A. Provide soft drawn solid copper conductors with type THHN/ THWN-2 insulation rated 90° C in dry locations. All conductors shall be color coded. Include a white neutral and green insulated grounding conductor. Branch circuits shall include a double sized neutral when more than one phase conductors are being utilized. The conductors shall use a binding tape with a printed legend and assembled in an interlocking steel armor raceway.

2.3 METAL CLAD CABLE - TYPE HCF (600 VOLT)

- A. Provide soft drawn solid copper conductors with type THHN insulation rated 90° C in dry locations. All conductors shall be color coded. Include a white neutral, a redundant 16 AWG aluminum bond conductor and green insulated grounding conductor. Branch circuits shall include a double sized neutral when more than one phase conductors are being utilized. The conductors shall use a binding tape to bond and assembled in an interlocking steel armor raceway. This assembly shall provide redundant ground paths.

PART 3 - EXECUTION

3.1 WIRE

- A. Do not pull wire into conduit until Work of an injurious nature is completed. Where two or more circuits run to a single outlet box, each circuit shall be properly tagged. Wyreze or approved equal may be used as a lubricant where necessary.
- B. Splices shall be fully made up in outlet boxes with compression crimp-on type splice connectors.

- C. Joints and splices will not be permitted in service entrance or in feeders. Joints in branch circuits will be permitted where branch circuits divide, and then shall consist of one through-circuit to which the branch shall be spliced. Joints shall not be left for the fixture hanger to make. Connect joints and splices with Buchanan Series "2000" solderless connectors complete with insulating caps or properly sized twist on wire nuts. "Wago" push-in connectors are not acceptable.
- D. All stranded conductors shall be furnished with lugs or connectors.
- E. Connectors furnished with circuit breakers or switches shall be suitable for copper wire termination.
- F. "Sta-Cons" shall be used to terminate stranded conductors on all switches and receptacles.
- G. Metal Clad Cable - Type MC
 - 1. All light fixtures shall be connected from a branch circuit junction box using 1/2" flexible metal conduit or MC cable fixture pigtails not exceeding 8'-0". Provide #12 AWG conductors. All fixtures must be grounded by using a grounding conductor. Fixture to fixture wiring installed in accessible ceiling is not permitted. Fixture whips shall not lay on ceiling tile or grid. Provide caddy clips to provide additional support.
- H. Metal Clad Hospital Grade MC Cable - Type HCF
 - 1. HCF cable shall not be used for homeruns. HCF cable shall only be used for branch circuit drops from ceiling mounted junction boxes to outlets and for horizontal runs in a common wall from outlet to outlet. Do not route to outlets to adjacent walls. HCF cable may be looped from outlet to outlet in areas where non-accessible ceilings are used.
 - 2. HCF cable shall use UL approved connectors and shall be installed per Article 330 of NFPA 70. The cable shall be supported at intervals not exceeding 4-1/2 feet and within 12 inches of every box.
 - 3. HCF cables shall be use in all exam rooms and patient rooms where acceptable by the AHJ and state codes.
 - 4. Provide anti-short bushing at cable ends.
 - 5. Refer to electrical details for additional information and restrictions.
 - 6. Metal clad hospital grade cable shall not be installed in concrete.
- I. All stranded #10 and small conductors shall be terminated with an approved solderless terminal if the device or light fixture does not have provisions for clamp type securing of the conductor.
- J. The jacket for all travelers used on 3-way and 4-way switches shall be pink.
- K. Route conductors for 480Y/277 systems in a separate raceway. Do not combine with 208Y/120 volt or 120/240 volt systems.
- L. Emergency circuits shall not be routed with normal conductors.

3.2 BALANCING SYSTEM

- A. The load on each distribution and lighting panel shall be balanced to within 10% by proper arrangement of branch circuits on the different phase legs. Provide written documentation showing results. Submit with O & M manuals.

3.3 LOW VOLTAGE WIRING

- A. Low voltage wiring, including dimming conductors, shall be plenum rated. All wiring in mechanical rooms, electrical rooms, drywall ceiling, inaccessible areas, underground, plaster ceiling, inside concealed walls areas exposed to occupant view, and other areas subject to physical damage shall be run in conduit.
- B. Low voltage wiring shall be routed in separate raceways from power wiring systems.

- C. Sleeves shall be placed in the forms of concrete, masonry and fire rated walls, floor slabs and beams, for the passage of wiring. Sleeves should be set in place a sufficient time ahead of the concrete work so as not to delay the work. Sleeves shall be rigid galvanized steel.
- D. Provide Caddy J-hooks supported independently from other system to support cable at 4-foot on center or closer if required by manufacturer.
- E. Provide a junction box to make up all joints and splices.
- F. Provide dimming conductors for all lighting circuits located in spaces with dimmer switches and theatrical lighting as indicated on the drawings and as specified.

3.4 GROUNDING

- A. Permanently connect all conduit work, motors, starters, and other electrical equipment to grounding system in accordance with NFPA 70.

3.5 CABLE SUPPORTS

- A. Provide cable supports in all vertical raceways in accordance with Article 300.19 of NFPA 70.

3.6 DEFECTS

- A. Defects shall include, but are not to limited to, the following:
 - 1. Tripping circuit breakers under normal operation.
 - 2. Improperly connected equipment.
 - 3. Damaged, torn, or skinned insulation.

END OF SECTION

SECTION 26 05 26 GROUNDING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

1.2 SCOPE

- A. WORK COMBINED WITH OTHER SECTIONS: Combine the work specified herein with the following Sections to form a single responsibility for the Work:
 - 1. Electrical.
 - 2. Basic materials and methods.
- B. Provide electrical service, equipment and wiring device grounding as shown, scheduled and as specified.
- C. The types of grounding include, but not limited to, the grounding bonding of all equipment devices, building steel piping, and as required by the National Electrical Code, Local Inspection Department and Power Company.

1.3 STANDARDS

- A. National Electrical Code (NFPA-70)
- B. Local municipal and State codes that have jurisdiction.
- C. NECA

1.4 ACCEPTABLE MANUFACTURES

- A. Provide grounding products manufactured by Copperweld and Cadweld.

1.5 SUBMITTALS

- A. Shop drawings shall include, but not limited to the following:
 - 1. Cut sheets of ground rods, clamps and connectors.
 - 2. Grounding system diagram.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide all materials required to construct a complete grounded electrical system.
- B. GROUND RODS: Ground rods shall be 3/4" inch diameter by 10 feet long construction with copper jacket and a steel core.
- C. CLAMPS: Ground clamps shall be copper except for steel or iron pipes in which the clamps shall be galvanized iron.
- D. CONDUCTORS: Conductors shall be connected by means of an approved pressure connector or clamp.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. GENERAL: Install grounding system as shown and specified to ensure a properly grounded system.

- B. SERVICE ENTRANCE GROUNDING SYSTEM: Provide a main bonding jumper between the neutral and ground bus of each switchboard. Route a separate grounding electrode conductor in conduit from each main distribution panel to the ground rod grid, incoming cold water piping system, and to the "lightning protection system" (250 - 106 of NEC) under ground bonding loop. Provide a bonding jumper around water meter. The grounding electrode conductor shall be stranded copper, 98% conductivity and shall be run continuous without splices or joints and installed at least 12" below grade.
- C. BUILDING STEEL AND PIPING SYSTEM: Install a bonding jumper between building steel and metallic piping systems to bond them to the electrical grounding system.
- D. NEUTRAL: The neutral shall be grounded only at the service entrance and other separately derived systems. The neutral shall be kept separate from the grounding system and shall not be used as a ground.
- E. GROUNDING SEPARATELY DERIVED ALTERNATING CURRENT SYSTEM
 - 1. TRANSFORMERS: The center point (neutral) of each wye connected transformer shall be bonded to the case and the grounding electrode conductor shall be connected to the grounded conductor (neutral).
 - 2. STANDBY EMERGENCY GENERATOR: The generator neutral shall be bonded to the generator when a 4-pole switched neutral automatic transfer switch is specified.
- F. GROUNDING CONDUCTOR: A grounding conductor and metallic conduit system shall bond all equipment served by the electrical system. Provide a flexible bonding jumper for isolated metallic piping and ductwork and around expansion fittings and joints.
- G. CONDUIT GROUNDING BUSHING: Conduit terminating in equipment that has a ground bus such as switchboards, panelboards, etc., shall have grounding bushings installed. Ground each conduit by means of a grounding bushing and to the ground bus in the equipment.
- H. MOTORS: The frame of all motors shall be grounded.
- I. SPECIAL GROUNDING: Provide a #6 AWG copper grounding conductor for each telephone board, television system, etc. Terminate the grounding conductor on ground bus and to the building electrical grounding system. Refer to 800-40(d) and 820-40(d) of the NEC.
- J. REMOTE PANELBOARDS: Provide a grounding electrode conductor all remote panels as required by the NEC and shown on drawings.
- K. LIGHTING FIXTURES: Flexible fixture whips containing a green grounding conductor shall be used to connect light fixtures. Flexible fixture whips shall not exceed ten feet.
- L. RECEPTACLES: All receptacles shall be grounded using the branch circuit grounding conductor. Receptacles shall use an approved grounding yoke.
- M. POLES SUPPORTING OUTDOOR LIGHTING FIXTURES: Provide grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- N. PATIENT CARE VICINITY: Ground buses of Critical and Normal power panelboards serving common patient care spaces shall be connected with a copper bonding conductor not smaller than #10 AWG.

3.2 TESTING

- A. Perform a ground resistance test using a biddle analog or digital portable earth/ground resistance tester. The system resistance shall not exceed 5 Ohms. Provide additional electrodes as required (refer to 250-84 and 250-56 of the most current edition NEC). Test shall not be conducted following wet weather. Provide personal instruments to conduct these tests and submit certified test for review. Test shall be verified by Engineer.

END OF SECTION

SECTION 26 05 33
RACEWAYS

PART 1 - GENERAL

1.1 SCOPE

- A. Provide electrical raceways and fittings as shown, scheduled and specified.
- B. The types of raceways and fittings required are as follows:
 - 1. Rigid hot-dipped galvanized steel conduit (GRC) (RMC)
 - 2. Intermediate hot-dipped galvanized steel conduit (IMC)
 - 3. Electrical metallic tubing (EMT)
 - 4. PVC (Sch. 40 & 80)
 - 5. Flexible metal conduit (FMC)
 - 6. Liquid-tight flexible metal conduit (LFMC)
 - 7. PVC coated rigid galvanized steel conduit (GRCC)
 - 8. Rigid Aluminum Conduit (RAC)

1.2 REFERENCE STANDARDS

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC).
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S).
- C. ANSI C80.5 - American National Standard for Electrical Rigid Metal Conduit - Aluminum (ERMC-A).
- D. NFPA 70 - National Electrical Code.
- E. SCTE 77 - Specifications for Underground Enclosure Integrity.
- F. UL 6 - Electrical Rigid Metal Conduit-Steel.
- G. UL 6A - Electrical Rigid Metal Conduit-Aluminum, Red Brass, and Stainless Steel.
- H. UL 360 - Liquid-Tight Flexible Metal Conduit.
- I. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
- J. UL 797 - Electrical Metallic Tubing-Steel.
- K. UL 1242 - Electrical Intermediate Metal Conduit-Steel.
- L. NEMA FB-1
- M. NEMA TC3

1.3 ACCEPTABLE MANUFACTURERS

- A. Raceways
 - 1. Allied
 - 2. Republic
 - 3. Prime Conduit (Carlon)
 - 4. Wheatland Tube
 - 5. Cantex
 - 6. Western Tube
 - 7. Robroy Industries
- B. Fittings
 - 1. Appleton
 - 2. Crouse Hinds
 - 3. Steel City
 - 4. O.Z. Gedney
 - 5. Carlon
 - 6. Raco, Inc.
 - 7. Bridgeport

- C. Boxes
 - 1. RACO
 - 2. Thomas and Betts
 - 3. EATON
 - 4. Crouse-Hinds
 - 5. Appleton
- D. Surface
 - 1. Hubbell
 - 2. Wiremold

1.4 SUBMITTALS

- A. Product data shall include but not be limited to:
 - 1. Cutsheets for raceways, fitting, solvents, primers, etc.

1.5 REQUIREMENTS OF REGULATORY AGENCIES WORK IN ACCORDANCE WITH

- A. NFPA 70
- B. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.1 CONDUIT AND FITTINGS

- A. Rigid Galvanized Steel Conduit (GRC/RMC)
 - 1. Construction, Materials, Codes, Standards:
 - a. Article 344 - NFPA 70.
 - b. Hot-dip galvanized rigid steel conduit, galvanized after fabrication. Products shall comply with UL 6 and ANSI C80.1. All threads shall be galvanized after cutting. A uniform zinc coating shall be applied to the inner and outer walls.
 - c. Fittings shall be threaded and shipped with thread protectors. Set Screw are not acceptable. Die Cast Fittings are not acceptable.
 - 2. Permitted for use in the following locations:
 - a. Outdoor or Exterior (Exposed)
 - b. Indoors, Conditioned Spaces
 - c. Unconditioned Spaces
 - d. Underslab (Void Form Slab): where not in contact with earth – only permitted where indicated on plan.
 - e. Underslab (Suspended Slab): Permitted – only where indicated on plan.
 - 3. Prohibited Locations: Underground, Corrosive environments, Underslab (Slab on Grade), Foundation penetrations.
 - 4. Specific Uses: Exposed Exterior installations, where within or attached to masonry or concrete, where subject to damage.
- B. Intermediate Metal Conduit (IMC)
 - 1. Construction, Materials, Codes, Standards:
 - a. Article 342 - NFPA 70.
 - b. Conduit shall be similar to rigid steel conduit except thinner wall.
 - c. Fittings shall be threaded hot-dipped galvanized and shipped with thread protectors. Set Screw or Die Cast Fittings are not acceptable
 - d. Products shall comply with UL 1242.
 - 2. Permitted for use in the following locations:
 - a. Outdoor or Exterior (Exposed)
 - b. Indoors, Conditioned Spaces
 - c. Unconditioned Spaces

- d. Underslab (Void Form Slab): not in contact with earth only as indicated on plan.
 - e. Underslab (Suspended Slab): only where indicated on plan.
- 3. Prohibited Locations: Corrosive Environment, Underground, Underslab (Slab on Grade), Foundation Penetrations
- 4. Specific Uses: Exposed exterior locations, Rooftops exposed to sunlight
- C. Electrical Metallic Tubing (EMT)
 - 1. Construction, Materials, Codes, Standards:
 - a. Article 358 - NFPA 70.
 - b. EMT shall be made of hot-dip galvanized strip steel. The interior shall be coated with a corrosion-resistant lubricant for ease of wiring pulling.
 - c. Shall utilize steel insulated throat, set-screw connectors and steel set-screw couplings in all indoor conditioned spaces.
 - d. Shall utilize steel insulated throat, threadless, watertight compression type connectors and steel threadless watertight compression type coupling in all non-conditioned spaces and in grout filled CMU walls.
 - e. Products shall comply with UL 797 and ANSI C80.3.
 - 2. Permitted for use in the following locations:
 - a. Indoors, Conditioned Spaces
 - b. Unconditioned Spaces
 - 3. Prohibited Locations: Corrosive Environment, Underground, Underslab (all types), Wet or Damp Locations, Exteriors, Within Concrete, foundation penetrations.
 - 4. Specific Uses: Primary use conduit for indoor spaces, where conditioned. Unconditioned locations shall require use of insulated throat water tight fittings.
- D. Rigid Nonmetallic Conduit (PVC Schedule 40 & 80)
 - 1. Construction, Materials, Codes, Standards:
 - a. Article 352 and 300.6 - NFPA 70.
 - b. Conduit shall be schedule 40 or 80 polyvinyl chloride (PVC), UV stabilized, rated for 90°C conductors.
 - c. Fittings shall be solvent weld socket type.
 - d. Products shall comply with UL 651.
 - 2. Permitted for use in the following locations:
 - a. Underground (Earth, outside foundation perimeter)
 - b. Underslab (Slab on Grade): only where indicated on plan.
 - c. Under Driveways, roadways, or vehicular crossings, and where required by Utility Company: PVC Schedule 80
 - 1) PVC Schedule 40 allowed where concrete encased.
 - 3. Prohibited Locations: return air Plenums, interstitial spaces, Outdoor or Exterior (Exposed), Unconditioned spaces, corrosive environments, underslab (suspended or void form), foundation penetrations.
 - 4. Specific Uses: For use underground or underslab (Slab on grade). Underground use is approved for all locations where transiting a project site, not underneath any foundation. For locations under the footprint of building/foundation, use only authorized where indicated on drawings.
- E. Flexible Metal Conduit (FMC/Greenfield)
 - 1. Construction, Materials, Codes, Standards:
 - a. Article 348 - NFPA 70.
 - b. Spirally wound continuously interlocked zinc coated strip steel.
 - c. Fittings shall be one screw for smaller than 1-1/2-inch, two screw for 1-1/2-inch and larger, double clamp steel or malleable iron, either cadmium plated or hot-dip galvanized.
 - d. Products shall comply with UL 360.

