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COMMON HVAC MATERIALS AND METHODS

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PART 1 - GENERAL

1.01 DESCRIPTION

- A. The provisions of the General Requirements, Supplementary Requirements, and Division 1 apply to the HVAC work specified in this Division.
- B. The requirements of this Section apply to the HVAC systems specified in these Specifications and in other Division 23 sections.
- C. Provide all items, articles, materials, equipment, operations and/or methods listed, mentioned, shown and/or scheduled on the Drawings and/or in these Specifications, including all labor, supervision, services, permits, fees, and incidentals necessary and required to provide a complete and operable facility with complete systems as shown, specified, and required by applicable codes.
- D. The work shall include, but not be limited to, the following systems:
 - 1. Central heating and cooling equipment.
 - 3. Complete piping systems including insulation, valves, supports, etc.
 - 4. Air handling equipment including packaged equipment and exhaust fans.
 - 5. Air distribution systems including ductwork, terminal units, dampers, insulation, and air inlets and outlets.
 - 6. HVAC control system.
 - 7. Special systems as specified herein.
- E. Advise subcontractor, suppliers, and vendors involved in the work specified in this Section of the applicable requirements.

1.02 QUALITY ASSURANCE

- A. All work and materials shall conform to all applicable local and state codes and all federal, state and other applicable laws and regulations. All clarifications and modifications which have been cleared with appropriate authorities are listed under the applicable sections. All electrical products shall bear the label of a recognized testing laboratory such as UL or CSA..
- B. Whenever the requirements of the Specifications or Drawings exceed those of the applicable code or standard, the requirements of the Specifications and Drawings shall govern.
- C. Codes and Standards: Comply with the provisions of the following referenced codes, standards and specifications:
 - 1. Federal Specifications (FS)
 - 2. American National Standards Institute (ANSI)
 - 3. National Electrical Manufacturer's Association (NEMA)
 - 4. National Fire Protection Association (NFPA)
 - 5. Underwriters Laboratories, Inc. (UL)
 - 6. Factory Mutual (FM)
 - 7. International Building Code (IBC) with State and Local Amendments
 - 8. International Mechanical Code (IMC) with State and Local Amendments
 - 9. Uniform Plumbing Code (UPC) with State and Local Amendments
 - 10. American Society for Testing and Materials (ASTM)
 - 11. Americans with Disabilities Act (ADA)
 - 12. International Fire Code (IFC) with State and Local Amendments
 - 13. Energy Policy Act (EPAct)
 - 14. Manufacturers Standardization Society (MSS)

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15. American Gas Association (AGA)

- D. Each piece of equipment furnished shall meet all detailed requirements of the Drawings and Specifications and shall be suitable for the installation shown. Equipment not meeting all requirements will not be acceptable, even though specified by name. Where two or more units of the same class of equipment are furnished, use product of the same manufacturer; component parts of the entire system need not be products of same manufacturer. Furnish all materials and equipment, new and free from defect and of size, make, type and quality herein specified or approved by the Architect. All materials shall be installed in a neat and professional manner.
- E. All apparatus shall be built and installed to deliver its full rated capacity at the efficiency for which it was designed.
- F. The Drawings and Specifications are complementary. What is called for by one shall be as though called for by both.
- G. Drawings: Do not scale drawings for roughing-in measurements, nor use as shop drawings. Make field measurements and prepare shop drawings as required. Coordinate work with shop drawings of other specification divisions.
- H. Field Wiring: It is the intent of these specifications that all systems shall be complete and operable. Refer to all drawings and specifications, especially the electrical drawings, to determine voltage, phase, circuit ampacity and number of connections provided. Provide all necessary field wiring and devices from the point of connection indicated on the electrical drawings. All equipment shall be installed in compliance with the Electrical Code and the equipment's UL listing. Bring to the attention of the Architect in writing, all conflicts, incompatibilities, and/or discrepancies prior to bid or as soon as discovered.

1.03 WORK OF OTHER CONTRACTS

- A. Work under this contract shall be conducted in a manner to allow for the future installations of such equipment or items listed in other sections of this Specification.

1.04 WORK OF OTHER DIVISIONS

- A. Work under this Division shall be conducted in a manner to cooperate with the installation of such equipment or items as specified in other Divisions.
- B. Plumbing piping systems and fixtures and fire suppression piping systems are specified under other Divisions of these Specifications except for provisions or items specifically noted on the Drawings or specified herein.
- C. Consult all Drawings and Specifications in this project and become familiar with all equipment to be installed. Coordinate all aspects of the construction with the other trades on the job to ensure that all work and materials required to provide a complete and operational facility are included in the bid.
- D. All sections of Division 23 are interrelated and shall be considered in their entirety when interpreting any material, method, or direction listed in any section of Division 23. Individual sections are not written for specific subcontractors or suppliers but for the general contractor.

1.05 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES (SUBMITTALS)

- A. Submit in accordance with Division 1 full technical and descriptive shop drawing data on proposed materials and equipment as detailed in each section.
- B. The Contractor shall verify that all equipment submitted can be delivered and installed within the time constraints of the construction period.

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- C. Include the manufacturer, type, style, catalog number, complete specification, certified dimensions, and description of physical appearance for each item and option submitted. Reproduction of catalog data sheets shall be clean and legible to show all details, including gauge of metal used.
- D. Include only information on exact equipment to be installed, not general catalogs of the manufacturer. Where sheets show proposed equipment as well as other equipment, identify proposed equipment with rubber stamp arrow or similar concise method.
- E. Submit with each copy a transmittal letter verifying that all included equipment submittals have been carefully considered for quality, dimensions, function, and have been coordinated with the Drawings and Specifications. Guarantee that proposed materials will meet or exceed the quality and function of those specified.
- F. Include field wiring diagrams and connection diagrams for all control and/or low voltage systems, including floor plans.
- G. Submittal Review: The submittal review process is a means to provide quality control. The action noted to be taken (or where conflicts with the contract documents are not noted) shall not be interpreted by the Contractor as automatic "change orders." Approval of the data for substitution and shop drawings shall not eliminate the contractor's responsibility for compliance with Drawings or Specifications, nor shall it eliminate the responsibility for freedom from errors of any sort in the data discovered prior to or after the review process. Deviations, discrepancies, and conflicts between the submittals and the Contract Documents shall be called to the Architect's attention in writing at the time of transmittal of the data.
- H. Unless otherwise directed by Division 1, submittal data shall be in a 3-ring plastic binder with a clear plastic sleeve and a project identification sheet inserted. Arrange submittals numerically with specification sections identified on divider tabs. All required sections shall be submitted at one time.

1.06 PRODUCT SUBSTITUTION

- A. Materials other than those specified may be approved for this project providing a written request is submitted to the Architect prior to bid in accordance with Instructions to Bidders. Requests shall include complete specifications, dimensions, manufacturer and catalog number for each item for which approval is desired. If, in the opinion of the Architect, the material is not complete or if it is not an acceptable substitute, he may reject it. The Architect's evaluation will be based solely on the material submitted.

1.07 CHANGE ORDERS

- A. All supplemental cost proposals by the Contractor shall be accompanied by a complete itemized breakdown of labor and materials without exception. At the Architect's request, the contractor's estimating sheets for the supplemental cost proposals shall be made available to the Architect. Labor must be separated and allocated for each item of work.

1.08 RECORD DOCUMENTS

- A. Project Record (As-Installed) Drawings:
 - 1. Maintain a set of record drawings on the job site as directed in Division 1.
 - 2. Keep Drawings clean, undamaged, and up to date.
 - 3. Record and accurately indicate the following:
 - a. Depths, sizes, and locations of all buried and concealed piping dimensioned from permanent building features.
 - b. Locations of all valves with assigned tag numbers.
 - c. Locations of all fire dampers and other airflow control devices.
 - d. Changes, additions, and revisions due to change orders, obstructions, etc. Eradicate

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extraneous information.

- e. Model numbers of installed equipment.
 - 4. Make Drawings available when requested by Architect for review.
 - 5. Submit as part of the required Project Closeout documents. Final submittal will be in the form of reproducible drawings.
 - 6. Quality of entire set of project record drawings to match the quality of the contract documents; quality to be judged by Architect. Computer-aided design drafting (CADD) shall be used to complete project record drawings. Use standards set in contract documents. Note field modifications, all addenda, and change order items on project record drawings. If deficiencies are found in either the quality or the accuracy of the drawings, they will be returned unapproved. Additional review of subsequent submissions shall be at the contractor's expense.
- B. Operating and Maintenance Manuals: Submit five (5) sets of Operating and Maintenance Instructions, including manufacturer's service data, wiring diagrams, and parts lists and vendors for all serviceable items of equipment, valve charts, balancing data, final control diagrams showing final set points, and any additional equipment added by change order, bound in three-ring, vinyl or canvas covered, loose-leaf binders organized with index and thumb-tab markers for each classification of equipment or data.
- C. Instruction Manual: Submit separate Instruction Manual 30 days prior to scheduling the required Instruction Period. Include the following:
- 1. Description of each system and operational sequences.
 - 2. Seasonal system adjustments.
 - 3. Description and normal settings for time clocks, thermostats, fan and other motor switches, etc.
 - 4. Normal valve settings.
 - 5. Emergency measures upon system failure.
 - 6. Cross reference information furnished by manufacturer in the Operating and Maintenance Manual above.