2. Permitted for use in the following locations:
 - a. Indoors, Conditioned Spaces.
 3. Prohibited Locations: outdoors/Exterior, unconditioned spaces, Corrosive, Wet, Concrete, underslab(all types), underground, foundation penetrations.
 4. Specific Uses and Applications: For use in connection to rotating equipment within conditioned spaces, including plenums. Also permitted for use with empty raceways in walls for use with Low Voltage, AV, telecom cabling.
- F. Liquid-Tight Flexible Steel Conduit (LFMC/Seal Tite)
1. Construction, Materials, Codes, Standards
 - a. Article 350 - NFPA 70.
 - b. Spirally wound continuously interlocked zinc coated strip steel with a UV stabilized polyvinyl chloride (PVC) outer jacket bonded to the conduit.
 - c. Fittings shall be compression type, malleable iron, with insulated throat, either cadmium plated or hot-dip galvanized. Plastic is not acceptable.
 2. Permitted for use in the following locations:
 - a. Outdoor or Exterior (Exposed)
 - b. Indoors, Conditioned Spaces
 - c. Unconditioned Spaces
 3. Prohibited Locations: Concrete, corrosive, underground, underslab (all types), foundation penetrations.
 4. Specific Uses and Applications: Primary use is connection to rotating equipment at unconditioned spaces. Transformer Primaries and Secondaries (excluding service transformer).
- G. PVC Coated Rigid Galvanized Steel Conduit (GRCC/Plastibond)
1. Construction, Materials, Codes, Standards:
 - a. Article 344 and 300.6 - NFPA 70.
 - b. Conduit shall be same as rigid metal conduit with a factory-applied 40-mil-thick covering of polyvinyl chloride (PVC) bonded to the metal, coated inside and outside.
 2. Permitted for use in the following locations:
 - a. Outdoor or Exterior (Exposed): except for stub-ups and penetrations.
 - b. Corrosive Environment: required throughout
 - 1) Where corrosive environments exist, such as pools, pool pump room, corrosive chemical storage, GRCC shall be provided throughout, up to the point of sealed penetration into a non-corrosive environment.
 - c. Underground (Earth, outside foundation perimeter): Required at bends of 15° or greater, Penetrations through concrete, Stub-ups through foundation or grade at concrete.
 - d. Foundation Penetrations
 3. Prohibited Locations: extended runs exposed to sunlight, Plenums, Underslab except for penetrations (all foundation types).
 4. Specific Uses: For use at Cooling Towers, Natatoriums, Pools, Pool Decks, Pool pump rooms, chemical storage, corrosive environments.
- H. Rigid Aluminum Conduit (RAC)
1. Construction, Materials, Codes, Standards:
 - a. Article 344 - NFPA 70.
 - b. Rigid aluminum (alloy 6063-T1) conduit shall be manufactured using 6063 Alloy in temper designation T-1.
 - c. Fittings for rigid aluminum conduit shall be threaded aluminum shipped with thread protectors. Set Screw or Die Cast Fittings are not acceptable
 - d. Products shall comply with UL 6A and ANSI C80.5.

2. Permitted for use in the following locations:
 - a. Outdoor or Exterior (Exposed)
 - b. Indoors, Conditioned Spaces
 - c. Unconditioned Spaces
3. Prohibited Locations: Corrosive environments, underground, within concrete, underslab (all types), foundation penetrations.
4. Specific Uses and Applications: Exposed Exterior such as rooftops or canopies.

2.2 PULL BOXES

- A. Exterior in-ground pull boxes shall be concrete or polymer as manufactured by Brooks, Dalworth, Hubbell Quazite, or approved equivalent. Covers shall include identification of systems contained.
- B. Where located in Roadways, Parking Lots, or Traffic zones, Pullboxes shall be rated to accept a minimum 22,500 lb. load per ANSI/SCTE 77.
- C. All Pullboxes shall be sized based on NEC wire-bending requirements at each individual location.
- D. Covers shall include identification of systems contained, such as:
 1. Electrical
 2. Telecom
 3. Communications
 4. Others, as required.
- E. Pull boxes in pole bases shall be as manufactured by Carlon.
- F. Pullboxes shall be provided in all raceway systems upon exceeding the following conditions:
 1. The equivalent of 270° in conduit bends, or after (3) 90° bends.
 2. Any 400ft of linear conduit or duct bank continuous segments.
 3. Where required to make transitions to prevent the damaging of conductor insulation.

2.3 WIREWAYS

- A. Wireways shall be made of not less than 16-gauge sheet steel for 4 inch and 6 inch square sizes and 14 gauge steel for 8 inch and 12 inch square sizes. Couplings end plates, and knockouts shall be furnished as required. Each section of wireways shall be rigidly supported.
- B. The finish shall be ANSI-49 gray epoxy paint applied by a cathodic electrode position paint process over a corrosion resistant phosphate preparation for NEMA 1 wireways. Provide galvanized steel for NEMA 3R wireways. NEMA 3R wireways and auxiliary gutters are for horizontal mounting only.

2.4 BUSHINGS

- A. Provide nylon bushing on end of all low voltage cabling system conduits (sleeves, rough-ins, etc.).
- B. Provide Grounding Bushing as required in 26 05 26 - Grounding.

PART 3 - EXECUTION

3.1 PROVIDE CONDUIT AS FOLLOWS:

- A. GENERAL: The Drawings are diagrammatic and are intended to show the general location of outlets, devices, fixtures, and arrangement and control of circuits. The Contractor shall determine exact locations by actual measurement of the building or by reference to the Architectural Drawings.

- B. All wiring shall be installed in galvanized rigid steel, rigid aluminum conduit or electrical steel tube (EMT) unless otherwise noted or specified. Each raceway shall be sized to contain the number of conductors required to comply with the latest edition of NFPA 70. Conduit sizes that are scheduled or shown on the drawings shall take preference.
- C. Raceways shall not be routed below or within slab-on-grade, foundations, or below grade of suspended slab structures, unless specifically noted or indicated otherwise on plan.
- D. EMT in sizes up to 4 inches when concealed or not exposed to damage and located indoors only. (EMT is not acceptable in wet and damp location.)
- E. MINIMUM SIZE: 3/4 inch.
- F. Flexible conduit of any type shall not be used except for connections to rotating or vibrating equipment, or where use for low voltage raceways. All conduit shall be provided as a rigid type conduit for homeruns, runs between termination boxes, outlets, etc.
- G. Fixture whips: Refer to 26 51 19 for additional information.
- H. Of such size, and so installed that conductors may be drawn in without injury or excessive strain.
- I. Where entering panels, pull boxes, junction boxes, or outlet boxes, shall be secured in place with lock nuts inside and outside, and insulated bushings inside.
- J. Have Red seal type VCC or approved equal cable supports in risers, as required by NFPA 70.
- K. Have ends reamed after cutting and application of die.
- L. Keep conduit corked and dry during construction and swab out before conductors are pulled.
- M. Have bends and offsets made with approved tools. Bends or offsets in which the pipe is crushed or deformed shall not be installed.
- N. Have O.Z. Gedney or approved equal expansion fittings where crossing building expansion joints.
- O. Fixtures in finished areas having suspended acoustical ceilings shall be connected to outlet boxes of lighting grid by flexible metal conduit; length not to exceed ten feet (six feet if using 3/8" manufactured fixture "whips").
- P. Outlet boxes in partitions shall never be set back-to-back. They shall be offset to prevent undue noise transmission from room to room.
- Q. Each entire conduit system shall be installed complete before any conductors are drawn in. Every run of conduit shall be finished before covering up to guard against obstructions and omissions.
- R. Sleeves shall be placed in the forms of concrete, masonry and fire rated walls, floor slabs and beams, for the passage of conduits. Sleeves should be set in place a sufficient time ahead of the concrete work so as not to delay the work. Sleeves shall be rigid galvanized steel with a minimum thickness of 1.07MM and set to extend 4" above slab.
- S. All pipe penetrations through walls and concrete floors shall be fire rated by applying USG Thermafiber in the space between the concrete and the pipe. The fire rating shall be additionally sealed by using 3M brand model CP 25 or 303 fire barrier caulk and putty. All fire rating material shall be installed in accordance with manufacturer's printed instructions.
- T. All conduit shall be cleaned and swabbed to remove all foreign matter and moisture prior to pulling wire and cable. All boxes in which conduits terminate shall be cleaned of all concrete mortar and other foreign matter.
- U. Provide #30 nylon pulling line in all conduits in which permanent wiring is not installed.

- V. All conduit shall be securely fastened and supported using hot galvanized malleable iron one-hole pipe straps, clamps, hanger or other means approved by the engineer. Supports shall be as required per NEC. Tie wire shall not be used as support or securing means. Support conduit independently of ceiling hanger wire. Use all thread rods to support outlet boxes, junction boxes and conduit.
- W. Contact the Architect and Engineer for an installation review before covering any below grade or above grade conduit.
- X. All new outlets shall be flush mounted. In remodeled areas where wall construction prohibits flush mounting, provide Hubbell 2400 series, unless noted otherwise. Verify exact location and routing with architect before installation.
- Y. Contractor shall not penetrate waterproof barriers without using proper fitting to maintain barriers. This shall include exterior walls and slabs. Coordinate with Architect for proper methods.

3.2 CONDUIT ROUTING

- A. Conduit shall be concealed and by using the shortest practicable route between outlets, including where located on CMU walls.
- B. Conduit may be exposed in electrical and mechanical rooms, and central plants, or other industrial type facilities such as warehouses or production plants.
- C. Install risers, drops, offsets to avoid ductwork and structural components. Ductwork and structural systems shall take precedence to conduit.
- D. Any exposed and visible conduit shall be parallel and perpendicular based on the lines of the building (such as ceiling lines, wall blocking lines, or architectural feature lines) using structural systems to conceal conduit visibility at all opportunities.
- E. Concealed conduit shall be run in as direct manner as possible, using long bends. All bend radii shall be 12x conduit diameter. Condulets in lieu of elbows where ease of installation and appearance warrant their use – confirmation with architect is required for this use.
- F. Conduit shall be continuous, with no more than (4) quarter bends between terminals, cabinets, boxes, or pullboxes is acceptable. Contractor is expected to provide wireway or boxes at appropriate intervals, in accordance with NFPA 70 for wire bending space. All conduit shall be electrically continuous throughout, including across boxes and cabinets. Terminals of all conduit shall be provided with double lock nuts and bushing, or terminated on conduit hubs. Use of Running Threads prohibited.

3.3 CONDUIT CORROSION PROTECTION

- A. Branch circuit conduits installed in concrete slabs on fill or grade shall be positioned in a manner to ensure complete concrete cover. In no case shall such conduits be exposed below or above the slab surfaces, or penetrate the waterproof membrane.
- B. At locations where metallic conduits pass through slabs on grade or transitions below grade, PVC coated rigid galvanized conduit shall be used.
- C. Conduit installed in the air gap between the water-resistant barrier and finish brick shall not exceed 2-ft. in length.

3.4 EXPANSION JOINTS

- A. Install approved expansion fitting in all conduit runs in excess of 150 feet or when crossing building expansion joints.

3.5 OUTLET AND JUNCTION BOXES

- A. Provide an approved galvanized outlet box with adequate volume for number of conductors installed.

- B. Provide standard galvanized switch boxes of the required number of gangs. Switch boxes where conduit is exposed shall be handy boxes or approved equal.
- C. Outlet boxes for receptacles shall be similar to Universal 52151 with suitable raised cover. Receptacle boxes where conduit is exposed shall be handy boxes or approved equal.
- D. Weatherproof boxes shall be FS or FD. Provide these boxes in all non-conditioned areas, exterior areas and natatoriums.
- E. Outdoor boxes shall be NEMA 3R, with conduit connections made by Myers Hubs.
- F. See notes and details on Drawings for special box requirements.
- G. Provide junction boxes required to facilitate installation of the various conduit systems. Provide support boxes required for risers, each complete with approved cable supports as described elsewhere in this Division.
- H. Outlet boxes for drywall shall be standard galvanized 4" square boxes with the appropriate device cover. Secure all outlet boxes with a backing brace connected to two adjacent studs. Mounting brackets with a single ear to rest against the backing sheet rock are not acceptable.
- I. Provide floor outlet fittings for telephone to match fittings for duplex floor receptacles.
- J. Provide 3-1/2" deep gangable masonry boxes in all masonry wall (CMU). Steel City GW-135-G or approved equal.
- K. Provide shallow 4"x4" boxes in all demountable partitions.
- L. Metallic boxes located in fire rated walls or partitions shall be separated by a minimum horizontal distance of 24 in. This minimum separation distance between metallic boxes may be reduced when "Wall Opening Protective Materials" (CLIV) are installed according to the requirements of their Classification. Metallic boxes shall not be installed on opposite side of walls or partitions of staggered stud construction unless "Wall Opening Protective Materials" are installed with the metallic boxes in accordance with Classification requirements for the protective materials.
- M. Junction, pull boxes, condulets, gutters, disconnects, contactors, etc., above 2-foot x 2-foot grid ceilings shall be mounted within 18-inches of ceiling grid. Above 2-foot x 4-foot grid ceiling they shall be mounted within 30-inches of ceiling grid. All junction box, pull box, gutter openings shall be side or bottom accessible.
- N. Junction boxes are prohibited above drywall or plaster ceilings except for lighting; and those must be mounted directly over light fixture opening. Route power, PA, fire alarm conduits to nearest lay-in ceiling.

3.6 THRU-WALL SEALS

- A. Provide O.Z. Gedney "Thru-wall" seals for all conduits passing through concrete structure below grade, above grade, and floor penetrations below grade. These prevent moisture from entering the building.
- B. Straight sleeves are not acceptable.

3.7 PULL BOXES

- A. Interior Pull boxes shall be provided for conduit systems as required and shall be constructed of galvanized steel of not less than gauge and size specified by National Electrical Code. Size pull boxes per Article 314.28 - NFPA 70.
- B. Where two or more feeders pass through a common pull box, they shall be tagged to indicate clearly their electrical characteristics, circuit number, and panel designation.
- C. Exterior in-ground pull boxes shall have open bottoms with sand and rock beds below box for drainage of water. Provide closed bottom boxes where specified. Closed bottom boxes shall be provided with sumps for portable pump to allow for extracting water. Refer to details on the drawings.

- D. Pull boxes mounted in pole bases shall be coordinated with the pour of the pole base and shall be flush with finished footing.

3.8 WIREWAYS

- A. Wireways shall be installed as indicated or required and locations shall be coordinated with architect.
- B. Wiring in wireways shall be neatly bundled, tied and suitably tagged.

3.9 UNDERGROUND DUCTBANK SYSTEM

A. DUCT SYSTEM

1. The duct system shall consist of Schedule 40 PVC or type 1-EB PVC conduits encased in red concrete as detailed on the drawings. Use rigid conduit for stub-ups and the last ten feet at the end of each ductbank. Duct lines shall be laid to a minimum grade of 4 inches per 100 feet and shall be free from either horizontal or vertical waves. Duct lines shall be straight unless otherwise noted on the drawings. Duct lines shall be installed so that the top of concrete in encased duct lines is not less than 24 inches below finished grade or finished paving at any point. Changes in direction or runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 5 feet. The long sweep bends may be made up of one or more curved or straight sections and/or combinations thereof using five degree angle couplings. Conduit shall be thoroughly cleaned before using or laying. During construction and after the duct line is completed, the ends of the conduit shall be plugged to prevent water washing mud into the conduits. Particular care shall be taken to keep the conduits clean of concrete, dirt, and any other substance during the course of construction.
 2. Each single conduit of the duct bank shall be completely encased in steel reinforced concrete as indicated. The thickness of concrete encasement indicated is the minimum thickness, and may be increased to fit the actual shape of trench.
 3. Concrete for duct bank envelopes shall be standard 2000 psi concrete mix as described in Division 03, and be colored deep red for permanent marking of underground electrical work. The concrete red pigment shall be pure inorganic natural metallic base pigment, approved by the Engineer before use. Organic pigments will not be permitted. The approved pigments shall be mixed four pounds per yard of cement.
 - a. Envelopes may be poured directly against sides of trenches if the "cut" is clean, even and free of loose material. All loose dirt and extraneous material shall be removed from the trenches before and during the pouring of concrete to ensure sound envelopes. Concrete shall be carefully spaded during pouring to eliminate all voids under and between the conduit and honeycombing of the exterior surfaces. Power driven tampers or agitators shall not be used, unless specifically designed for the application, in order to ensure that the watertightness of the conduits is not destroyed.
 - b. Generally, each run of envelopes shall be poured in one continuous operation. Where more than one pour is necessary, each pour shall terminate in a vertical plane. Partial pours shall not terminate in horizontal or angular planes.
- B. For normal underground installation see Section 26 02 00, paragraph 3.1 for Excavating and Backfilling.

END OF SECTION

SECTION 26 05 73
SHORT CIRCUIT COORDINATION STUDY ARC FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 SCOPE

- A. The Contractor shall furnish short-circuit and protective device coordination studies for the electrical power system, including all existing and newly installed electrical equipment. The analysis and study shall include all distribution branches, and begin at the main overcurrent protective device.
- B. Provide a complete short circuit study, equipment interrupting or withstand evaluation, and protective device coordination study for the power distribution system. Normal operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly addressed in the study. The study shall assume all motors operating at rated voltage and speed. Electrical equipment bus impedance shall be assumed as zero. Short circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at the switchboard busses and motor control centers (where installed).
- C. A protective device coordination study shall be performed to determine appropriate relay settings. The study shall include all distribution switchboards, motor control centers (where installed, and panel board main circuit breakers. Panel board branch circuit devices need not be considered. The phase over current and ground fault protection shall be included as well as setting for all other adjustable protective devices.
- D. An equipment evaluation study shall be performed to determine the adequacy of circuit breakers, controllers, surge arresters, busways, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents.
- E. Any problem areas or inadequacies shall be promptly brought to the ENGINEERS attention.
- F. The Contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Annex D.

1.2 REFERENCES

- A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1. IEEE 141 - Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
 - 2. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
 - 3. IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis
 - 4. IEEE 241 - Recommended Practice for Electric Power Systems in Commercial Buildings
 - 5. IEEE 1015 - Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
 - 6. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations
- B. American National Standards Institute (ANSI):
 - 1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
 - 2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures

3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.
- C. The National Fire Protection Association (NFPA)
 1. NFPA 70 - National Electrical Code, latest edition
 2. NFPA 70E - Standard for Electrical Safety in the Workplace

1.3 SUBMITTALS FOR REVIEW/APPROVAL

- A. The short-circuit and protective device coordination studies shall be submitted to the design Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1.4 SUBMITTALS FOR CONSTRUCTION

- A. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies, where required, shall be provided on CD in PDF format.
- B. The report shall include the following sections:
 1. One-line diagram
 2. Descriptions, purpose, basis and scope of the study
 3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties
 4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
 5. Fault current calculations including a definition of terms and guide for interpretation of the computer printout
 6. Incident energy and flash protection boundary calculations
 7. Recommendations for system improvements, where needed
 8. Executive Summary.
 9. Equipment manufacturer's information used to prepare study
 10. Assumptions made during study.

1.5 QUALIFICATIONS

- A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the Engineering Services Organization.

PART 2 - PRODUCT

2.1 DATA COLLECTION

- A. The Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
- B. Source combination may include present and future motors and generators.
- C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor.
- D. Include fault contribution of existing motors in the study, with motors <100 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.2 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

- A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE 141.
- B. Transformer design impedances shall be used when test impedances are not available.
- C. Provide the following:
 - 1. Calculation methods and assumptions
 - 2. Selected base per unit quantities
 - 3. One-line diagram of the system being evaluated
 - 4. Source impedance data, including electric utility system and motor fault contribution characteristics
 - 5. Typical calculations
 - 6. Tabulations of calculated quantities
 - 7. Results, conclusions, and recommendations.
- D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:
 - 1. Electric utility's supply termination point
 - 2. Incoming switchgear
 - 3. Low voltage switchgear
 - 4. Motor control centers
 - 5. Branch circuit panelboards
 - 6. Other significant locations throughout the system.
- E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.
- F. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short circuit ratings
 - 2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
 - 3. Adequacy of transformer windings to withstand short-circuit stresses
 - 4. Cable and busway sizes for ability to withstand short-circuit heating
 - 5. Notify Owner in writing of any new or existing circuit protective devices improperly rated for the calculated available fault current.

2.3 PROTECTIVE DEVICE COORDINATION STUDY

- A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.
- B. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.
- C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
- D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
- E. Plot the following characteristics on the curve sheets, where applicable for this project:
 - 1. Electric utility's protective device
 - 2. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
 - 3. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
 - 4. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
 - 5. Conductor damage curves
 - 6. Ground fault protective devices, as applicable
 - 7. Pertinent motor starting characteristics and motor damage points
 - 8. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center.
- F. Provide time margins between device characteristics per the following requirements such that selective coordination is provided. Selective coordination shall be proven with a coordination study provided by the equipment manufacturer with the use of time current curves, or manufacturers' selective coordination tables, or both.
 - 1. Emergency (NEC Article 700) - all currents, all times
 - 2. Legally Required Stand-by (NEC Article 701) - all currents, all times
 - 3. Elevator Systems (NEC Article 620) - all currents, all times
 - 4. Health Care Essential Electrical Systems (NEC Article 517)
 - a. Equipment Branch - 0.10 seconds
 - b. Critical Branch - 0.10 seconds
 - c. Life Safety Branch - 0.10 seconds

2.4 ARC FLASH HAZARD ANALYSIS

- A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA 70E, Annex D.
- B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.
- C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.
- D. The Arc-Flash Hazard Analysis shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 75 kVA.
- E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm².

- F. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- G. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.
- H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584 section B.1.2.

2.5 REPORT SECTIONS

- A. Input Data:
 - 1. Short-circuit reactance of rotating machines
 - 2. Cable and conduit materials
 - 3. Transformers
 - 4. Circuit resistance and reactive values.
- B. Short-Circuit Data:
 - 1. Source fault impedance and generator contributions
 - 2. X to R ratios
 - 3. Asymmetry factors
 - 4. Motor contributions
 - 5. Short circuit kVA
 - 6. Symmetrical and asymmetrical fault currents.
- C. Recommended Protective Device Settings:
 - 1. Phase and Ground Relays:
 - a. Current transformer ratio
 - b. Current setting
 - c. Time setting
 - d. Instantaneous setting
 - e. Specialty non-overcurrent device settings
 - f. Recommendations on improved relaying systems, if applicable
 - 2. Circuit Breakers:
 - a. Adjustable pickups and time delays (long time, short time, ground)
 - b. Adjustable time-current characteristic
 - c. Adjustable instantaneous pickup
 - d. Recommendations on improved trip systems, if applicable.
- D. Incident energy and flash protection boundary calculations
 - 1. Arcing fault magnitude
 - 2. Device clearing time
 - 3. Duration of arc
 - 4. Arc flash boundary
 - 5. Working distance
 - 6. Incident energy
 - 7. Hazard Risk Category
 - 8. Recommendations for arc flash energy reduction

PART 3 - EXECUTION

3.1 FIELD ADJUSTMENT

- A. The Contractor shall adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- 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.
- D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

3.2 ARC FLASH WARNING LABELS

- A. The vendor shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.
- B. The label shall have an orange header with the wording, "WARNING, ARC FLASH HAZARD", and shall include the following information:
 - 1. Location designation
 - 2. Nominal voltage
 - 3. Flash protection boundary
 - 4. Hazard risk category
 - 5. Incident energy
 - 6. Working distance
 - 7. Engineering report number, revision number and issue date.
- C. Labels shall be machine printed, with no field markings.
- D. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
 - 1. For each 600, 480 and applicable 208 volt panelboards, one arc flash label shall be provided.
 - 2. For each motor control center, one arc flash label shall be provided.
 - 3. For each low voltage switchboard, one arc flash label shall be provided.
- E. Labels shall be field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

3.3 ARC FLASH TRAINING

- A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E shall be provided in the equipment manuals. The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET).

END OF SECTION

SECTION 26 06 34
LOW VOLTAGE RACEWAY SYSTEM

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

1.2 WORK INCLUDED

- A. Provide a complete raceway system for telephone system, consisting of cabinets, conduit, junction boxes, etc. This shall include but not limited to fire alarm, access control, structured cabling, audio-video, intercommunications, sound reinforcing, intrusion detection, telephone.

1.3 WORK SPECIFIED ELSEWHERE

- A. Section 26 02 00 - Basic Materials and Methods for Electrical
- B. Section 26 05 33 - Raceways
- C. Section 26 05 19 - Wire, Cable and Related Materials

1.4 WORK NOT INCLUDED

- A. Cabling
- B. Equipment
- C. Division 27
- D. Division 28

PART 2 - PRODUCTS

2.1 COMPONENTS

- A. Conduit - Refer to Section 26 05 33.
- B. Backboards - 3/4" X 4' X 8' fire rated plywood painted white.
- C. Outlet Boxes - Refer to Section 26 05 33.
- D. Pull and junction boxes - Refer to Section 26 05 33.
- E. Floor Boxes - Refer to Section 26 05 33.
- F. Cabinets - Consult low voltage system installer/supplier.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Section 26 05 33 for underground service entrance.
- B. Provide pull boxes in telephone conduit runs spaced not greater than 100 ft. apart, and on backboard side of runs with more than two right angle bends.
- C. Place telephone label on pull and junction boxes.
- D. Provide pull wire in each telephone run.
- E. Provide plywood backboards and duplex receptacle in the telephone equipment room. Confirm location on jobsite prior to installation.
- F. All terminal cabinets/backboards and conduit shall be sized per the recommendations of the telephone system installer.

END OF SECTION

SECTION 26 09 13
ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SCOPE

- A. Provide quantity of monitoring devices as shown on drawings.
- B. Monitoring devices shall include all necessary accessories to be fully functional as described by this specification.
- C. Devices shall be UL listed and CE marked.

1.2 REFERENCE STANDARDS

- A. ANSI C12.1 - Electric Meters - Code for Electricity Metering.
- B. ANSI C12.20 - American National Standard for Electricity Meters - 0.2 and 0.5 Accuracy Classes.
- C. IEC 62053-22 - Electricity Metering Equipment - Particular Requirements - Part 22: Static Meters for AC Active Energy (Classes 0,1S,0,2S and 0,5S).
- D. IEEE C37.90.1 - IEEE Standard for Relays, Relay Systems, and Control Devices Used for Protection and Control of Electric Power Apparatus--Surge Withstand Capability (SWC) and Electrical Fast Transient (EFT) Requirements and Tests.

1.3 ACCEPTABLE MANUFACTURERS

- A. Electro Industries/GaugeTech
- B. Schneider Electric
- C. Eaton
- D. ABB
- E. Leviton
- F. Siemens

1.4 SUBMITTALS

- A. Shop drawings shall include, but not be limited to:
 - 1. Cutsheets of devices with ratings, physical dimensions and all accessories clearly labeled.
 - 2. Device labels shall be clearly indicated in cutsheets.
 - 3. All standards and listings shall be clearly labeled in cutsheets provided.
 - 4. Cutsheets shall clearly outline that design requirements of this specification have been met.

1.5 WARRANTY

- A. Provide a 4 year warranty on devices.

PART 2 - PRODUCTS

2.1 IMPLEMENTATION

- A. Equipment shall be a combination of single-phase, three-phase, and/or multipoint metering assemblies as required to meet the performance of this specification and quantities indicated on plans.
- B. Provide enclosures as required by manufacturer.

2.2 DESIGN

- A. Power meter shall be designed for Multifunction Electrical Measurement on 3 phase power systems.
 - 1. Meter shall support 3 element Wye, 2.5 element Wye, 2 element Delta, 4 wire Delta systems.
 - 2. The meter shall accept universal voltage input.
 - 3. Surge withstand shall conform to IEEE C37.90.1.
 - 4. The meter shall be user programmable for voltage range to any PT ratio.
 - 5. Meter shall accept a burden of up to 0.36VA per phase, Max at 600V, 0.014VA at 120 Volts.
 - 6. The meter shall accept a voltage input range of up to 416 Volts Line to Neutral, and a range of up to 721 Volts Line to Line.
 - 7. Meter shall accept a current reading of up to 11 Amps continuous.
- B. The meter shall include a three line, 0.56" LED display.
 - 1. The meter shall fit in both DIN 92mm and ANSI C39.1 Round cut-outs.
 - 2. The meter must display a % of Load Bar on the front panel to provide an analog feel. The % Load bar shall have not less than 10 segments.
- C. The meter shall support power supply of 90 to 265 Volts AC and 100 to 370 Volts DC. Universal AC/DC Supply shall be available.
 - 1. Meter power supply shall accept burden of 10VA max.
 - 2. Meter shall provide upgrade rate of 100msec for Watts, Var and VA. All other parameters shall be 1 second
- D. Meter shall be available in transducer only version, which shall not include a display. The meter shall mount directly to a DIN rail.

2.3 OPERATION

- A. Power meter shall use a dual input method for current inputs. Method one shall allow the CT to pass directly through the meter without any physical termination on the meter, ensuring the meter cannot be a point of failure on the CT circuit. The second method shall provide additional termination pass-through bars, allowing the CT leads to be terminated on the meter. The meter must support both termination methods.
 - 1. Fault Current Withstand shall be 100 Amps for 10 seconds, 300 Amps for 3 seconds, and 500 Amps for 1 second.
 - 2. Meter shall be programmable for current to any CT ratio. DIP switches or other fixed ratios shall not be acceptable
 - 3. Meter shall accept burden of 0.005VA per phase, Max at 11 Amps.
 - 4. Meter shall begin reading at a 5mA pickup current.
 - 5. Pass through wire gauge dimension of 0.177" / 4.5 mm shall be available.
 - 6. All inputs and outputs shall be galvanically isolated to 2500 Volts AC.
 - 7. The meter shall accept current inputs of class 10: (0 to 11) A, 5 Amp Nominal, and class 2 (0 to 2) A, 1A Nominal Secondary.

2.4 ACCURACY REQUIREMENTS

- A. The meter shall have an accuracy of +/- 0.1% or better for volts and amps, and 0.2% for power and energy functions. The meter shall meet the accuracy requirements of IEC 62053-22 and ANSI C12.1.
 - 1. The meter shall provide true RMS measurements of voltage, phase to neutral and phase to phase; current, per phase and neutral.
 - 2. The meter shall provide sampling at 400+ samples per cycle on all channels measured readings simultaneously.
 - 3. The meter shall utilize 24 bit Analog to Digital conversion.

4. Meter shall provide Harmonics %THD (% of total Harmonic Distortion).
- B. Meter shall be a traceable revenue meter, which shall contain a utility grade test pulse allowing power providers to verify and confirm that the meter is performing to its rated accuracy.

2.5 STANDARD FEATURES

- A. The meter shall include 2 independent communications ports on the back and face plate, with advanced features.
 1. One port, through backplate, shall be an RJ45 port, providing 100BaseT Ethernet communication speaking BACnet/IP protocol and Modbus TCP, and a Web server.
 2. The meter shall provide an optical IrDA port (through faceplate), as the second communication port, which shall allow the unit to be set up and programmed using a remote laptop PC without need for a communication cable.
- B. The meter shall provide user configured fixed window or rolling window demand. This shall allow user to set up the particular utility demand profile.
 1. Readings for kW, kVAR, kVA and PF shall be calculated using utility demand features.
 2. All other parameters shall offer max and min capability over the user selectable averaging period.
 3. Voltage shall provide an instantaneous max and min reading displaying the highest surge and lowest sag seen by the meter.
- C. The meter shall have native BACnet/IP protocol.
 1. The meter shall provide 40 embedded BACnet Objects consisting of standard voltage, current, and power parameters. The Objects shall be named such that they can be readily identified.
 2. The meter shall have an embedded Web interface for configuration and viewing.
 - a. The Web interface shall have a Home page with power and energy snapshot information.
 - b. The Web interface shall have a page for configuring the BACnet/IP settings, including IP address, Network mask, Default Gateway, and the like.
 - c. The Web interface shall allow the user to activate the new configuration and reboot the meter.
 - d. The Web interface shall have a feature that lets the user download BACnet Object data as a .csv file that can be viewed in MS Excel© or saved as an MS Excel© file.
 - e. The Web interface shall have a webpage that displays the BACnet objects, their readings, and information about the objects.
 - f. The Web interface shall have a webpage displaying statistics for the unit, e.g., the number of meter reboots, and the number of BACnet/IP packets sent and received.
 - g. The Web interface shall allow the user to discard any changes and return to the saved configuration, or return to the factory default configuration.
 - h. The Web interface shall be viewable with any standard Internet browser.
 3. The meter shall be configurable on the Host PC through LAN configuration.
 4. The meter's BACnet/IP shall integrate with any BACnet applications or servers.
 5. The meter shall also have an open socket for Modbus TCP that shall be simultaneously available through the LAN interface.

2.6 ENVIRONMENTAL REQUIREMENTS

- A. Power meter shall be able to be stored in (-20 to +70) degrees C.
- B. Operating temperature shall be (-20 to +70) degrees C.

2.7 FEATURES FOR ENERGY CODE COMPLIANCE

- A. Provide meters to monitor, store and report energy data for each end-use category prescribed in energy code.
 - 1. Provide meters with CT's installed on load side of branch circuit breakers. Where load categories are aggregated on a panelboard/switchboard basis and indicated as such on the drawings, meters and CT's can be installed at feeders in lieu of branch circuits.
 - 2. 100mA CT's, rated 600V rigidly mounted external to branch breakers
 - 3. 1% accuracy or better meters in accordance with ANSI C12.20 with the following readings:
 - a. Voltage; phase-phase, phase-neutral
 - b. Current; per phase
 - c. Active, reactive and apparent power; per phase and total
 - d. Frequency
 - e. Phase angle
 - f. Current demand; per phase and total
 - g. Maximum values and average values; voltage, current, kWActive, reactive and apparent energy
 - h. Active, reactive and apparent energy
 - 4. Controller: mounted internal to panelboard/switchboard or external enclosure with the following features:
 - a. Built-in webpage
 - b. Inputs for up to 45 single phase meters
 - c. Two digital inputs to allow data from other metering devices such as gas and water on metered network
 - d. Provides single slave communication address for entire panel/switchboard
 - e. Communication protocols: Modbus RTU, Pulse I/O and Modbus TCP/IP or Bacnet/IP
 - f. Communication to on-site Data Collection Unit (DCU) or EPMS software via communication network infrastructure.
 - 5. Provide a data acquisition system in accordance energy code. Data acquisition system shall consist of an on-site computer with EPMS software or on-site Data Collection Unit to store metered data for a minimum of 36 months. Provide a stand-alone data acquisition system where data integration is not accomplished via energy management and control system (EMCS).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide 6x6x6 NEMA 1 enclosure for meters that are not mounted within electrical gear enclosures.
- B. Provide start-up/commissioning by factory representative. Start-up/commissioning shall be coordinated with Engineer or Owner's representative so they may observe.
- C. All metering equipment shall be installed in the electrical room of the equipment being metered.

3.2 OPERATIONS PERSONNEL TRAINING

- A. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:

1. Purpose of equipment.
2. Principle of how the equipment works.
3. Important parts and assemblies.
4. How the equipment achieves its purpose and necessary operating conditions.
5. Most likely failure modes, causes and corrections.
6. On site demonstration.

END OF SECTION

SECTION 26 09 43 NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SCOPE

- A. Contractor shall provide complete networked lighting control system that controls all interior and exterior lighting fixtures, including emergency fixtures. All lighting fixtures shall be controllable from the district energy management office. It is the contractor's responsibility to provide and install a complete and functional system, including, but not limited to all room controllers, occupancy sensors, low voltage control stations, emergency bypass controllers, and network bridges, low voltage control cable and lighting network equipment, even if not specifically called out on the plans.
- B. To Establish equivalent performance, all references in this specification are to products manufactured by Wattstopper. Other Manufacturers are acceptable as listed below.

1.2 SUMMARY

- A. Section Includes:
 - 1. Digital Occupancy and Daylighting Sensor Control
 - 2. Emergency Lighting Control
 - 3. Control Intent - Control Intent includes, but is not limited to:
 - a. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
 - b. Initial sensor and switching zones
 - c. Initial time switch settings
 - d. Task lighting and receptacle controls
 - e. Emergency Lighting control

1.3 RELATED SECTIONS

- A. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section
- B. Section 26 02 00 - Basic Materials and Methods for Electrical
- C. Section 26 05 19 - Wire, Cable and Related Materials
- D. Section 26 27 26 - Wiring Devices
- E. Section 26 29 26 - Miscellaneous Electrical Controls and Wiring
- F. Section 26 51 19 - Lighting Fixtures - Light Emitting Diode (LED)
- G. Section 25000 - Integrated Automation Building integrator shall provide integration of the lighting control system with Building Automation Systems.

1.4 REFERENCES

- A. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- B. ICC (IECC) - International Energy Conservation Code.
- C. NFPA 70 - National Electrical Code.
- D. UL 924 - Emergency Lighting and Power Equipment.