1.09 WARRANTY

- A. Furnish, prior to application for final payment, three copies of written and signed guarantee effective a period of one year from date of completion and acceptance of entire project; agree to correct, repair and/or replace defective materials and/or equipment or the results of defective workmanship without additional expense to the Owner. Where no response satisfactory to the Owner has occurred within three working days from the written report of a warranty covered defect, the contractor shall agree to pay for the cost of repair of the reported defect by a contractor of the Owner's choice.
- B. Where the manufacturer's guarantee exceeds one year, the longer guarantee shall govern and include the Contractor's labor.

PART 2 - PRODUCTS

2.01 GENERAL

- A. General: Provide all new materials and equipment, identical to apparatus or equipment in successful operation for a minimum of two years. Provide materials of comparable quality omitted here but necessary to complete the work. Maximum allowable variation from stated capacities, minus 5% to plus 10% as approved in each case.
- B. Compatibility: Provide products which are compatible with other portions of the work and provide products with the proper or correct power and fuel-burning characteristics, and similar adaptations for the project.

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- C. Efficiency: Heating and cooling equipment shall comply with ASHRAE Standard 90.1-2001 and the State Energy Code. Where equipment efficiencies are indicated, the use of alternate or substitute manufacturer's equipment with lower efficiencies is not permitted.
- D. Storage and Handling:
 - 1. Delivery: Deliver to project site with manufacturer's labels intact and legible.
 - 2. Handling: Avoid damage.
 - 3. Storage: Inside protected from weather, dirt and construction dust. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping.

2.02 MOTORS

- A. General: Motors shall conform to UL, CSA, and NEMA MG-1 and bear a permanently attached nameplate indicating compliance and motor characteristics. Provide motors meeting UL 507 standard where applicable.
- B. Manufacturers: General Electric, Lincoln, Baldor, Wagner, Westinghouse or accepted substitute. Where selection of motor manufacturer is within Contractor's control (independent of equipment selection), provide motors produced by a single manufacturer to the greatest extent possible.
- C. Temperature Rating: Class B insulation, except where otherwise indicated or required for service indicated.
- D. Starting Capability: As required for service indicated, but not less than 5 starts per hour.
- E. Phases and Current: 1/3 horsepower and smaller capacitor-start, capacitor-run single-phase; 1/2 horsepower and larger, squirrel-cage induction polyphase. Coordinate with actual current characteristics; specified in Division 16 and use no 230/460 voltage motors on 208 voltage power or vice versa.
- F. Service Factor: 1.15 for polyphase; 1.25 for single-phase.
- G. Construction: General purpose, continuous duty; NEMA design "B," except "C" for high starting torque applications.
- H. Frames: For single phase motor sizes NEMA No. 48, except 56 for heavy-duty applications. NEMA "T" frames for 1 horsepower and larger polyphase motors. Special frame types as required for close coupled pumps and similar applications.
- I. Bearings: Ball or roller, and design for thrust where applicable; double shielded and regreasable, except provide permanently sealed where not accessible for greasing. Sleeve-type bearings permitted only where indicated for fractional (1/6 hp or less) horsepower motors with direct drive loads. Minimum L-10 bearing life of 40,000 hours when used with minimum pitch sheaves per NEMA Table 14-1.
- J. Enclosure Type: Unless otherwise indicated, open drip-proof for normal concealed indoor use, guarded where exposed to employees or occupants. Type II for outdoor use, except weather-protected Type I where adequately housed.
- K. Overload Protection: Built-in thermal with internal sensing device for stopping motor, and for signaling where indicated on single phase motors.
- L. Speed: Not faster than synchronous speeds of 1,800 RPM except on some pumps as approved in each case.
- M. Efficiency: The manufacturer's highest (premium) efficiency motors tested under procedures recommended by NEMA MG-1 (IEEE Standard 112, Test Method B). Intermittent duty motors,

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operating less than 6 hours per day, shall comply with EPA standards. Submit manufacturer's data if motor nameplate does not indicate minimum efficiency. Nominal full load efficiencies for 460 volt, 1,800 rpm motors:

<u>HP</u>	<u>Efficiency %</u>
1-1/2	87.5
2	87.5
3	88.5
5	89.5
7-1/2	91.5
10	91.5
15	93.0
20	93.5
25 and larger	94.0

- N. Inverter Duty Motors: Where motors are controlled by an adjustable frequency drive, provide motors labeled "Inverter Duty," complying with NEMA MG1-31, and meeting the requirements of the adjustable frequency drive manufacturer.