1.5 SYSTEM DESCRIPTION & OPERATION

- A. The Lighting Control and Automation system as defined under this section covers the following equipment:

1. Digital Room Controllers - Self-configuring, digitally addressable one, two or three relays controllers with integral current thyristor, 0-10 volt control for ballasts (if applicable).
 2. Digital Occupancy Sensors - Self-configuring, digitally addressable and calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.
 3. Digital Switches - Self-configuring, digitally addressable pushbutton switches, dimmers, and scene switches with two-way active infrared (IR) communications.
 4. Digital Photosensors - Single-zone closed loop and multi-zone open loop daylighting sensors with two-way active infrared (IR) communications can provide switching or dimming control for daylight harvesting.
 5. Configuration Tools - Handheld remote for room configuration provides two way infrared (IR) communications to digital devices and allows complete configuration and reconfiguration of the device / room from up to 30 feet away. Unit to have Organic LED display, simple pushbutton interface, and allow send and receive of room variables and store of occupancy sensor settings. Computer software also customizes room settings.
 6. Handheld remotes for personal control - One-button dimming, two-button on/off, or five-button scene remotes provide control using infrared communications. Remote may be configured in the field to control selected loads or scenes without special tools.
 7. Digital Lighting Management (DLM) local network - Free topology, plug-in wiring system (Cat 5e) for power and data to room devices.
 8. Network Bridge - provides BACnet MS/TP-compliant digital networked communication between rooms, panels and the Segment Manager or building automation system (BAS).
 9. Segment Manager - provides web browser-based user interface for system control, scheduling, power monitoring, room device parameter administration and reporting.
 10. Emergency Lighting Control Unit (ELCU) - allows a standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building.
 11. System shall conform to requirements of NFPA 70.
- B. Lighting control system shall be configured to fail "on".

1.6 SUBMITTALS

- A. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.
- B. Shop Drawings:
 1. Composite wiring and/or schematic diagram of each control circuit as proposed to be installed (standard diagrams will not be accepted).
 2. Scale drawing for each area showing exact location of each sensor, room controller, and digital switch.
- C. Product Data: Catalog sheets, specifications and installation instructions.
- D. Include data for each device which:
 1. Indicates where sensor is proposed to be installed.
 2. Prove that the sensor is suitable for the proposed application.

1.7 QUALITY ASSURANCE

- A. Manufacturer: Minimum 10 years experience in manufacture of lighting controls.

- B. Lighting controls shall meet the minimum requirements of ICC (IECC) and ASHRAE Std 90.1 I-P as applicable.

1.8 PROJECT CONDITIONS

- A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
 - 1. Ambient temperature: 0° to 40° C (32° to 104° F).
 - 2. Relative humidity: Maximum 90 percent, non-condensing.

1.9 WARRANTY

- A. Provide a five year complete manufacturer's warranty on all products to be free of manufacturers' defects.

1.10 MAINTENANCE

- A. Spare Parts:
 - 1. Provide 1 spare LMSM-603. Provide 5 spares of each product listed below to be used for maintenance. Electrical contractor deliver items to maintenance department within 30 days of substantial completion.
 - a. Room Controllers
 - b. Occupancy Sensors
 - c. Emergency Bypass controllers
 - d. Low voltage switches
 - e. Daylighting harvesting photocells

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. WattStopper
- B. Acuity Brands
- C. Cooper/Eaton/Greengate

2.2 WALL SWITCH OCCUPANCY SENSORS

- A. Type DW: Manual-ON, Automatic-OFF dual technology (passive infrared and ultrasonic) wall switch occupancy sensor. Furnish the Company's model which suits the electrical system parameters, and accommodates the square-foot coverage and wattage requirement for each area (and type of lighting) controlled; WattStopper LMDW-101 or LMDW-102

2.3 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR SYSTEM

- A. Ceiling mounted (to suit installation) passive infrared (PIR), ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor. Furnish the Company's system which accommodates the square-foot coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors and accessories which suit the lighting and electrical system parameters. Passive infrared only sensors shall not be used for classroom applications.
- B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:
 - 1. Digital calibration and pushbutton programming for the following variables:
 - a. Sensitivity - 0-100% in 10% increments
 - b. Time delay - 1-30 minutes in 1 minute increments
 - c. Test mode - Five second time delay

- d. Detection technology - PIR, Ultrasonic or Dual Technology activation and/or re-activation.
 - e. Walk-through mode
 - f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
- 2. One or two RJ-45 port(s) for connection to DLM local network.
- 3. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.
- 4. Device Status LEDs including:
 - a. PIR Detection
 - b. Ultrasonic detection
 - c. Configuration mode
 - d. Load binding
- 5. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.
- 6. Manual override of controlled loads.
- C. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.
- D. All devices shall be hard wired. No wireless devices shall be permitted.
- E. WattStopper product numbers: LMPX, LMDX, LMPC, LMUC, LMDC

2.4 DIGITAL WALL SWITCHES

- A. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration; available in white, light almond, ivory, grey and black; compatible with wall plates with decorator opening.
- B. Wall switches shall include the following features:
 - 1. Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
 - 2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
 - 3. Red configuration LED on each switch that blinks to indicate data transmission.
 - 4. Blue Load/Scene Status LED on each switch button with the following characteristics:
 - a. Bi-level LED
 - b. Dim locator level indicates power to switch
 - c. Bright status level indicates that load or scene is active
 - 5. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.
- C. Two RJ-45 ports for connection to DLM local network.
- D. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required to achieve multi-way switching.
- E. The following switch attributes may be changed or selected using a wireless configuration tool:
 - 1. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
 - 2. Individual button function may be configured to Toggle, On only or Off only.
 - 3. Individual scenes may be locked to prevent unauthorized change.
 - 4. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.

5. Ramp rate may be adjusted for each dimmer switch.
6. Switch buttons may be bound to any load on a room controller and are not load type dependent; each button may be bound to multiple loads.
- F. WattStopper product numbers: LMSW-101, LMSW-102, LMSW-103, LMSW-104, LMSW-105, LMSW-108, LMDM-101.

2.5 ROOM CONTROLLERS

- A. Room Controllers automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room Controllers shall be provided to match the room lighting load and control requirements. The controllers will be simple to install and will not have, dip switches, potentiometers or require special configuration.
- B. The control units will include the following features:
 1. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
 2. Simple replacement - Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf unit without requiring any configuration or setup.
 3. Device Status LEDs to indicate:
 - a. Data transmission
 - b. Device has power
 - c. Status for each load
 - d. Configuration status
 4. Quick installation features including:
 - a. Standard junction box mounting
 - b. Quick low voltage connections using standard RJ-45 patch cable
 5. Plenum rated
 6. Manual override and LED indication for each load
 7. Dual voltage (120/277 VAC, 60 Hz)
 8. Zero cross circuitry for each load.
- C. On/Off/Dimming enhanced Room Controllers shall include:
 1. Real time current monitoring
 2. One, two or three relay configuration
 3. Efficient 250 mA switching power supply
 4. Four RJ-45 DLM local network ports.
 5. One 0-10 volt analog output per relay for control of compatible ballasts and LED drivers.
 6. The following dimming attributes may be changed or selected using a wireless configuration tool:
 - a. Establish preset level for each load from 0-100%
 - b. Set high and low trim for each load
 - c. Set lamp burn in time for each load up to 100 hours
 7. Discrete model listed for connection to receptacles, for occupancy-based control of plug loads within the space.
 - a. One relay configuration only
 - b. Automatic-ON/OFF configuration
 8. WattStopper product numbers: LMRC-211, LMRC-212, LMRC-213, LMRC- 221, LMRC-222, LMPL-201

2.6 DIGITAL PHOTOSENSORS

- A. Digital photosensors work with room controllers to provide automatic switching or dimming daylight harvesting capabilities for any load type connected to a room controller. Closed loop photosensors measure the ambient light in the space and control a single lighting zone. Open loop photosensors measure incoming daylight in the space, and are capable of controlling up to three lighting zones. Photosensors shall be interchangeable without the need for rewiring.
- B. Digital photosensors include the following features:
 - 1. An internal photodiode that measures only within the visible spectrum, and has a response curve that closely matches the photopic curve. The photodiode shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5% for any wavelengths less than 400 nanometers or greater than 700 nanometers.
 - 2. Sensor light level range shall be from 1-10,000 footcandles (fc).
 - 3. The capability of switching one-third, one-half or all lighting ON and OFF, or raising or lowering lighting levels, for each controlled zone, depending on the selection of room controller(s) and load binding to room controller(s).
 - 4. For switching daylight harvesting, the photosensor shall provide a deadband or a separation between the "ON Setpoint" and the "OFF Setpoint" that will prevent the lights from cycling after they turn off.
 - 5. For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a user-selectable minimum level.
 - 6. Optional programmable wall switch override to allow occupants to reduce lighting level to increase energy savings or, if permitted by system administrator, raise and lower lighting levels for a selected period of time or cycle of occupancy.
 - 7. Infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool, and for communication with personal remote controls.
 - 8. Red configuration LED that blinks to indicate data transmission.
 - 9. Blue status LED indicates test mode, override mode and load binding.
 - 10. Recessed switch to turn controlled load(s) ON and OFF.
 - 11. One RJ-45 port for connection to DLM local network.
 - 12. An adjustable head and a mounting bracket to accommodate multiple mounting methods and building materials. The photosensor may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox.
- C. Closed loop digital photosensors include the following additional features:
 - 1. An internal photodiode that measures light in a 100 degree angle, cutting off the unwanted light from bright sources outside of this cone.
 - 2. Automatic self-calibration, initiated from the photosensor, a wireless configuration tool or a PC with appropriate software.
 - 3. Automatically establishes setpoints following self-calibration.
 - 4. A sliding setpoint control algorithm for dimming daylight harvesting with a "Day Setpoint" and the "Night Setpoint" to prevent the lights from cycling.
 - 5. WattStopper Product Number: LMLS-400.
- D. Open loop digital photosensors include the following additional features:
 - 1. An internal photodiode that measures light in a 60 degree angle cutting off the unwanted light from the interior of the room.
 - 2. Automatically establishes setpoints following calibration using a wireless configuration tool or a PC with appropriate software.

3. A proportional control algorithm for dimming daylight harvesting with a "Setpoint" to be maintained during operation.
4. WattStopper Product Number: LMLS-500.

2.7 EMERGENCY LIGHTING

- A. Emergency Lighting Control Unit - A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:
 1. 120/277 volts, 50/60 Hz., 20 amp ballast rating
 2. Push to test button
 3. Auxiliary contact for remote test.
- B. WattStopper Product Numbers: ELCU-100, ELCU-200.

2.8 ROOM NETWORK (DLM LOCAL NETWORK)

- A. The DLM local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building. Digital room devices connect to the network using CAT 5e cables with RJ-45 connectors which provide both data and power to room devices. Features of the DLM local network include:
 1. Plug n' Go automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
 2. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
 3. Push n' Learn configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
 4. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

2.9 BACNET BASED DIGITAL COMMUNICATIONS

- A. The lighting control panel shall support digital communications to facilitate the extension of control to include interoperation with building automation systems and other intelligent field devices. Digital communications shall be RS485 master/slave token passing-based using the BACnet® protocol.
- B. The panel shall have provision for an individual BACnet device ID. The device ID description property shall be writable via the network to allow unique identification of the lighting control panel on the network.
- C. The panel shall support MS/TP MAC addresses in the range of 0 - 127 and baud rates of 9600k, 38400k, 76800k, and 115.2k bits per second.
- D. Lighting control relays shall be controllable as binary output objects in the instance range of 1 - 64. The state of each relay shall be readable and writable by the BAS via the object present value property
- E. Lighting control relays shall report their true on/off state as binary input objects in the instance range of 1 - 64.

- F. The 99 channel groups associated with the panel shall be represented by binary value objects in the instance range of 201 - 299. The occupancy state of each channel group shall be readable and writable by the BAS via the object present value property. Commanding 1 to a channel group will put all relays associated with the channel into the normal hours mode. Commanding 0 or NULL shall put the relays into the after hours mode.
- G. Setup and commissioning of the panel shall not require manufacturer-specific software or a computer. All configuration of the lighting control panel shall be performed using standard BACnet objects or via the handheld IR programming remote. Provide BACnet objects for panel setup and control as follows:
 - 1. Binary output objects in the instance range of 1 - 64 (one per relay) for on/off control of relays.
 - 2. Binary value objects in the instance range of 1 - 99 (one per channel) for normal hours/after hours schedule control.
 - 3. Binary input objects in the instance range of 1 - 64 (one per relay) for reading true on/off state of the relays.
 - 4. Analog value objects in the instance range of 1 - 64 (one per relay) shall assign relays to channel groups in the range of 1 - 99.
 - 5. Analog value objects in the instance range of 101 - 199 (one per channel group) shall assign a blink warn time value to each channel. A value of 5 shall activate the blink warn feature for the channel and set a 5-minute gracetime period. A value of 250 shall activate the sweep feature for the channel and enable the use of sweep type automatic wall switches.
 - 6. Analog value objects in the instance range of 201 - 299 (one per channel) shall assign an after hours time delay value to the channel in the range of 1 - 240 minutes.
 - 7. Multi-state value objects in the instance range of 1 - 99 (one per channel) shall provide the state of the relays assigned to the channel. Valid states shall be ALL ON, MIXED, BLINK, and ALL OFF.
- H. The description property for all objects shall be writable via the network and shall be saved in non-volatile memory within the panel.
- I. The BO and BV 1 - 99 objects shall support BACnet priority array with a relinquish default of off and after hours respectively. Prioritized writes to the channel BV objects shall propagate prioritized control to each member relay in a way analogous to the BACnet Channel object described in addendum aa. (<http://www.bacnet.org/Addenda/Add-135-2010aa.pdf>)
- J. Panel-aggregate control of relay Force Off at priority 2 shall be available via a single BV5 object. Force On at priority 1 shall be available via a single BV4 object.
- K. Lockout of all digital switch buttons connected to a given panel shall be command-able via a single BV2 object. The lock status of any connected switch station shall be represented as BV101-196.
- L. Lighting control accessory devices connected to the panel shall be represented via BACnet objects including but not limited to the following:
 - 1. Digital occupancy sensor detection states shall be readable as BI objects ranging from BI1-96.
 - 2. Digital occupancy sensor configuration parameters shall each be accessible as BACnet objects when applicable to a given product.
 - a. Occupancy sensor time delay in minutes shall be writeable via AV101-196.
 - b. Occupancy sensor passive infrared (PIR) sensitivity percentage shall be writeable via AV201-296.

- c. Occupancy sensor ultrasonic (US) sensitivity percentage shall be writeable via AV301-396.
- 3. Digital switch buttons shall be readable and writeable as BI objects ranging from BI101 - 9608.
- 4. Digital daylight sensors foot-candle readings shall be readable as follows:
 - a. Analog 0-5V/0-10V sensors connected to a digital input module shall be represented as AI1-96.
 - b. Digital closed loop sensors shall be represented as AI4001-4096.
 - c. Digital open loop sensors shall be represented as AI5001-5096.
 - d. Digital dual loop sensors shall be represented as follows:
 - 1) The upward facing open loop sensor shall be represented as AI6001-6096.
 - 2) The downward facing closed loop sensor shall be represented as AI6101-6196.
- 5. Digital daylight sensor configuration shall be exposed as BACnet objects as follows:
 - a. Digital closed loop sensors shall be represented as follows:
 - 1) Daylight Sensor Day Setpoint (ftcd) AV4201-4296.
 - 2) Daylight Sensor Night Setpoint (ftcd) AV4301-4396.
 - 3) Daylight Sensor Off Setpoint Delay (minutes) AV4401-4496.
 - 4) Daylight Sensor On Setpoint (ftcd) AV4501-4596.
 - 5) Daylight Sensor Off Setpoint (ftcd) AV4601-4696.

2.10 USER INTERFACE

- A. Each lighting control panel system shall be supplied with at least (1) handheld IR remote programming interface consisting of a keypad and associated OLED display screen. The user interface shall allow setup, configuration, and diagnostics of the panel without the need for software or connection of a computer. The user interface shall have the following functions as a minimum:
- B. Set network parameters including panel device ID, MS/TP MAC address, baud rate and max master range.
- C. Relay Group creation of up to 99 groups. Group creation shall result in programming of all seven key relay parameters for member relays. The seven parameters are as follows: After-hours Override Time Delay, Normal Hours Override Time Delay, Action on Transition to Normal Hours, Action on Transition to After Hours, Sensor Action During Normal Hours, Sensor Action During After Hours, Blink-Warn Time for After Hours.
- D. Program up to 254 separate scheduled events. Events shall occur on seven (7) day intervals with each day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays. Holidays are also defined through the User Interface.
- E. Program up to 32 separate Dark/Light events. Events shall have a selectable source as either calculated Astro with delay, or a digital IO module with an integral 0-5V or 0-10V analog photocell. Dark/Light events shall occur on seven (7) day intervals with each day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays.
- F. Button binding of digital switches to groups shall be accessible via the handheld IR remote and accomplished from the digital switch station.
- G. Programming of panel location information shall be accomplished by the handheld IR remote and include at a minimum LAT, LON, DST zone, and an approximate city/state location.

- H. An additional handheld IR remote may optionally be specified to be permanently mounted to the panel interior via a retractable anti-theft lanyard to allow for convenient programming of the panel while assuring that the handheld programmer is always present at that panel. An unlimited number of handheld IR remotes may also be purchased for facilities staff as seen fit by the end user's representative.

2.11 CONFIGURATIONS TOOLS

- A. A configuration tool facilitates optional customization of DLM local networks and is used to setup open loop daylighting sensors. A wireless configuration tool features infrared communications, while PC software connects to each local network via a USB interface.
- B. Features and functionality of the wireless configuration tool shall include:
 - 1. Two-way infrared (IR) communication with DLM IR-enabled devices within a range of approximately 30 feet.
 - 2. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
 - 3. Read, modify and send parameters for occupancy sensors, daylighting sensors, room controllers and buttons on digital wall switches.
 - 4. Save up to nine occupancy sensor setting profiles, and apply profiles to selected sensors.
 - 5. Temporarily adjust light level of any load(s) on the local network, and incorporate those levels in scene setting.
 - 6. Adjust or fine-tune daylighting settings established during auto-commissioning, and input light level data to complete commissioning of open loop daylighting controls.
- C. WattStopper Product Numbers: LMCT-100, LMCI-100/LMCS-100

2.12 NETWORK BRIDGE

- A. The network bridge connects a DLM local network to a BACnet-compliant network for communication between rooms, panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication. Closed or proprietary network communication shall not be acceptable.
 - 1. The network bridge may be incorporated directly into the room controller hardware (LMRC-3xx Room Controllers) or be provided as a separate module connected on the local network through an available RJ-45 port.
 - 2. Provide Plug n' Go operation to automatically discover all room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.
 - 3. The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet-compliant BAS to include lighting control and power monitoring features as provided by the DLM room devices on each local network. Standard BACnet objects shall be provided as follows:
 - a. Read/write the normal or after-hours schedule state for the room
 - b. Read the detection state of the occupancy sensor
 - c. Read/write the On/Off state of loads
 - d. Read/write the dimmed light level of loads
 - e. Read the button states of switches
 - f. Read total current in amps, and total power in watts through the room controller

- g. Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings
- h. Activate a preset scene for the room
- i. Read/write daylight sensor fade time and day and night setpoints
- j. Read the current light level, in footcandles, from interior and exterior photosensors and photocells
- k. Set daylight sensor operating mode
- l. Read/write wall switch lock status
- 4. WattStopper product numbers: LMBC-300

2.13 SEGMENT MANAGER

- A. The Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall serve up a graphical user interface via a standard web browser. Each segment manager shall have support for one, two or three segment networks as required and allow for control of a maximum of 40 local networks (rooms) and/or lighting control panels per segment network.
- B. Operational features of the Segment Manager shall include the following:
 - 1. Connection to PC or LAN via standard Ethernet TCP/IP.
 - 2. Easy to learn and use graphical user interface, compatible with Internet Explorer 8, or equal browser.
 - 3. Log in security capable of restricting some users to view-only or other limited operations.
 - 4. Automatic discovery of all DLM devices on the segment network(s). Commissioning beyond activation of the discovery function shall not be required.
 - 5. After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree will allow the device settings and operational parameters to be viewed and changed by the user.
 - 6. Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation.
 - 7. Ability to set up schedules for rooms and panels. Schedules shall automatically set controlled zones or areas to either a normal hours or after hours mode of operation.
 - 8. Ability to group rooms and loads for common control by schedules, switches or network commands.
 - 9. Ability to monitor connected load current and display power consumption for areas equipped with room controllers incorporating the integral current monitoring feature.
 - 10. Provide seamless integration with the BAS via BACnet IP. Provide export table with available parameters.

2.14 REALTIME COLOR GRAPHICS

- A. System Description
 - 1. Color graphics screens shall allow a user to monitor and control the lighting control system through a graphical color interface. The system will control the room controllers in a real-time environment.
 - 2. The application will provide a visual representation of the floor plan, drawn to scale, with each fixture displayed on screen. Fixtures can automatically indicate the relay controlling them on screen.
- B. Graphic Screen Generation
 - 1. The General Contractor shall provide as built CAD floor plans to the manufacturer for generation of graphic screens.

2. As-Built relay panel and reflected ceiling documentation must be provided to the manufacturer before graphic screen development can begin. Graphic screens will be provided and demonstrated to the owner within 90 days of receiving as built CAD files.
3. District Wide Home Screen
 - a. Links to all existing WattStopper Schools in the district
4. School Home screen
 - a. School Rendering
 - b. Day/ Time
 - c. Schedule for that day
 - d. Exterior FC reading
 - e. Current Lighting Watts per sq.ft.
5. Quick Access System tree
 - a. Links
 - b. 365 day Scheduler
6. Site Plan
 - a. All exterior lighting shown on/ off
7. Screens per floor
 - a. For navigation and showing lighting on/off
8. Detail screen per architectural area
 - a. Room Occupancy (room shaded green)
 - b. Lighting states (3 zones with override)
 - c. Real time wattage for lighting
 - d. Real Time Wattage for plug load
 - e. Real time Photocell footcandle reading if applicable
9. Alarms Reports
- C. WattStopper Product Numbers: LMSM-6E.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Contractor shall provide to the manufacturer all quantities for system including but not limited to relays, room controllers, relay panels, plug load controllers, switches, sensors and wire lengths and configurations for both network and device cable at least 1 week before bid.
- B. When using wire for connections other than the DLM local network (Cat 5e with RJ-45 connectors), provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements
- C. All MSTP network and Cat 5e low voltage wiring must have "WattStopper" printed on the wire jacket. Any cable substitutions shall be removed and replaced at the contractor's expense.
- D. All MSTP network terminations shall utilize wire ferrules for terminations and MSTP network manufacturer's instructions. Any network deficiencies shall be repaired at the contractor's expense.
- E. Electrical contractor must provide a detailed as-built plan in CAD showing MSTP network cable routing and network bridge serial numbers to the manufacturer at least 2 weeks prior to factory commissioning Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.

3.2 FACTORY COMMISSIONING

- A. Upon completion of the installation, the system shall be commissioned by the manufacturer's factory authorized representative who will verify a complete fully functional system.
- B. The factory commissioning shall include the following services. Programming of all button stations, configuration of all occupancy sensors and photocells. Verification of a complete and working system including MSTP network status. Provide written or computer-generated documentation on the commissioning of the system including room by room description including:
 - 1. Sensor parameters, time delays, sensitivities, and daylighting setpoints.
 - 2. Sequence of operation, (e.g. manual ON, Auto OFF. etc.)
 - 3. Load Parameters (e.g. blink warning, etc.)
- C. The electrical contractor shall request factory commissioning by submitting a startup request form at least (4) weeks before startup is required.
- D. The electrical contractor shall provide at least (1) journeyman electrician, familiar with the installation of the system, dedicated to assisting the factory start-up technician for the entire duration of the commissioning process.
- E. Upon completion of the system commissioning the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.
- F. Provide a training session for the owner's operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
 - 1. Purpose of equipment.
 - 2. Principle of how the equipment works.
 - 3. Important parts and assemblies.
 - 4. How the equipment achieves its purpose and necessary operating conditions.
 - 5. Most likely failure modes, causes and corrections.
 - 6. On site demonstration.

3.3 RE-COMMISSIONING

- A. After 90 days from occupancy the factory authorized representative and electrical contractor shall re-calibrate all sensor time delays and sensitivities to meet the Owner's Project Requirements. Provide a detailed report to the Architect / Owner of re-commissioning activity

END OF SECTION

SECTION 26 22 13
LOW VOLTAGE DISTRIBUTIONS TRANSFORMERS

PART 1 - GENERAL

1.1 SCOPE

- A. Provide 480 volt primary step down transformers as shown, scheduled and as specified.
- B. The type of transformers required includes dry-type general purpose transformers.

1.2 STANDARDS

- A. Products shall be designed, manufactured, tested and installed in compliance with applicable ANSI/IEEE and NEMA standards.
- B. All low voltage transformers shall be UL listed and labeled.
- C. All low voltage transformers 15 kVA and larger shall meet or exceed post-January 1, 2016 U.S. DOE efficiency requirements Energy, 10 C.F.R. §431.196(a)(2) (2015) regardless of whether transformer date of manufacture is pre or post January 1, 2016.
- D. All low voltage transformers 15 kVA and larger shall be tested for efficiency in accordance with U.S. DOE test methods Energy, 10 C.F.R. §431, Subpart K, Appendix A (2015).

1.3 ACCEPTABLE MANUFACTURERS

- A. Provide one of the following manufacturers for general purpose use:
 - 1. General Electric Company/ABB
 - 2. Square D Company
 - 3. Power Quality International
 - 4. Eaton

1.4 SUBMITTALS

- A. Shop drawings shall include, but not be limited to:
 - 1. Cutsheets of transformers with sound and load ratings, dimensions, weights, impedance rating, insulation type, temperature rise and tap configurations.

1.5 REQUIREMENTS OF REGULATORY AGENCIES

- A. National Electrical Code.
- B. Local, municipal, and/or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.1 GENERAL PURPOSE

- A. Provide dry type, two-winding transformers with primary and secondary voltages and KVA ratings as shown on plans. Transformers shall operate at 60 hertz. All transformers shall be manufacture with standard materials and components.

2.2 MATERIALS AND COMPONENTS FOR GENERAL PURPOSE TRANSFORMERS

- A. All cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be clamped together with structural steel angles. The completed core and coil shall be isolated from the base by means of rubber, vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure. The vibration isolating system shall be designed to provide a permanent fastening of the core and coil to the enclosure. Sound isolating system requiring the complete removal of all fastening devices will not be accepted. Windings shall be copper or electrical grade aluminum terminated on tin plated or copper bars. Foil windings are not acceptable.
- B. The transformer core shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with NEMA, IEEE and ANSI standards.
- C. Transformer coils shall be of continuous-wound type construction and shall be impregnated with non-hygroscopic, thermo-setting varnish.
- D. Transformers shall be enclosed in drip-proof, metallic enclosures designed to provide for air cooling and prevent accidental contact with live conductors. Wiring compartment shall be located below the core and coil and cooled by air circulation or insulated from the core and coil by means of a suitable thermal insulation barrier. Transformer exposed to weather or installed in a sprinkled area shall have rain shields on all openings. Entire transformer enclosure shall be cleaned, phosphatized, primed and painted with a gray, baked enamel.
- E. Transformers shall operate at 100% nameplate KVA rating continuously while in a 40 degree C ambient without exceeding the rated average winding temperature rise of the ANSI insulation system as described below.

Temperature rating shall be as follows:

RATING	PHASE INSULATION-TEMP. RISE
0.025 through 3 KVA	SingleType B - 80° C
5 through 25 KVA	SingleType F - 115° C
3 through 15 KVA	ThreeType F - 115° C
37½ KVA and larger	SingleType H - 150° C
30 KVA and larger	ThreeType H - 150° C

- F. Transformers shall have minimum full load rated taps in the primary windings as follows:

RATING	TAPS
3 through 25 KVA	2 - 5% FCBN
15 through 300 KVA	6 - 2-½% TAPS, 2 above and 4 below nominal

- G. Maximum sound ratings shall be as follows:

KVA	dBA
0 to 9	40
10 to 50	45
51 to 150	50
151 to 300	55
301 to 500	60

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install transformer in accordance with manufacturer's written instructions, and recognized industry practices.
- B. Housekeeping Pad: Provide a nominal 3-½" high, 2500 PSI (28 Day) concrete reinforced pad with number 6 welded wire mesh. The pad shall conform to the shape of the transformer and extend at least 3 inches beyond the length and width of the transformer. All corners of the pad shall be rounded.
- C. Mounting: Install floor mounted transformers on properly sized rubber-in-shear vibration isolators. Trapeze mounted transformers shall use rubber-in-shear hangers. Wall mounted transformers shall not be mounted directly to the wall without vibration isolation.
- D. Connection: Route conductors in a minimum of 2 feet of flexible steel conduit to transformer enclosure. Provide grounding conductor sized per NEC, connected to the building grounding electrode system.

3.2 TESTING

- A. Insulation, Tests: Prior to energization, check transformers windings for continuity and test the insulation resistance. Tests shall be made using a Biddle Megger or equivalent test instrument, per manufacturers' recommendations. Provide written documentation of testing. Submit with O & M manuals.
- B. Tap Setting: Measure current and voltage under load conditions to provide correct tap settings.

END OF SECTION

SECTION 26 24 16 PANELBOARDS

PART 1 - GENERAL

1.1 SCOPE

- A. Provide panelboards as shown, scheduled and as specified herein.
- B. The types of panelboards include:
 - 1. Panelboards.
 - 2. Power distribution panelboards.
 - 3. Load centers

1.2 REFERENCE STANDARDS

- A. ANSI C12.1 - Electric Meters - Code for Electricity Metering.
- B. ANSI C12.20 - American National Standard for Electricity Meters - 0.2 and 0.5 Accuracy Classes.
- C. NFPA 70 - National Electrical Code.
- D. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.
- E. UL 67 - Panelboards.
- F. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
- G. UL 943 - Ground fault Circuit Interrupters
- H. NEMA PB 1 - Panelboards
- I. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less
- J. NEMA, ABI, Molded Car Circuit Breakers and Molded Case Switches
- K. Federal Spec W-P 115, Rev C, Panel, Power Distribution
- L. NEMA KSI, Enclosed and Miscellaneous Distribution Equipment Switches (600V)

1.3 ACCEPTABLE MANUFACTURERS

- A. Provide one of the following manufacturers:
 - 1. General Electric Company/ABB
 - 2. Square D Company
 - 3. Siemens
 - 4. Eaton

1.4 SUBMITTALS

- A. Shop drawings shall include, but not be limited to:
 - 1. Cutsheets of all enclosures, circuit breakers, fusible switches, bussing, rating, schedules and all accessories clearly labeled.

1.5 REQUIREMENTS OF REGULATORY AGENCIES

- A. WORK IN ACCORDANCE WITH:
 - 1. NFPA 70
 - 2. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.1 MATERIALS AND COMPONENTS

- A. General

1. Provide power distribution and panelboards as indicated in the panelboard schedule and as shown on the plans. Load centers are acceptable for use in dwelling units. Power distribution panelboards shall be equipped with fusible switches or circuit breakers as shown on the schedule. Panelboards shall be equipped with thermal-magnetic, molded case circuit breakers of frame and trip ratings as shown on the schedule.
- B. Busing Assembly and Temperature Rise
1. Panelboard bus structure and main lugs or main breaker shall have current ratings as shown on the panelboard schedule. Such ratings shall be established by heat rise tests with maximum hot spot temperature on any connector or bus bar not to exceed 65°C. rise above 40°C ambient. Heat rise test shall be conducted in accordance with Underwriters Laboratories Standard UL 67. The use of conductor dimensions will not be accepted in lieu of actual heat tests. All current carrying parts of the bus shall be tin or silver plated copper.
 2. Bus structure shall be isolated. Bus bar connections to the branch circuit breakers shall be distributed phase or phase sequence type and shall accept bolt-on circuit breakers for lighting and appliance panelboards.
 3. The lugs for terminating conductors shall be rated at 75°C on all panel boards and circuit breakers.
 4. Provide a non-insulated bare copper ground bus. Provide an isolated ground copper bus in each panel serving isolated ground circuits as indicated on panel schedule or one-line diagram. Provide a full size copper neutral bus in each panelboard enclosure. Provide a 200% neutral buss when served by a harmonic mitigating transformer and any K4 or higher rated transformers.
- C. Distribution Panelboards
1. Provide arc energy reduction switch for each overcurrent device rated 1,200 amps or larger to comply with 240.87 of the NEC. Switch shall be equipped with a pad lockable cover with a blue LED pilot light that illuminates when system is activated. Locate switch and cover recessed mounted adjacent to the switch it serves or remote as indicated on the plans. Provide label and all required hardware. Remote switch(es) shall be flush mounted in wall near entry to the room.
 2. Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large, permanent, individual circuit numbers shall be affixed to each breaker in a uniform position. Tripped indication shall be clearly shown by the breaker handle taking a position between "ON" and "OFF". Provisions for additional breakers shall be such that no additional connectors will be required to add breakers. Circuit breakers shall be of the frame size, trip setting and interrupting capacity as indicated on the drawings. Circuit breakers shall be rated 65,000 AIC unless otherwise noted on plans.
 3. All fusible switches shall be quick-make, quick-break with visible blades and dual horsepower ratings. Switch handles shall physically indicate "ON" and "OFF" positions. Switches shall be lockable only in the "OFF" position and accept three industrial type heavy duty padlocks. Switch covers and handles shall be interlocked to prevent opening in the "ON" position. A means shall be provided to permit authorized personnel to release the interlock for inspection purposes. Switches shall include positive pressure rejection type fuse clips for use with UL Class R fuses or Class J fuses and be UL labeled for 200,000 AIC.
- D. 480/277 Volt Panelboards

1. Main breakers shall be vertically mounted. Branch mounted main breakers are not acceptable. Provide electronic trip mains with long term, short term and instantaneous trips as indicated on drawings and required for selective coordination.
 2. Circuit breakers shall be bolt-on thermal-magnetic, molded case circuit breakers. Breakers shall be 1, 2 or 3 pole with an integral crossbar to assure simultaneous opening of all poles in multiple circuit breakers. Breaker shall have an over-center, trip-free, toggle-type operating mechanism with quick-make, quick-break action and positive handle indication. Handles shall have "ON", "OFF" and "TRIPPED" positions. Circuit breakers shall be UL listed in accordance with UL Standard 489 and shall be rated 277 volt ac (single pole, 15-30 amperes) or 480Y/277 volts ac (2 and 3 pole) with continuous current ratings as noted on the plan. Interrupting ratings shall be a minimum of 18,000 rms symmetrical amperes at 277 volts ac (single pole) or 480Y/277 volts ac (2 and 3 pole) unless otherwise noted on plans.
 3. Provide circuit breakers with lock-on devices for applications where dedicated branch circuits are serving battery-equipped emergency lighting fixtures, exit signs or fire alarm equipment per Article 700 of NFPA 70.
- E. 240 Volt Panelboards
1. Main breakers shall be vertically mounted. Branch mounted main breakers are not acceptable. Provide electronic trip mains with long term, short term and instantaneous trips as indicated on drawings and required for selective coordination.
 2. Circuit breakers shall be bolt-on thermal-magnetic, molded case circuit breakers. Breakers shall be 1, 2, or 3 pole with an integral crossbar to assure simultaneous opening of all poles in multiple circuit breakers. Breakers shall have an overcenter, trip-free, toggle-type operating mechanism with quick-make, quick-break action and positive handle indication. Handles shall have "ON", "OFF" and "TRIPPED" positions.
 3. Circuit breakers shall be UL listed in accordance with UL 489 and shall be rated 240 volts ac maximum with continuous current rating as noted on the plans.
 4. Branch circuit breakers feeding convenience outlets shall have sensitive instantaneous trip settings of not more than 10 times the trip settings of the breaker to prevent repeated arcing short resulting from frayed appliance cords. Single pole 15 and 20 ampere circuit breakers shall be UL listed as "Switching Breakers" at 120V ac and carry the SWD marking.
 5. UL Class A 5mA ground fault circuit protection shall be provided on all receptacle circuits serving wet areas and on all 120V ac branch circuits as specified on the plans or panelboard schedule. This protection shall be an integral part of the branch circuit breaker which also provides overload and short circuit protection for branch circuit wiring. Tripping of a branch circuit breaker containing ground fault circuit interruption shall not disturb the feeder circuit to the panelboard. A single pole circuit breaker with integral ground fault circuit interruption shall require no more panelboard branch circuit space than a conventional circuit breaker.
 6. UL Class B 30mA ground fault circuit protection (GFEP) shall be provided on all equipment circuits requiring ground fault protection. This protection shall be an integral part of the branch circuit breaker which also provides overload and short circuit protection for branch circuit wiring.
 7. Provide Shunt Trip Breakers including control power for circuits under cooking hoods and other equipment having this requirement.