2.03 STARTERS AND SWITCHES

- A. Manufacturers: General Electric, ITE, Allen Bradley, Square D, Cutler-Hammer, Cerus Industrial or accepted substitute. Provide starters by same manufacturer throughout project.
- B. General: Provide each motor with starter or switch as approved and recommended by manufacturer of motor or equipment of which motor is a part.
- C. Starter Characteristics: Type I general purpose enclosure with padlock ears and supports for mounting as indicated. Starter type and size as recommended by motor manufacturer. Use no starter smaller than NEMA Size 1.
- D. Manual Switches: Provide on motors 1/3 horsepower and smaller except where automatic control or interlock is indicated. Include pilot light. Provide overload protection where not protected by internal motor overload protection.
- E. Magnetic Starters: Provide for 1/2 horsepower and larger motors, and for smaller motors on automatic control or with interlock switch. Full voltage, across the line, single speed, non-reversing except where otherwise required. Include power on and running pilot lights, on-off-auto selector switch, external reset button, overload relay on each phase, and devices for coordination with control system (including fused transformer for control circuit). Provide automatic ambient temperature compensation for starter heaters.

2.04 GUARDS

- A. Provide guards in accordance with State Safety Code and OSHA requirements over all rotating equipment including belts, shafts and couplings. Drive guards over belts and sheaves shall include 2-1/2" diameter access opening at shaft ends for speed counter.

2.05 DRIVES

- A. Acceptable Manufacturers: Dayton, Gates, Browning.
- B. General: "V" section belt drives, multiple as required, sized on 1.5 times installed motor horsepower. Provide variable pitch motor sheaves on all one or two belt drives and standard slide rails or approved means of adjustment for each motor with belt drive. Use standard section belts and no sheave smaller than cataloged industry standard; provide countersunk center on shaft ends to receive speed counter tip.

- A. General: Controllers listed and labeled as a complete unit and arranged to provide variable speed of a standard NEMA Design B 3-phase induction motor by adjusting output voltage and frequency of controller. Designed and rated by the manufacturer for the type of load (e.g., fans, blowers, and pumps) used and also approved by the manufacturer for the type of connection used between the motor and load (direct connection or power transmission connection).
- B. Input Line Reactors: 3% for reduction of harmonics.
- C. Output Line Reactors: Specially designed and constructed for IGBT controllers and designed to protect motor from voltage spikes over 150% of the bus voltage. Required where controller to motor cable length exceeds 50 feet. Provide dV/dT filters for 460 volt motors with extreme cable lengths.
- D. In lieu of providing line reactors, the drive manufacturers may submit a power system analysis demonstrating compliance with IEEE 519.
- E. Ratings:
 - 1. Output Ratings: 3-phase, 6 to 60 Hz, with voltage proportional to frequency throughout the voltage range.
 - 2. Starting Torque: 100 percent of rated torque, or as indicated.
 - 3. Speed Regulation: Plus or minus 1 percent.
 - 4. Ambient Temperature: 0° C to 40° C.
 - 5. Efficiency: 95 percent minimum features shall at full load, 60 Hz.
- F. Isolated Control Interface: Allow the controller to follow one of the following over an 11:1 speed range:
 - 1. Electrical Signal: 4 to 20 milliamperes at 24 V.
 - 2. Pneumatic Signal: 3 to 15 psig.
- G. Internal Adjustability: Provide the following internal adjustment capabilities:
 - 1. Minimum Speed: 5 to 25 percent of maximum RPM.
 - 2. Maximum Speed: 80 to 100 percent of maximum RPM.
 - 3. Acceleration: 2 to 22 seconds.
 - 4. Deceleration: 2 to 22 seconds.
 - 5. Current Limit: 50 to 110 percent of maximum rating.
- H. Self-Protection and Reliability Features:
 - 1. Input transient protection by means of surge suppressors.
 - 2. Snubber networks to protect against malfunction due to system voltage transients.
 - 3. Motor Overload Relay: Adjustable and capable of NEMA class 10 performance.
 - 4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 - 5. Instantaneous Overcurrent Trip.
 - 6. Loss of Phase Protection.
 - 7. Reverse Phase Protection.
 - 8. Under- and Over-Voltage Trips.
 - 9. Overtemperature Trip.
 - 10. Short Circuit Protection.
- I. Automatic Reset/Restart: Attempt three restarts after controller fault or on return of power to the system following an interruption and before shutting down for manual reset or fault correction. Provide for restarting during deceleration without damage to the controller, motor, or load.