8. Provide Breakers with Switched Neutral circuits with common trip for gasoline pumps and other equipment having this requirement.
 9. Circuit breakers shall be rated 10,000 AIC at 240V unless otherwise noted on plans or served by transformers greater than 150 kVA.
 10. Provide 200% sized neutral bus with panels served from a non-linear transformer and any K4 or higher rated transformers. This shall be a UL approved assembly.
 11. Provide circuit breakers with lock-on devices for applications where dedicated branch circuits are serving battery-equipped emergency lighting fixtures, exit signs or fire alarm equipment per Article 700 of NFPA 70.
- F. Cabinets and Fronts
1. The panelboard bus assembly shall be enclosed in a steel cabinet. The rigidity and gauge of steel to be as specified in UL 50 for cabinets. Wiring gutter space shall be in accordance with UL 67 for panelboards. The box shall be fabricated from galvanized steel or equivalent rust resistant steel. Provide stainless steel front cover for all panels located in all Pool Equipment rooms, Food Labs, Snack Bars, Culinary Arts, Kitchens and Life Skills rooms. All NEMA-1 panels shall have hinged front covers. The front cover shall have a door with hinges, latch and a lock. The piano hinged front covers door-in-door shall allow full access to the circuit breaker gutter area without having to remove the entire front cover. All panelboard lock shall be keyed alike. Circuit breaker and fusible distribution panels shall have four-piece trims. A welded circuit directory frame and card with a clear plastic covering shall be provided on the inside of the door. Provide NEMA 1 enclosure where installed indoors unless otherwise noted. Provide NEMA 3R enclosure where installed outside or in a sprinkled area.
- G. Safety Barrier
1. The distribution panelboard interior assembly shall be dead front with panelboard cover removed. Main lugs or main breakers shall have a barrier. The barrier in front of the main lugs shall be hinged to a fixed part of the interior. The end of the bus structure opposite the mains shall have barriers.
- H. Integrated Equipment Short Circuit Rating
1. Each panelboard, as a complete unit, shall have a short circuit current rating equal to or greater than the integrated equipment rating shown on the panelboard schedule or on the plans. This rating shall be established by testing with the over-current devices mounted in the panelboard. The short circuit tests on the over-current devices and on the panelboard structure shall be made simultaneously by connecting the fault to each over-current device with the panelboard connected to its rated voltage source. Method of testing shall be per UL 67. The source shall be capable of supplying the specified panelboard short circuit current or greater. Testing of panelboard over-current devices for short circuit rating only while individually mounted is not acceptable. Also, testing of the bus structure alone is not acceptable. Panelboards shall be marked with their maximum short circuit current rating at the supply voltage and shall be UL listed.
- I. Metering
1. Provide a branch circuit meter to meter the branch circuits indicated on the drawings. It shall provide kW, kVA, kWh and kVAh. It shall be mounted in the panelboard or externally mounted next to the panel. Communication protocol shall include BACnet and Modbus TCP over ethernet. Connect to the Building Automation System. Program to notify building owner if the load exceeds values set by the energy code indicated on the load analysis. This shall comply with Article 220.42 of NFPA 70.

2. Provide a panelboard meter to meter the entire panel as indicated on the drawings. It shall include per phase and total kW, kVA, accumulated kWh, kVAh, power factor, peak demand, frequency, current and voltage. It shall be mounted in the panel board or externally mounted next to the panelboard. Communication protocol shall include BACnet and Modbus TCP over ethernet. Connect to the Building Automation System. Program to notify building owner if the load exceeds values set by the energy code indicated on the load analysis. This shall comply with Article 220.42 of NF. Connect the meter to the building automation system before energizing.¹
 3. Meters shall be provided with an accuracy of 1.0% and shall be certified to ANSI C12.1.
- J. Load Centers
1. Provide load centers where indicated.
 2. Load centers shall have mains ratings and branch circuit breaker ratings of the size and number as indicated on drawings. Load centers shall be plug-on type construction. All current carrying parts of the bus assembly shall be plated copper. Terminals for feeder conductors to mains and branch neutral shall be UL listed as suitable for the type conductor specified. The load center bus assembly shall be enclosed in steel cabinet. The size of the wiring gutters and gauge steel shall be in accordance with UL 50 and UL 67. Fronts shall include door and be provided with a directory for circuit identification. Load center boxes and fronts shall have corrosion resisting phosphate treatment and a gray baked enamel finish. Load centers shall be UL listed and meet Federal Specification W-P-115B as Type I, Class 2.
 3. All breakers shall be full width, plug-on-type, toggle action with quick-make, quick-break mechanism. Provide Square D 'QO', GE 'THQL' breakers or approved equal. Piggy-back or half width breakers are not acceptable. Trip indication shall be clearly shown by the breaker handle taking a position between "ON" and "OFF" when the breaker is tripped. All multi-pole breakers shall be single operating handle, common trip variety. Branch circuit breakers feeding convenience outlets shall have sensitive, instantaneous trip in order to give "flash protection" for frayed, stranded wire cords. QWIK-GARD circuit breakers with ground fault circuit interrupters shall be used in accordance with the National Electrical Code. Circuit breakers shall be UL listed and meet the requirements of Federal Specification W-C-375B/GEN, Class 1. Provide ARC Fault circuit interrupter breaker to comply with 210.12 of the NEC.
 4. Provide Surge Protection Device with a minimum of 100 kA.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install panelboards, including electrical connections, in accordance with manufacturers written instructions, NFPA 70 and recognized industry practices.
- B. All panels shall be mounted to unistrut. Unistrut shall be securely mounted to the floor and structural ceiling. Toggle bolts or anchor bolts attached to drywall is not acceptable.
- C. Housekeeping Pads: Mount floor mounted panelboards on 4 inch high concrete housekeeping pads.
- D. Fuses: Install fuses of the rating and class as shown in each fusible distribution panel scheduled on drawings.

- E. Conduits: Stub up three one inch conduits to an accessible location above the ceiling for each recessed panelboard.

3.2 IDENTIFICATION

- A. Nameplate: Each panelboard shall have an engraved bakelite nameplate. Nameplates shall be white with black letters and show panel designation. Nameplates shall be attached with stainless steel screws. Refer to Section 26 02 00, paragraph 2.8(C).
- B. Directory Card: Cardholders and directory cards shall be furnished for circuit identification in panelboards. Cardholder shall be located on inside of panel door and shall be in a metal frame with clear plastic front. Circuit lists shall be typewritten. Circuit descriptions shall include location and name of each item of equipment served. Spares and spaces shall be written in erasable pencil for future use. Circuit directory shall show the room served by each circuit. The final graphs/signage room numbers shall be used. Do not use Architectural numbering on plans.
- C. Replacement Components: Where circuit breakers or fuses are applied in compliance with the series combination ratings marked on the equipment by the manufacturers, the equipment enclosure(s) shall be legibly marked in the field to indicate the equipment has been applied with a series combination rating. The marking shall be readily visible and state "caution - Series Rated System." (NEC 110-22). Nameplate shall also identify replacement components.
- D. Replacement Components: Nameplate shall identify replacement components.

3.3 INFRARED SCANNING

- A. After Substantial Completion by not more than 2 months after Final Acceptance, perform an infrared scan of each panelboard. Remove fronts if not equipped with viewing ports to make joints and connections accessible to a portable scanner. Submit a copy the owner and engineer for review. If O&M manuals are submitted prior to performance of infrared scan, contractor shall submit a signed letter to verify the scan has been arranged. Letter shall indicate the scan provider and the date It will be performed.

END OF SECTION

SECTION 26 27 26 WIRING DEVICES

PART 1 - GENERAL

1.1 SCOPE

- A. Provide wiring devices as shown, scheduled, required and as specified.
- B. The types of wiring devices required include:
 - 1. Switches
 - 2. Receptacles
 - 3. Flat Panel Display Outlet AV Wall Boxes
 - 4. Occupancy Sensors
 - 5. Digital Timer Switches
 - 6. Coverplates
 - 7. Floor Boxes
 - 8. Fire Rated Poke Through Devices

1.2 REFERENCE STANDARDS

- A. FS W-C-596 - Connector, Electrical, Power, General Specification for.
- B. FS W-S-896 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
- C. NEMA WD 1 - General Color Requirements for Wiring Devices.
- D. NEMA WD 6 - Wiring Devices - Dimensional Specifications.
- E. NFPA 70 - National Electrical Code.
- F. UL 20 - General-Use Snap Switches.
- G. UL 498 - Attachment Plugs and Receptacles.
- H. UL 943 - Ground-Fault Circuit-Interrupters.
- I. UL 1310 - Class 2 Power Units.
- J. UL 1699 - Arc-Fault Circuit-Interrupters.

1.3 QUALITY ASSURANCE

- A. All wiring devices shall comply with NEMA WD 1 and NEMA WD 6 as well as FS W-C-596 and FS W-S-896 as applicable.
- B. All switches shall comply with UL 20 as applicable.
- C. All receptacles shall comply with UL 498 as applicable.
- D. All GFCI receptacles shall comply with UL 943.
- E. All USB charging receptacles shall comply with UL 1310.
- F. All AFCI receptacles shall comply with UL 1699.

1.4 ACCEPTABLE MANUFACTURERS

- A. Hubbell
- B. Leviton
- C. Pass & Seymour

1.5 SUBMITTALS

- A. Shop drawings shall include but not be limited to:
 - 1. Cut sheets of all devices indicating NEMA configuration, rating, materials, color, and all accessories.
 - 2. Cut sheets of all coverplates indicating materials, color and any engraving specified on drawing or in the specifications.

1.6 REQUIREMENTS OF REGULATORY AGENCIES WORK IN ACCORDANCE WITH

- A. National Electric Code.
- B. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.1 MATERIALS AND COMPONENTS

A. GENERAL

1. Provide factory assemble wiring devices with the rating type and color as required and specified for the service indicated.
2. Provide matching one-piece multiple gang plates where switches are ganged.
3. Provide wall plates for each receptacle furnished.
4. Architect reserves the right to select wiring device styles and colors to match wall finish.
5. Wall plates shall be of same manufacturer as devices.

2.2 SWITCHES

- A. Provide specification grade White toggle switches where indicated on the Drawings. Provide "Red" switches for switching emergency lighting circuits where switching is indicated. Coordinate exact locations with architect.

1. Wall switches shall be 20 amp, 120-277 volt and shall be Hubbell, Leviton or P&S as follows:

TOGGLE SWITCHES	HUBBELL	LEVITON	P&S
SINGLE POLE	HBL1221	1221-2	PS20AC1
DOUBLE POLE	HBL1222	1222-2	PS20AC2
THREE WAY	HBL1223	1223-2	PS20AC3
FOUR WAY	HBL1224	1224-2	PS20AC4
MOMENTARY CONTACT	HBL1557	1257	1251
THREE POSITION, TWO CIRCUIT MAINTAINED CONTACT	HBL1385	1285	1225
KEY TYPE LOCKABLE BARREL KEY OR CORBIN STYLE	HBL1221-RKL	1221-2KL	PS20AC1-KL
PROVIDE WITH EXTRA KEYS	HBL1209RKL	2KL	4609
DISCONNECT SWITCH / INSTA HOT	HBL7810DS	MS303-DSS	7803

2. Dwelling units shall use Hubbell CS115I, CS120I, P&S CS15AC1, and CS20AC1.
3. Dimmers: Provide Lutron DIVA or equal as shown on drawings. Wall box dimmers shall be sized to handle the load served. Provide phase dimmers to control LED lamps when 0-10 volt dimming drivers are not provided.
4. Light Handle Switches: Provide Hubbell HBL1221-IL, Leviton 1221-LHC, P&S PS20AC1-ISI lighted handles to switch emergency lights where noted on the drawings.
- B. Provide specification grade White decora style rocker switches where indicated on the Drawings. Provide "Red" switches for switching emergency lighting circuits where switching is indicated. Coordinate exact locations with architect.
 1. Wall switches shall be 20 amp, 120-277 volt and shall be Hubbell Decorator Series, Leviton, Decora or Pass & Seymour Decorator, as follows:

ROCKER/DECORATOR SWITCHES	HUBBELL	LEVITON	P&S
SINGLE POLE	DS120	5621-2	2621
DOUBLE POLE	DS220	5622-2	2622
THREE WAY	DS320	5623-2	2623
FOUR WAY	DS420	5624-2	2624
MOMENTARY CONTACT	HBL1557	1257	1251
THREE POSITION, TWO CIRCUIT MAINTAINED CONTACT	HBL1385	1285	1225
KEY TYPE LOCKABLE BARREL KEY OR CORBIN STYLE	HBL1221-RKL	1221-2KL	PS20AC1-KL
PROVIDE WITH EXTRA KEYS	HBL1209RKL	2KL	4609
DISCONNECT SWITCH / INSTA HOT	HBL7810DS	MS303-DSS	7803

- Dimmers: Provide Lutron DIVA or equal where required. Wall Box dimmers shall be sized to handle the load. Provide Phase dimmers to control LED lamps when 0-10V drivers are not provided.
- Light Handle Switches: Provide Leviton 5649-2 or P&S 2625 lighted handles to switch emergency lights where noted on the drawings.

2.3 RECEPTACLES

- A. Provide specification grade White receptacles where indicated on the drawings. Provide "Red" receptacles for receptacles on emergency power. Coordinate exact location with architect.

- Receptacles shall be Hubbell, Leviton or Pass & Seymour as follows:

CONVENTIONAL RECEPTACLES	HUBBELL	LEVITON	P&S
HEAVY DUTY BRASS MOUNTING YOKE NEMA 5-20R DUPLEX	HBL5352	5362	5362
HEAVY DUTY BRASS MOUNTING YOKE NEMA 5-20R SIMPLEX	HBL5361	5361	5361
ISOLATED GROUND 20A, 125V ORANGE NEMA 5-20R DUPLEX	IG5352	5362IG	IG5362
CLOCK HANGER 15A-125V BROWN WITH STAINLESS STEEL PLATE WITH HANGER	HBL5235	5361-CH	S3733-SS
GFCI DUPLEX 20A, 125V SELF TESTING, FEED THRU CAPABLE, TAMPER RESISTANT FOR LOCATIONS REQUIRING TAMPER RESISTANT INSTALLATION OR AS INDICATED ON THE DRAWINGS	GFRST20	GFTR2	2097TR
GFCI DUPLEX 20A, 125V SELF TESTING, FEED THRU CAPABLE, TAMPER/WEATHER RESISTANT FOR	GFTWRST20	GFWR2	2097TRWR

INSTALLATION IN DAMP/WET LOCATION OR AS INDICATED ON THE DRAWINGS			
HEAVY DUTY TAMPER RESISTANT BRASS MOUNTING YOKE	HBL5362WTR	5362-SG	---
TAMPER RESISTANT 20A, 125V DUPLEX	BR20WHITR	8300-SG	TR63-H
SURGE PROTECTION 20A, 125V DUPLEX, BLUE NEMA 5-20R WITH AUDIBLE ALARM	HBL5362SA	7380-B	5362SP
USB CHARGER TYPE DUPLEX 20A, 125V TAMPER RESISTANT, ONE USB TYPE A PORT, ONE USB TYPE C PORT. MIN. OF 5A USB OUTPUT.	USB20AC5 5A OUTPUT	T5833 5.1A OUTPUT	TR20USBAC6 A OUTPUT
USB CHARGER TYPE DUPLEX 20A, 125V TAMPER RESISTANT, ONE HIGH OUTPUT POWER DELIVERY USB TYPE C PORT, ONE STANDARD USB TYPE A PORT.	USB20ACPD 20V, 55W TYPE C; 5V, 1.5A TYPE A	T5834 20V, 50W TYPE C; 5V, 2A TYPE A	---
PLUG LOAD CONTROLLED RECEPTACLES 20A, 125V TAMPER RESISTANT WITH TWO CONTROLLED FACES	BR20C2WHITR	TBR20-S2W	TR5362CDW
PLUG LOAD CONTROLLED RECEPTACLES 20A, 125V TAMPER RESISTANT WITH ONE CONTROLLED FACE	BR20C1WHITR	TBR20-S1W	TR5362CHW
ARC FAULT CIRCUIT INTERRUPTER RECEPTACLES	AF20TRW	AFTR2-W	AF202TRW
GROUND FAULT CIRCUIT INTERRUPTER / ARC FAULT DUAL FUNCTION	AFGF20TR	AGTR2-W	AFGF202TR

- B. Provide specification grade, Decora type White receptacles where indicated on the drawings. Provide "Red" receptacles for receptacles on emergency power. Coordinate exact location with architect.