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J. Operation and Maintenance Features: Include:

1. Status Lights: Door-mounted LED indicators to indicate power on, run, overvoltage, line fault, overcurrent, and external fault.
2. Elapsed Time Meter.
3. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer.
4. Current-Voltage-Frequency Indicating Devices: Mount meters or digital readout device and selector switch flush in controller door and connect to indicate controller output.
5. Auxiliary Motor Contactors: Electrically interlocked. One contactor connected between the controller output and the motor, controlled by the controller regulator, and one between the bypass power line and the motor, providing across-the-line starting capability in the bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.

K. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. ABB Power Distribution, Inc.
2. Allen-Bradley Co.
3. Furnas Electric Co.
4. General Electric Co.
5. Graham
6. Reliance Electric Co.
7. Square D Co.
8. Westinghouse Electric Corp.
9. Cerus Industrial

2.07 ACCESS PANELS

- A. Manufacturers: Inryco/Milcor, Bilco, Elmdor, Karp, Potter-Roemer or accepted substitute. Inryco/Milcor Style DW, K, or M panels as required by construction.
- B. Construction: Flush style, fire rated in fire rated partitions and ceilings. Screwdriver latches on all access panels.

2.08 EXPANSION JOINTS AND LOOPS

- A. Flexible Expansion/Seismic Loop: Factory fabricated assembly consisting of two 90 degree elbows, two lengths of flexible hose, and a 180 degree return bend to allow free movement in three axis. Return bend shall include attachment point for support and a drain/vent fitting. Hose shall be corrugated metal style with metal overbraid. Connections to match piping system except connection 2" and larger shall be flanged style. Metraflex "Metraloop."

2.9 METERS AND GAUGES

- A. General: Install meters and gauges where shown on the plans or specified elsewhere in these specifications.
- B. Pressure-Temperature Test Plugs:
 1. 1/4" or 1/2" NPT fitting of solid brass capable of receiving either an 1/8" OD pressure or temperature probe and rated for zero leakage from vacuum to 1000 psig. Neoprene valve core for temperatures to 200 deg. F., Nordel to 350 deg. F.
 2. Provide for each test plug a pressure gauge adapter with 1/16" or 1/8" OD pressure probe.
 3. Furnish a test kit containing one 2-1/2" dial pressure test gauge of suitable range, one gauge adapter with 1/16" or 1/8" OD probe and two 5" stem pocket test thermometers – one 0 to 220 degrees F and one 50 to 550 degrees F. Turn the kit over to the Architect.

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4. Cisco "P/T Plugs," Peterson "Pete's Plug" or approved substitute.

C. Thermometers: Liquid-in-glass, adjustable stem, separable sockets, plus 40 to 240 degrees F range (unless indicated otherwise). Weiss numbers are listed. Equivalent Taylor, Trerice, Weksler or approved substitute.

1. Wide case (9") in equipment rooms and all major equipment items. Weiss "9VS" series.
2. Narrow case (7") in all other locations. Weiss "7VS" series.

D. Pressure Gauges: Install on suction and discharge of all pumps and where shown on Drawings 4-1/2" dial, 0-100 psig graduation pressure gauges with Ashcroft No. 1106 pulsation dampers and stop cocks. Weiss UGE-1 or equivalent Ashcroft, Marsh, Trerice, Weksler.

2.10 VALVES

- A. General: Provide factory fabricated valves of the type, body material, temperature and pressure class, and service indicated. Bronze gate, globe and check valves shall comply with MSS-SP-80. Ball valves shall comply with MSS-SP-110. Iron gate and globe valves shall comply with MSS-SP-70. Iron check valves shall comply with MSS-SP-71. Butterfly valves shall comply with MSS-SP-67. Valve size same as connecting pipe size.
- B. Acceptable Manufacturers: Milwaukee, Crane, Grinnell, Nibco, Hammond, Stockham, Legend, Watts, and Walworth. Grooved end valves Victaulic, Tyco-Grinnell, Gruvlock, or accepted substitute. NIBCO numbers are given except as noted. Where possible, provide valves from a single manufacturer.
- C. Valve Styles: See individual Division 23 sections for valve styles.
- D. Butterfly Valve Operators: Locking lever for shut-off service; "Memory Stop" for lever handle with 10-position throttling plate for throttling service; gear operator with babbitt sprocket rim for chain-operated valves and gear operators on all 8" or larger valves.
- E. Butterfly Valve Style: Lug-type with cap screws for all valves utilized for equipment isolation for servicing. Lug and grooved style valves shall be capable for use as isolation valves and recommended by manufacturer for dead-end service at full system pressure.
- F. Insulated Valves: Install extended-stem valves in all piping specified as insulated, and arrange in the proper manner to receive insulation.
- G. Mechanical Actuators: Provide mechanical actuators with chain operators where indicated, where valves 4" and larger are mounted more than 7' above the floor, and where manual operation is difficult because of valve size, pressure differential or other operating conditions. Drop chains to 6'-6" above the floor.
- H. Selection of Valve Ends (Pipe Connections): Select and install valves with ends matching the types of pipe/tube connections.

2.11 HANGERS AND SUPPORTS

- A. General: Provide factory-fabricated horizontal piping hangers, clamps, hanger rod, inserts, supports, etc., of the indicated MSS type and size. The Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry Practice SP-58 and SP-69 are referenced in this section.
- B. Manufacturers: B-Line, Carpenter & Paterson, Grinnell, Michigan, Superstrut, Tolco, Erico, or accepted substitute. Grinnell figure numbers in parentheses where applicable (or other manufacturers as noted).
- C. Corrosion Protection: Provide materials which are zinc plated or factory painted to prevent

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corrosion. Prevent electrolysis in the support of copper tubing by the use of hangers and supports which are copper plated, plastic coated, or by other recognized industry methods.

- D. Seismic Requirements: Provide seismic restraints in accordance with OSSC Section 1613. Design restraint systems in accordance with "Seismic Restraint Manual: Guidelines for Mechanical Systems," Second Edition, 1998, SMACNA, or "A Practical Guide to Seismic Restraint" ASHRAE RP-812, 1999.
 - E. Horizontal Piping Hangers and Supports:
 - 1. Adjustable Clevis Hanger: MSS Type 1 (Fig. 260).
 - 2. Adjustable Band Hanger: MSS Type 7 (Fig. 97), fabricated from steel.
 - 3. Adjustable Swivel-Band Hanger: MSS Type 10 (Fig. 70).
 - 4. Clamp: MSS Type 4 (Fig. 212, 216).
 - 5. Double-Bolt Clamp: MSS Type 3 (Fig. 295A, 295H), including pipe spacers.
 - 6. Adjustable Saddle-Support: MSS Type 36 (Fig. 258) and MSS Type 37 (Fig. 259), including saddle, pipe and reducer. Fabricate base-support from steel pipe and include cast-iron flange or welded-steel plate.
 - 7. Channel Support System: Galvanized, 12 gauge channel and bracket support systems, single or double channel as indicated on the Drawings or as required by piping and equipment weights. Grinnell "Power Strut" channel. Acceptable Manufacturers: Super Strut, Globestrut, Bee, Kindorf or Unistrut.
 - F. Vertical Pipe Clamps:
 - 1. Two-Bolt Riser Clamp: MSS Type 8 (Fig. 261).
 - 2. Four-Bolt Riser Clamp: MSS Type 42 include pipe spacers at inner bolt-holes.
 - G. Hanger Attachment:
 - 1. Hanger Rod: Rolled threads, zinc plated. Right hand threaded.
 - 2. Turnbuckles: MSS Type 13 (Fig. 230).
 - 3. Weldless Eye-Nut: MSS Type 17 (Fig. 290).
 - 4. Malleable Eye-Socket: MSS Type 16 (Fig. 110R).
 - 5. Clevises: MSS Type 14 (Fig. 299).
 - H. Building Attachments:
 - 1. Concrete Inserts: MSS Type 18 (Fig. 282), steel or Grinnell Power-Strut PS349 continuous channel. Acceptable Manufacturers: Michigan Hanger, Globestrut, Unistrut, Super Strut.
 - 2. Clamps: MSS Type 19 (Fig. 285, 281), Type 20, 21 (Fig. 225, 226, 131), Type 23 (Fig. 86, 87, 88), Type 25 (Fig. 227), Type 27 through 30 where applicable.
- 2.12 IDENTIFICATION MARKERS
- A. Pipe Markers:
 - 1. Adhesive pipe markers of width, letter size and background color conforming to ANSI A13.1.
 - 2. Acceptable Manufacturers: Brady B946 with arrow banding tape or similar Seaton, Zeston, MSI.
 - B. Duct Markers:
 - 1. Adhesive duct markers 2¼"x14" with black text indicating contents on white background with directional flow arrow.
 - 2. Acceptable Manufacturers: Brady B946 or similar Seaton, Zeston, MSI.
 - C. Nameplates:

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1. Engraved nameplates, 1/16" thick, laminated 2-ply plastic, bottom ply white, outer ply black, letters formed by exposing bottom ply.
2. Size: 2" by 4" nameplates with 1/4" high letters.

D. Valve Tags:

1. 2" diameter, 18-gauge polished brass tags with 3/16" chain hole and 1/4" high stamped, black-filled service designation.
2. Acceptable Manufacturers: Seaton, Brady, MSI.