1. Receptacles shall be Hubbell, Leviton, or Pass & Seymour as follows:

DECORATOR / DECORA RECEPTACLES	HUBBELL	LEVITON	P&S
DECORATOR DUPLEX 20A, 125V NEMA 5-15R SELF GROUNDING	DR20	16362	26342
DECORATOR SIMPLEX 20A, 125V NEMA 5-15R SELF GROUNDING	---	1635	26361

ISOLATED GROUND DUPLEX 20A, 125V ORANGE NEMA 5-20R	IG20DRx	16362-IG	IG26362
CLOCK HANGER 15A-125V BROWN WITH STAINLESS STEEL PLATE WITH HANGER	HBL5235	5361-CH	S3733-SS
GFCI DUPLEX 20A, 125V SELF TESTING, FEED THRU CAPABLE, TAMPER RESISTANT FOR LOCATIONS REQUIRING TAMPER RESISTANT INSTALLATION OR AS INDICATED ON THE DRAWINGS	GFRST20	GFTR2	2097TR
GFCI DUPLEX 20A, 125V SELF TESTING, FEED THRU CAPABLE, TAMPER/WEATHER RESISTANT FOR INSTALLATION IN DAMP/WET LOCATION OR AS INDICATED ON THE DRAWINGS	GFTWRST20	GFWR2	2097TRWR
TAMPER RESISTANT DUPLEX 20A, 125V NEMA 5-20R	DR20WHITR	16362-SG	TR26362
SURGE PROTECTION 20A, 125V DUPLEX, BLUE NEMA 5-20R WITH AUDIBLE ALARM	HBL5362SA	7380-W	5362SP
USB CHARGER TYPE DUPLEX 20A, 125V TAMPER RESISTANT, ONE USB TYPE A PORT, ONE USB TYPE C PORT. MIN. OF 5A USB OUTPUT.	USB20AC5 5A OUTPUT	T5833 5.1A OUTPUT	TR20USBAC6 6A OUTPUT
USB CHARGER TYPE DUPLEX 20A, 125V TAMPER RESISTANT, ONE HIGH OUTPUT POWER DELIVERY USB TYPE C PORT, ONE STANDARD USB TYPE A PORT.	USB20ACPD 20V, 55W TYPE C; 5V, 1.5A TYPE A	T5834 20V, 50W TYPE C; 5V, 2A TYPE A	---
PLUG LOAD CONTROLLED RECEPTACLES 20A, 125V TAMPER RESISTANT WITH TWO CONTROLLED FACE	DR20C2WHITR	16352-2PW	TR26362CDW
PLUG LOAD CONTROLLED RECEPTACLES 20A, 125V TAMPER RESISTANT WITH ONE CONTROLLED FACE	DR20C1WHITR	16352-1PW	TR26362CHW
ARC FAULT CIRCUIT INTERRUPTER RECEPTACLES	AF20TRW	AFTR2-W	AF202TRW
GROUND FAULT CIRCUIT INTERRUPTER / ARC FAULT DUAL	AFGF20TR	AGTR2-W	AFGF202TR

FUNCTION			
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- C. Provide hospital grade, White receptacles where indicated on the drawings. Provide "Red" receptacles for receptacles on emergency power. Coordinate exact location with architect.

1. Receptacles shall be Hubbell, Leviton, or Pass & Seymour as follows:

HOSPITAL GRADE RECEPTACLES	HUBBELL	LEVITON	P&S
HOSPITAL GRADE DUPLEX 20A, 125V NEMA 5-20R TAMPER RESISTANT FOR ALL LOCATIONS OTHER THAN BEHAVIOR HEALTH	8300TRA	T8300	26342
HOSPITAL GRADE DECORATOR DUPLEX NEMA 5-20R TAMPER RESISTANT	2182TRA	16362-SG	26361
HOSPITAL GRADE DUPLEX 20A, 125V NEMA 5-20R WITH INTEGRAL WIRE LEADS FOR INSTALLATION IN ONLY BEHAVIOR HEALTH LOCATIONS TO COMPLY WITH NEC 517-18(c)	HBL8300SGA	8300-SG	IG26362
HOSPITAL GRADE SIMPLEX, 20A, 125V NEMA 5-20R	HBL8310	8310	S3733-SS
HOSPITAL GRADE SURGE PROTECTIVE 5-20R, NEMA 5-20R, DUPLEX	HBL8362SA	T8380-B	2097TR
HOSPITAL GRADE GFCI TAMPER RESISTANT 20A, 125V, NEMA 5-20R SELF TESTING, FEED THRU CAPABLE	GFTRST83	GFNL2-HG	2097TRWR
HOSPITAL GRADE GFCI TAMPER/WEATHER RESISTANT, SELF TESTING, FEED THRU CAPABLE	GFRTW83	GFWT2-HG	TR26362
HOSPITAL GRADE USB DUPLEX CHARGER, 20A, 125V NEMA 5-20R TAMPER RESISTANT WITH ONE USB TYPE A PORT, ONE USB TYPE C PORT. MIN. OF 5A USB OUTPUT.	USB8300AC5 5A OUTPUT	T5833-HG* 3.6A OUTPUT	TR20HUSBAC .1A OUTPUT
HOSPITAL GRADE USB DUPLEX CHARGER, 20A, 125V NEMA 5-20R TAMPER RESISTANT WITH ONE HIGH OUTPUT POWER DELIVERY USB TYPE C PORT, ONE STANDARD USB TYPE A PORT.	USB8300ACPD 20V, 55W TYPE C; 5V, 1.5A TYPE A	---	---

2.4 FLAT PANEL DISPLAY OUTLET AV WALL BOXES

- A. Provide flush against wall Flat Panel TV Wall Enclosure, white painted 18 gauge cold rolled steel base with 1-1/2" and 1-1/4" conduit knockouts. Stud or Sheetrock mounting capable with standard power kit with tamper resistant duplex receptacle in one gang with remaining gang dedicated for AV connectivity.
- B. Provide Hubbell NSAV62M or NSAV124M AV wall enclosure, 20A power kit and AV Connectivity as noted on the Plans.

2.5 OCCUPANCY SENSORS

- A. Provide White dual technology wall mounted sensors, provide one of the following:
 - 1. Single Pole:
 - a. Wattstopper #DSW301
 - 2. Double Pole:
 - a. Wattstopper # DSW302
 - 3. Dimmer:
 - a. Wattstopper #DW311
- B. Provide dual technology ceiling sensor with low voltage controlling switch and power pack.
 - 1. Single Button:
 - a. Wattstopper # DT300 Sensor, BZ150 Power Pack and LVSW101 Digital Switch
 - b. Provide isolated relay for additional signaling to HVAC controls.
- C. Provide Ultra Sonic Ceiling sensor for restrooms.
 - 1. Wattstopper #UT3000, BZ150 Power Pack

2.6 DIGITAL TIMER SWITCHES

- A. Provide Wattstopper TS-400-G digital timer.
- B. The time switch shall provide audible notification and visual notification (blink the room lights) prior to turning lights off.
- C. The time switch shall have a 12-hour manual override setting.

2.7 COVERPLATES

- A. Furnish and install coverplates on all outlet boxes. Oversize (Jumbo) coverplates are not acceptable.
- B. Coverplates shall be smooth nylon and 302/304 smooth stainless steel in kitchen and coffee bar areas.
- C. Provide Hubbell WP Series, Bell, Carlon or Leviton NEMA 3R weatherproof coverplates on all exterior wiring devices. Enclosure shall be suitable for wet locations when in use.
- D. Coverplates shall be Hubbell SS Series, Leviton, Pass & Seymour 302/304 smooth stainless steel on all receptacles 30 amps and larger.
- E. Stainless steel device plates shall be provided at locations with tile or stone walls.

2.8 FLOOR BOXES

- A. Floor boxes with surface activation shall be cast iron as manufactured by Hubbell or equal by Wiremold 880CS/CM series and as indicated below:
 - 1. Slab at grade (dual level, fully adjustable type 1).
 - a. Single gang: #B-2436 w/#SB-3083 carpet flange.
 - b. Two gang: #B-4233 w/#SB-3084 carpet flange.
 - c. Three gang: #B-4333 w/#SB-3085 carpet flange.
 - 2. Slab above grade (shallow, fully-adjustable, type II)
 - a. Single gang: #B-2421 w/#SB-3083 carpet flange.
 - b. Two gang: #B-2422 w/#SB-3084 carpet flange.

- c. Three gang: #B-2423 w/#SB-3085 carpet flange.
- 3. Cover plates shall have brass finish as follows:
 - a. #S-3825 for duplex flap for duplex receptacles.
 - b. #S-3826 for data/communications.
- B. PVC floor boxes manufactured by Hubbell or equal shall be as follows:
 - 1. Provide CFBS1R4CFB dual service cast iron body floor box with PVC riser. Provide CFBS1R4CUP adjustable mounting cup, S1R4SP2X2DUPLEX sub-plate for (1) Duplex and (2) RJ-45 Keystone jacks OR S1R4SP2X2STYLE for (1) GFCI duplex, USB or Surge Device & (2) Keystone jacks, OR S1R4SPQUAD sub-plate with (4) 20A simplex receptacles, single and dual circuit wiring capability. Provide with CFBS1R4CVR cover, Color to be chosen by Architect.
 - a. Maximum finished floor thickness (above top of box collar) with maximum adjustability is 1-1/2-inches at 5-inch, at 6-inches maximum adjustability is 1/2".
- C. Floor boxes, recessed activation type, meet UL 514A scrub water requirements, shall be stamped steel with corrosion resistant finish, UL Listed for slab-on-grade installations, or stamped steel for above-grade installations as manufactured by Hubbell or equal by Wiremold RFB2-11 series and as indicated below:
 - 1. Recessed Activation Slab at grade:
 - a. Two gang: #CFB2G30CR or CFB2G30RCR (provisions for round cover), capable of up to 2" entry per gang. Flush flange, Surface flange and Furniture Feed cover availability. Surface Type Covers shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past 0.15" rise
 - b. Four Gang: #CFB4G30CR or CFB4G30RCR (provisions for round cover), capable of up to 2" entry per gang. Flush flange, Surface flange availability. Cover shall not exceed 0.15" rise. Surface Type Covers shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15" rise.
 - c. Six Gang: #CFB6G30CR or CFB6G30RCR (provisions for round cover), capable of up to 2" entry per gang. Flush flange, Surface flange availability. Surface Type Covers shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall maintain the 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15" rise.
 - d. Ten Gang AV: #CFB10G55CR or CFB10G55RCR (provisions for round cover), with minimum (2) 2" KO's, multiple front and back 3/4" to 1-1/2" concentric KO's.. Flush flange, Surface flange availability. Cover shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15" rise.
 - 2. Recessed Activation Slab above grade
 - a. Two Gang: #CFB2G30 or CFB2G30R (provisions for round cover), capable of up to 2" entry per gang. Flush flange, Surface flange and Furniture Feed cover availability. Surface Type Covers shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15" rise.
 - b. Four Gang: #CFB4G30 or CFB4G30R (provisions for round cover), capable of up to 2" entry per gang. Flush flange, Surface flange availability. Cover shall not exceed 0.15" rise. Surface Type Covers shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past 0.15" rise.

- c. Six Gang: #CFB6G30 or CFB6G30R (provisions for round cover), capable of up to 2" entry per gang. Flush flange, Surface flange availability. Surface Type Covers shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall maintain the 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15" rise
- d. Ten Gang AV: #CFB10G55 or CFB10G55R (provisions for round cover), with minimum (2) 2" KO's, multiple front and back ¾" to 1-1/2" concentric KO's.. Flush flange, Surface flange availability. Cover shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15" rise.
- 3. Service Fittings
 - a. Surface Style Rectangular for use with carpet, tile, VCT and other engineered floors, available with or without carpet insert and offer system's furniture feed type cover providing (1) 1-inch and (1) 2-inch threaded openings
 - b. Flush Style Rectangular for use with tile, finished concrete or Terrazzo floors, available with or without carpet insert and offer system's furniture feed type cover providing (1) 1-inch and (1) 2-inch threaded openings
 - c. Rectangular covers shall be powder coated in variety of common finishes, Aluminum, Black, Brass, Bronze and Satin Nickel.
 - d. Round Covers for use with all floor types Shall provide cable egress doors and systems furniture feed type cover providing (1) ¾-inch and (1) 2-inch threaded openings Round covers shall be plated metal in variety of finishes except Black (powder coated) Brushed Aluminum, Brass Plated, Bronze Plated, Satin Nickel Plated.

2.9 FIRE RATED POKE THROUGH DEVICES

- A. Installations requiring 4-inch cored openings, poke thru devices shall be manufactured by Hubbell or approved equal, Hubbell S1R4PTFIT Recessed Activation poke thru with either S1R4SP2X2STYLE or S1R4SP2X2DUPLEX sub-plate for (1) 20A Duplex, GFCI OR USB 2 Port Duplex with (2) openings for (2) RJ-45 Jacks with S1R4CVR - color to be chosen by Architect.
- B. Installations requiring 6-inch cored openings, with duplex power, shall be manufactured by Hubbell or Wiremold 6AT, Hubbell S1R6PTWZ-XXX Recessed Activation poke thru which includes S1R6SPW and S1RSSPZ sub plates and S1R6CVR cover, where XXX is finish. Color to be chosen by Architect. This includes (1) pre-wired 20A, 125 V duplex receptacle and (2) NEMA configured rectangular Decorator openings for telephone, signal or up to (12) Category 5e/Cat 6 RJ-45 Jacks.
- C. Installations requiring 6-inch cored openings, with quad power, shall be manufactured by Hubbell or Wiremold 6AT, Hubbell S1R6PTDEH-XXX Recessed Activation poke thru which includes S1R6SPH and S1R6SPE sub-plates and S1R6CVR cover where XXX is finish. Color to be chosen by Architect. This includes (2) pre-wired 20A, 125 V duplex receptacles (quad) single, dual circuit capable and (1) NEMA configured rectangular Decorator opening for telephone, signal or up to (6) Category 5e/Cat 6 RJ-45 Jacks plus (2) additional Keystone openings for a total of (8) Category 5e/Cat 6 RJ-45 Jacks for this sub-plate
- D. Installations requiring 8-inch cored openings, shall be manufactured by Hubbell or Wiremold 8AT, Hubbell S1R8PTFIT3 Recessed Activation poke thru offering (2) perimeter (outer) sub-plate locations and (3) standard NEMA configured openings in center sub-plate location allowing multiple combinations for power, data and AV connectivity devices including acceptance for third party AV devices such as Crestron, FSR, Extron.

- E. Poke thru devices with above floor service fittings shall be Hubbell PT7XC Series or Wiremold RC9 approved equal for 3-inch cored openings with FR280BKA Pedestal Service Fitting for (1) 20A, 125V duplex receptacle and (1) NEMA configured Decorator opening for telephone, signal or Cat 5e/Cat 6 data cables with RJ-45 jacks.
- F. Poke Thru devices for furniture feed applications shall be Hubbell S1R6PTFF-XXX or Wiremold 6AFTT where XXX is finish, to be chosen by Architect. Provides (1) ¾" threaded entry for Power feed and (1) 2-0" threaded opening for Data/AV Cables. Installed in 6-inch cored openings.
- G. Poke Thru devices for furniture feed applications shall be Hubbell S1PTFF-XX or Wiremold 4FF or approved equal where XX is finish, to be chosen by Architect. Provides (1) ¾" threaded entry for Power feed and (1) 1-1/2" threaded opening for Data/AV Cables. Installed in 4-inch cored openings.

PART 3 - EXECUTION

3.1 WIRING DEVICE MOUNTING HEIGHTS

- A. Unless noted to the contrary on plans, or directed otherwise during the progress of the Work, wiring devices shall be set as follows:
 - 1. Switches 42" above finished floor.
 - 2. Wall mounted receptacles shall be installed vertically at 15 inches to the bottom outlet above finished floor unless otherwise noted or as required by local codes.
 - 3. Wall telephone outlets shall be mounted 15 inches to the bottom above finished floor unless otherwise noted. Mount even with wall mounted receptacles.
 - 4. At locations above counters, set devices at 6 inches above to the centerline counter tops, verify exact mounting height with the architect.

3.2 INSTALLATION (REFER TO 26 05 33 FOR OUTLET BOX SPECIFICATIONS)

- A. Wall switches shall be set in a suitable steel box and shall be installed on the strike side of the door as finally hung, whether so indicated on the Drawings or not.
- B. Receptacles shall be installed in a suitable steel box.
- C. The Architect reserves the right to relocate wiring device up to a distance of 5 feet from the location shown, before rough-in, without additional cost.
- D. Provide multi-gang device covers at locations where devices gang together.
- E. Device locations are indicated schematically on the drawings along with the type and mounting height. Final locations and mounting heights shall be coordinated with the Architect on the jobsite, and with shop drawings of equipment; including equipment to be furnished and installed by the Owner. Devices installed in walls covered with vinyl, fabric wallpaper or other special finishes shall be coordinated and verified with the Architect on the job site.
- F. Stranded wire termination to switches, receptacles, devices and miscellaneous control devices shall be with an approved solderless terminal if clamp type securing is not possible (i.e. Sta-Con crimp on fork tongue connectors; Burndy Type TP-F).
- G. Provide keyed switches in all common areas not monitored by the faculty (i.e. gym, corridors, cafeteria, commons natatoriums).
- H. All 15 amp and 20 amp receptacles shall be tamper-resistant type.
- I. All 20A, 120V receptacles in food service areas shall be GFCI.
- J. Provide GFCI circuit breakers for all drinking fountain branch circuits where GFCI receptacles are not indicated on plan.
- K. Provide ARC Fault circuit interrupters (AFCI) as required to comply with article 210.12 of NFPA 70. This shall include but not be limited to dwelling units and dormitories. AFCI breakers may be used.

- L. Provide ground fault circuit interrupter (GFCI)/ARC Fault circuit interrupter (AFCI) dual function receptacles to comply with articles 210.8, 210.12 and 406.4 of NFPA 70.
- M. Provide high output model for USB receptacles for applications where end user charging time is of high priority or where specifically indicated on the drawings. Provide standard output USB receptacles for all other applications.
- N. Contractor shall indicate the circuit serving each wiring device. Provide a typewritten label located on the inside face of the coverplate for all recessed mounted devices and on the outside of the coverplate on all surface mounted devices.

END OF SECTION

SECTION 26 28 13 FUSES

PART 1 - GENERAL

1.1 SCOPE

- A. Provide fuses as shown and scheduled and indicate by this specification section and other specifications sections.
- B. The type of fuses include:
 - 1. 600 volt current limiting.
 - 2. 250 volt current limiting.

1.2 STANDARDS

- A. ANSI
- B. UL

1.3 ACCEPTABLE MANUFACTURERS

- A. Eaton Bussmann
- B. Mersen

1.4 SUBMITTALS

- A. Shop drawings shall include, but not be limited to:
 - 1. Cutsheets of all fuses showing ratings and fuse curves.