2.13 CONCRETE FOR MECHANICAL WORK

A. Classes and Applications: Provide strength classes with the following cement content and water/cement ratios for the indicated applications and similar required applications:

1. 4000 psi Class: 565 pounds cement/yard (6.0 sacks); 0.57 water/cement ratio. Provide 4000 Class for tanks, vaults, beam-type foundations and similar structures.
2. 3000 psi Class: 500 pounds cement/yard (5.25 sacks); 0.68 water/cement ratio. Provide 3000 Class for miscellaneous underground structural concrete, reinforced encasement, block type foundations (with smallest dimension at least 0.2 times largest dimension), curbs, pads, inertia blocks (unframed type), and similar structural support work.
3. 2500 psi Class: 450 pounds cement/yard (4.75 sacks); 0.75 water/cement ratio. Provide 2500 Class for plain encasement, thrust blocks, filling steel-framed units, and similar work.
4. Rough Grouting Class: 565 pounds cement/yard (6.0 sacks); 0.75 water-cement ratio; adjust aggregate sizes to facilitate placement. Use for rough grouting, not for setting equipment bases.
5. Backfill Class (Lean Concrete): 375 pounds cement/yard (4.0 sacks); 0.87 water/cement ratio. Use for backfilling where excavations are extended below point of support for mechanical work.

2.14 PENETRATION FIRE STOPPING

- A. Through-penetration fire stopping system tested and listed by Underwriters Laboratories. 3M, Metacaulk, SpecSeal, or approved.
- B. Select system for proper application based on wall construction, type of penetrating item, wall rating, etc.

PART 3 - EXECUTION

3.01 LAYOUT AND COORDINATION

- A. Site Examination: Before starting work, carefully examine site and all contract Drawings. Become thoroughly familiar with conditions governing work on this project. Verify all indicated elevations, building measurements, roughing-in dimensions and equipment locations before proceeding with any of the work.
- B. Utility Locations: The location of existing utilities, wires, conduits, pipes, ducts, or other service facilities are shown in a general way only on the Drawings and are taken from existing records. Ascertain whether any additional facilities other than those shown on the plans may be present and determine the exact location and elevations of all utilities prior to commencing installation.
- C. Sleeves, Inserts, Cast-in-Place Work: Provide sleeves, inserts, anchoring devices, cast-in-place work, etc. which must be set in concrete sequenced at the proper time for the project schedule.

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D. Coordination:

1. The drawings are based on equipment of a certain manufacturer and may be identified as such. Where alternate manufacturers or approved substitutes are incorporated into the work, any required design changes are the responsibility of the contractor. Such changes may include changes in utility or system connection sizes, location, or orientation, service clearances, structural support or acoustic considerations.
 2. Where the work must be sequenced and positioned with precision in order to fit into the available space, prepare accurate scale shop drawings showing the actual physical dimensions required for the installation and submit prior to purchase/fabrication/installation of any of the elements involved in the coordination.
 3. Cooperate with other trades in furnishing material and information for sleeves, bucks, chases, mountings, backing, foundations and wiring required for installation of mechanical items.
 4. Coordinate all work with other trades and determine in advance where interfacing of the mechanical work and other work are required to be connected together. Provide all materials and equipment to make those connections. Submit shop drawings showing required connections where special conditions exist.
- E. Discrepancies: Report immediately any error, conflict or discrepancy in Plans, Specifications and/or existing conditions. Do not proceed with any questionable items of work until clarification of same has been made. Should rearrangement or re-routing of piping be necessary, provide for approval the simplest layout possible for that particular portion of the work.

3.02 MECHANICAL EQUIPMENT WIRING

- A. Provide all mechanical equipment motors, automatic temperature, limit, float and similar control devices required, with wiring complete from power source indicated on Electrical Drawings.
- B. Provide properly rated motor overload and undervoltage protection and all manual or automatic motor operating devices for all mechanical equipment.
- C. Equipment and systems shown on the Drawings and/or specified, are based upon requirements of specific manufacturers which are intended as somewhat typical of several makes which may be approved. Provide all field wiring and/or devices necessary for a complete and operable system including controls for the actual selected equipment/system.
- D. Provide all starters for mechanical motors. Review Electrical Specifications and Drawings to determine which mechanical motor starters will be provided under the Electrical Specification Sections and provide all others.