1.5 REQUIREMENTS OF REGULATORY AGENCIES

- A. WORK IN ACCORDANCE WITH:
 - 1. National Electrical Code.
 - 2. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.1 CURRENT - LIMITING FUSES

- A. General: Provide 200,000 amp interrupting capacity current limiting fuses of the ampacity and voltage indicated and scheduled.
- B. Mains, Feeders and Branch Circuits
 - 1. Circuits 601 to 6000 ampere shall be protected by current limiting BUSSMANN HI-CAP Time Delay Fuses KRP-C. Fuses shall employ "O" ring as positive seals between the end bells and the glass melamine fuse barrel. The terminals shall be peened. Fuses shall be time-delay and must hold 500% of rated current for a minimum of 4 seconds, clear 20 times rated current in .1 seconds or less and be listed by Underwriters` Laboratories Inc., with an interrupting rating of 200,000 amperes r.m.s. symmetrical. The fuses shall be UL Class L.
- C. Class J Fuses
 - 1. Circuits 0 to 600 ampere shall be protected by current limiting BUSSMANN LOW-PEAK Dual Element Fuses LPJ. All dual-element fuses shall have separate overload and short-circuit elements. Fuse shall incorporate a spring activated thermal overload element having a 284 degree Fahrenheit melting point alloy and shall be independent of the short-circuited clearing chamber. The fuse must hold 500% of rated current for a minimum of 10 seconds and listed by Underwriters' Laboratories Inc., with an interrupting rating of 200,000 amperes rRMS symmetrical. The fuses shall be UL Class J.

2. Motor Circuits - All individual motor circuits rated 600 amperes or less shall be protected by BUSSMANN LOW-PEAK LPJ. The fuses for 1.15 service factor motors shall be installed in ratings approximately 125% of motor full current except where high ambient temperatures prevail, or where the motor drives a heavy revolving part which cannot be brought up to full speed quickly, such as large fans. Under such conditions the fuse should be 150% to 200% of the motor full load current. Larger H.P. Motor shall be protected by BUSSMANN Type KRP-C HI-CAP Time-Delay Fuses of the rating shown on the drawings. 1.0 service factor motors shall be protected by BUSSMANN LOW-PEAK Dual-Element Fuses LPJ installed in ratings approximately 115% of the motor full load current except as noted above. The fuses shall be UL Class LPJ or L. Circuit breaker panels shall be protected by BUSSMANN LOW-PEAK Dual-Element LPJ as shown on the drawings. The fuses shall be UL Class J.
- D. Class RK1 Fuses
1. Circuits 0 to 600 ampere shall be protected by current limiting BUSSMANN LOW-PEAK Dual Element Fuses LPN-RK (250 volts) or LPS-RK (600 volts). All dual-element fuses shall have separate overload and short-circuit elements. Fuse shall incorporate a spring activated thermal overload element having a 284 degree Fahrenheit melting point alloy and shall be independent of the short-circuited clearing chamber. The fuse must hold 500% of rated current for a minimum of 10 seconds and listed by Underwriters' Laboratories Inc., with an interrupting rating of 200,000 amperes RMS symmetrical. The fuses shall be UL Class RK1.
 2. Motor Circuits - All individual motor circuits rated 600 amperes or less shall be protected by BUSSMANN LOW-PEAK Dual Element Fuses LPN-RK (250 volts) or LPS-RK (600 volts). The fuses for 1.15 service factor motors shall be installed in ratings approximately 125% of motor full current except where high ambient temperatures prevail, or where the motor drives a heavy revolving part which cannot be brought up to full speed quickly, such as large fans. Under such conditions the fuse should be 150% to 200% of the motor full load current. Larger H.P. Motor shall be protected by BUSSMANN Type KRP-C HI-CAP Time-Delay Fuses of the rating shown on the drawings. 1.0 service factor motors shall be protected by BUSSMANN LOW-PEAK Dual-Element Fuses LPN-RK (250 volts) or LPS-RK (600 volts) installed in ratings approximately 115% of the motor full load current except as noted above. The fuses shall be UL Class RK1 or L.
 3. Circuit breaker panels shall be protected by BUSSMANN LOW-PEAK Dual-Element LPN-RK (250 volts) or LPS-RK (600 volts) as shown on the drawings. The fuses shall be UL Class RK1.

2.2 SPARES

- A. Upon completion of the building the contractor shall provide the owner with spare fuses as shown below.
1. 10% (minimum of 3) of each type and rating of installed fuses shall be supplied as spares.
 2. BUSSMANN spare fuse cabinets - Catalog No. SFC - shall be provided to store the above spares.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Fuses: Fuses shall not be installed until equipment is ready to be energized. This measure prevents fuse damage during shipment of the equipment from the manufacturer to the job-site or from installation. All fuses shall be furnished and installed by the electrical contractor. All fuses shall be of the same manufacturer.
- B. All fuses shall be installed in fuse holders.

END OF SECTION

SECTION 26 28 16
SAFETY AND DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SCOPE

- A. Provide safety and disconnect switches as shown, scheduled and as specified herein.

1.2 STANDARDS

- A. Products shall be designed, manufactured, tested and installed in compliance with applicable standards.
1. NEMA KS1 - Enclosed switches
 2. Federal specification W-S-865C-Heavy duty switches
- B. Products shall conform all applicable UL standards, including UL98 (standard for safety, enclosed and dead front switches) and shall be UL-labeled.

1.3 ACCEPTABLE MANUFACTURERS

- A. Provide one of the following manufacturers:
1. General Electric Company/ABB
 2. Square D Company
 3. Siemens
 4. Eaton

1.4 SUBMITTALS

- A. Shop drawings shall include, but not be limited to:
1. Cutsheets of switches with ratings, physical dimensions and all accessories clearly labeled.

1.5 REQUIREMENTS OF REGULATORY AGENCIES

- A. WORK IN ACCORDANCE WITH:
1. National Electrical Code.
 2. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Furnish and install heavy duty type safety switches with the number of switched poles as indicated on the plans and specifications. All safety switches shall be NEMA Heavy Duty Type HD, and Underwriters Laboratories listed.

2.2 MATERIALS AND COMPONENTS

- A. Switch Interior
1. All switches shall have switch blades that are fully visible in the "OFF" position when the door is open. Switches shall have removable arc suppressor where necessary, to permit easy access to line side lugs. Lugs shall be front removable and UL listed for 60°C and 75°C copper or aluminum cables. All switches blades and contacts shall be plated copper. Adjust fuse block to accept Class J fuses.
- B. Switch Mechanism

1. Switches shall have a quick-make and quick-break operating handle and mechanism, which shall be an integral part of the box, not the cover. Padlocking provisions shall be provided for locking in the "OFF" position with at least three padlocks. Switches shall have a dual cover interlock to prevent unauthorized opening of the switch door when the handle is in the "ON" position, and to prevent closing of the switch mechanism with the door open. A means shall be provided to permit authorized personnel to release the interlock for inspection purposes. Handle position shall indicate if switch is "ON" or "OFF".
- C. Neutral
 1. Provide a solid neutral with the safety switch where a neutral is present in the circuit.
- D. Ratings
 1. Switches shall be horsepower rated for ac and/or dc as indicated by the plans. The fused switches shall have Class R rejection fuse clips or adjusted for Class J fuses. UL listed short circuit ratings of the switches, when equipped with Class R fuses, shall be 200,000 symmetrical amperes.
- E. Enclosures
 1. Indoor switches shall be furnished in NEMA 1 enclosures.
 2. Outdoor switches, switches located in wet areas or sprinkled areas shall be furnished in NEMA 3R enclosures.
 3. Switches installed in wet areas such as cooling tower areas shall be NEMA 4X stainless steel or fiberglass reinforced polyester.
 4. Switches installed in kitchens shall be stainless steel.
 5. Switches installed in areas of a corrosive nature and subjected to salt air shall be NEMA 4X stainless steel or fiberglass reinforced polyester.
- F. Electrical Interlock Contacts
 1. Provide electrical interlock contacts on all disconnect switches serving motors in which remote VFDs are serving the motor. Provide conductors from contacts to the safe circuit inside the VFD. De-energizing the disconnect switch shall signal VFD to stop.
- G. Service Entrance
 1. Switch shall be suitable for use as service entrance equipment when installed in accordance with the National Electrical Code.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install safety and disconnect switches, including electrical connections, and fuses in accordance with manufacturer's written instructions, NEC and recognized industry practices.
- B. Location: Install switches within sight of controllers.
- C. Hubs: Provide bolt-on hubs for rainproof or wet area applications.

3.2 IDENTIFICATION

- A. Nameplate: Each disconnect switch shall have an engraved bakelite nameplate. Nameplates shall be white with black letters and show equipment served. Nameplates shall be attached with stainless steel screws.

END OF SECTION

SECTION 26 29 13 MOTOR STARTERS

PART 1 - GENERAL

1.1 SCOPE

- A. Provide motor starters as shown, scheduled and as specified herein.
- B. The types of motor starters include:
 - 1. Individual motor starters.
 - 2. Combination motor starters.
 - 3. Manual motor starters.
- C. All motor starters for equipment furnished under Division 23 shall be installed under Division 26 requirements unless noted otherwise on the plans.

1.2 STANDARDS

- A. Products shall be designed, manufactured, tested and installed in compliance with applicable standards.
- B. Products shall conform to all applicable UL standards and shall be UL-labeled.

1.3 ACCEPTABLE MANUFACTURERS

- A. Provide one of the following manufacturers:
 - 1. General Electric Company/ABB
 - 2. Square D Company
 - 3. Siemens
 - 4. Eaton

1.4 SUBMITTALS

- A. Shop drawings shall include, but not be limited to:
 - 1. Cutsheets of all enclosures, circuit breakers, fusible and non-fusible switches, overloads, ratings, schedules and all accessories clearly labeled.

1.5 REQUIREMENTS OF REGULATORY AGENCIES

- A. WORK IN ACCORDANCE WITH:
 - 1. National Electrical Code.
 - 2. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.1 MOTOR STARTERS

- A. GENERAL: Motor starters shall be Square D Company Class 8536 across-the-line magnetic type, full-voltage, non-reversing (FVNR) starter. Provide FVNR speed, single winding starter where indicated. Provide FVNR two speed, single winding or two speed, two winding starters where indicated. Provide Square D Class 8736 "FVR" with selector switch for motors being served by a variable speed drive. All starters shall be constructed and tested in accordance with the latest NEMA standards, sizes and horsepower. IEC sizes are not acceptable. Starters shall be mounted in a general purpose dead front, painted steel enclosure and surface-mounted. Provide size and number of poles as shown and required by equipment served.
- B. CONTACTS: Magnetic starters contacts shall be double break solid silver alloy.
 - 1. All contacts shall be replaceable without removing power wiring or removing starter from panel. The starter shall have straight-through wiring.

- C. OPERATING COILS: Operating coils shall be 120 volts and shall be of molded construction. When the coil fails, the starter shall open and shall not lock in the closed position.
- D. OVERLOAD RELAYS: Provide manual reset, trip-free Class 20 overload relays in each phase conductor in of all starters. Overload relays shall be melting alloy type with visual trip indication. All 3 phase and single-phase starters shall have one overload relay in each underground conductor. Relay shall not be field adjustable from manual to automatic reset.
- E. PILOT LIGHTS: Provide a red "on" running pilot light and green "off" pilot light for all motor starters. Provide fast and slow pilot lights for two speed starters. Pilot lights shall be mounted in the starter enclosure cover and shall be "L.E.D.". Pilot lights shall be operated from an interlock on the motor starter and shall not be wired across the operating coil.
- F. CONTROLS: Provide starters with HAND-OFF-AUTOMATIC switches. Coordinate additional motor starter controls with the requirements of Division 23. Motor starter controls shall be mounted in the starter enclosure cover.
- G. CONTROL POWER TRANSFORMER: Provide a single-phase 480 volt control power transformer with each starter for 120 volt control power. Connect the primary side to the line side of the motor starter. The primary side shall be protected by a fuse for each conductor. The secondary side shall have one leg fused and one leg grounded. Arrange transformer terminals so that wiring to terminals will not be located above the transformer.
- H. AUXILIARY CONTACTS: Each starter shall have one normally open and one normally closed convertible auxiliary contact in addition to the number of contacts required for the "holding interlock", remote monitoring, and control wiring. In addition, it shall be possible to field-install three more additional auxiliary contacts without removing existing wiring or removing the starter from its enclosure.
- I. UNIT WIRING: Unit shall be completely pre-wired to terminals to eliminate any interior field wiring except for line and load power wiring and HVAC control wiring.
- J. ENCLOSURES: All motor starter enclosures shall be NEMA 1, general purpose enclosures or NEMA-3R if mounted outside. Provide NEMA 4X stainless steel mounted next to cooling towers.
- K. Power Monitor: Provide a Square "D" RM3TAR114TS7 or approved equal phase failure and under-voltage relay, base and wiring required for starters serving motors 5 horse power and larger. Set the under-voltage setting according to minimum voltage required for the motor to operate within its range.

2.2 COMBINATION MOTOR STARTERS

- A. GENERAL: Combination motor starters shall consist of a magnetic starter and a fusible or non-fusible disconnect switch in a dead front, painted steel NEMA 1 enclosure unless otherwise noted and shall be surface-mounted. Size and number of poles shall as shown and required by equipment served. Combination motor starters shall be as specified for motor starters in Paragraph 2.1/A, except as modified herein.
- B. DISCONNECT SWITCH: Disconnect switches shall be as specified in Section 26 28 16.

2.3 MANUAL MOTOR STARTERS

- A. GENERAL: Manual starters shall consist of a manually operated toggle switch equipped with melting alloy type thermal overload relay. Thermal unit shall be of one-piece construction and interchangeable. Starter shall be inoperative if thermal unit is removed. Contacts shall be double break, silver alloy, visible from both sides of starter. Manual starters shall be Square D class 2510 or 2512 or approved equal. Provide the size and number of poles shall be as shown and required by equipment served. Furnish red pilot light as indicated.
- B. ENCLOSURES: All manual motor starter enclosures shall be NEMA 1, general purpose enclosures, or NEMA-3R if mounted exposed to high moisture conditions. Provide NEMA-4X when mounted next to cooling tower.

PART 3 - EXECUTION

3.1 INSTALLATION OF MOTORS

- A. GENERAL: Mount electric motors which are not factory installed.
- B. MOTOR CONNECTIONS: Provide electrical and grounding connections to motors as indicated. Connections as follows:
 - 1. Not less than 18 inch length of Sealtite, extending from motor connection box to motor branch circuit conduit on outdoor and wet locations Provide Greenfield for inside dry locations
 - 2. Install connections mechanically secure, assuring electrical continuity, proper and effective grounding

3.2 INSTALLATION OF MOTOR STARTERS

- A. GENERAL: Install motor starters in accordance with the manufacturer's written instructions, the applicable requirements of the NEC and the NECA's "Standard of Installation", and recognized industry practices to ensure that products serve the intended function.
- B. OVERLOADS: Install overload heaters in each motor starter. Heater ratings shall be based on actual motor nameplate full load amps.
- C. COORDINATION: Motor starters shall be provided to properly coordinate with motors as furnished by Division 23. Motor starter controls shall be provided to properly coordinate with controls specified in Division 23.
- D. SUPPORTS: Motor starter enclosures shall be installed on galvanized unistrut or other supports where mounting on wall and shall not be supported by conduit alone. When enclosures are unit mounted on equipment served, the switch shall not inhibit the removal of any service panels or interfere with any required access areas. Combination starter disconnects and starters mounted in ceiling plenums shall be installed 18" above ceiling grid.

3.3 TESTING

- A. GENERAL: Check motor starters for continuity of circuits, for short circuits and demonstrate that it is functioning properly with HVAC controls.
- B. MOTOR-STARTER COORDINATION DOCUMENTATION: Provide motor-starter coordination documents including, but not limited to, the following information in the operation and maintenance manuals.
 - 1. Motor size in horsepower
 - 2. Motor full load amp
 - 3. Motor efficiency
 - 4. Service factor

5. Size and manufacturer catalog number of starter and thermal overloads.

END OF SECTION

SECTION 26 29 26
MISCELLANEOUS ELECTRICAL CONTROLS AND WIRING

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

1.2 SCOPE

- A. Provide the various miscellaneous control devices, wiring and additional branch circuits as required, shown and specified.
- B. The types of miscellaneous control devices and wiring include but not limited to the following.
 - 1. Contactors
 - 2. Relays
 - 3. Photocells
 - 4. Time switches
 - 5. Relay Panels
 - 6. Additional control wiring and safety devices as shown and specified
 - 7. Connect power from fire alarm relays to starters to shut down air handling units
 - 8. Elevator power module switches
 - 9. Motorized Dampers
 - 10. Smoke Dampers and Combination Fire/Smoke Dampers
- C. WORK SPECIFIED ELSEWHERE:
 - 1. Various control devices, of an electrical nature, for the safe operation and temperature control of the heating, ventilating, air conditioning and plumbing systems provided under Division 22 and Division 23.
 - 2. All control wiring and conduit shall be furnished under Division 23. All power wiring 120 volt or larger shall be provided by Division 26.
 - 3. Refer to building controls specification, Division 23 for scope of work required to be performed by Division 26 (electrical contractor).
 - 4. Specification 26 05 19 - Wire, Cable and Related Materials.

1.3 REFERENCE STANDARDS

- A. ASME A17.1 - Safety Code for Elevators and Escalators Includes Requirements for Elevators, Escalators, Dumbwaiters, Moving Walks, Material Lifts, and Dumbwaiters with Automatic Transfer Devices.
- B. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts.
- C. NFPA 70 - National Electrical Code.
- D. NFPA 72 - National Fire Alarm and Signaling Code.
- E. UL 98 - Enclosed and Dead-Front Switches.
- F. UL 508 - Industrial Control Equipment.
- G. UL 916 - Energy Management Equipment.
- H. UL 924 - Emergency Lighting and Power Equipment.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

- A. WORK IN ACCORDANCE WITH:
 - 1. NFPA 70
 - 2. Local municipal or state codes that have jurisdiction.