3.03 GENERAL INSTALLATION

- A. Locating and Positioning Equipment: Observe all Codes, Regulations and good common practice in locating and installing mechanical equipment and material so that completed installation presents the least possible hazard. Maintain adequate clearances for repair and service to all equipment and comply with Code requirements.
- B. Arrangement: Arrange piping parallel with primary lines of the building construction, and with a minimum of 7' overhead clearance in all areas where possible. Unless indicated otherwise, conceal all piping. Locate operating and control equipment properly to provide easy access, and arrange entire mechanical work with adequate access for operation and maintenance. Give right-of-way to piping which must slope for drainage. Set all equipment level or as recommended by manufacturer. Under no conditions shall beams, girders, footings or columns be cut for mechanical items. Casting of pipes into concrete is prohibited unless so shown on Drawings.
- C. Drip Pans: Locate pan immediately below piping and equipment, and extend a minimum of 6" on each side and lengthwise 18" beyond equipment being protected. Fabricate pans 2" deep, of reinforced 20 gauge galvanized sheet metal with watertight seams and rolled or hemmed edges.

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Provide 3/4" drainage piping, properly discharged to over floor drain or as shown on the Drawings. Comply with Mechanical Code for overflow protection and pipe sizing.

- D. Access Panels: Provide access panels with proper backing reinforcement for all equipment, dielectric unions, valves and items requiring service and installed above ceilings, behind walls, or in furring, complete with correct frame for type of building construction involved. Exact size, number and location of access panels are not necessarily shown on Drawings. Use no panel smaller than 12" by 12" for simple manual access or smaller than 16" x 20" where personnel must pass through.
- E. Adjusting: Adjust and calibrate all automatic mechanical equipment, temperature controls, float devices, etc. Adjust flow rates at each piece of equipment or fixture.
- F. Building Vapor Barrier: Wherever the building insulation vapor barrier is penetrated by piping, hangers, conduits, etc., provide clear self-adhesive tape recommended by the insulation manufacturer around the penetrations.
- G. Concrete Work: Coordinate with other work, particularly other concrete work and accessories. Comply with applicable provisions for mechanical work concrete, including formwork, reinforcement, mix design, materials (use mix designs and materials accepted for Division 3 work where possible), admixtures, accessories, (including waterstops), placing of wet concrete, finishing, curing, protecting, testing, submittals and other requirements of the concrete work.
- H. Housekeeping Pads: Construct minimum 3" thick with chamfered edges using 3000 psi concrete. Provide #4 reinforcing bars 8" on center in each direction and within 4" of each edge, centered in pad thickness. Provide 1/2" dowel with 3" embedment into floor slab for each 2 square feet of pad area. Dowels and equipment anchor bolts shall be spaced a minimum of 6" from pad edges.

3.04 VALVE INSTALLATION

- A. General: Comply with the following requirements:
 - 1. Install valves where required for proper operation of piping and isolation of equipment, including valves in branch lines where necessary to isolate sections of piping, and where shown on the drawings. Install valves at low points in piping systems that must be drained for service or freeze protection.
 - 2. Locate valves in accessible spaces (or behind access panels) and so that separate support can be provided when necessary.
 - 3. Install valves with stems pointed up, in the vertical position where possible, but in no case with stems pointed downward from a horizontal plane.
- B. Insulated Valves: Install extended-stem valves in all piping specified as insulated, and arrange in the proper manner to receive insulation.
- C. Valve Access: Provide access panels to all valves installed behind walls, in furring or otherwise inaccessible.
- D. Lubricant-Seal: Select and install plug valves with lubricant-seal except where frequent usage is indicated or can be reasonably expected to occur.

3.05 INSTALLATION OF HANGERS AND SUPPORTS

- A. General: Proceed with the installation of hangers, supports and anchors only after the required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) the proper placement of inserts, anchors and other building structural attachments.
 - 1. Install hangers, supports, clamps, and attachments to support piping and equipment properly from the building structure. Use no wire or perforated metal to support piping, and no supports

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from other piping or equipment. For exposed continuous pipe runs, install hangers and supports of the same type and style as installed for adjacent similar piping.

2. Prevent electrolysis in the support of copper tubing by the use of hangers and supports which are copper plated or by other recognized industry methods.
3. Support fire sprinkler piping independently of other piping and in accordance with NFPA Pamphlet 13.
4. Arrange supports to prevent eccentric loading of joists and joist girders. Locate supports at panel points only.

B. Provisions for Movement:

1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate the action of expansion joints, expansion loops, expansion bends and similar units. Install specified seismic restraints to restrict excessive movement.
2. Install hangers and supports so that equipment and piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
3. Install hangers and supports to provide the indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 are not exceeded. Comply with the following installation requirements:
 - a. Clamps: Attach clamps, including spacers (if any), to piping outside the insulated piping support. Do not exceed pipe stresses allowed by ANSI B31.
 - b. Insulated Pipe Supports: Insulated pipe supports shall be supplied and installed on all insulated pipe and tubing.
 - c. Load Rating: All insulated pipe supports shall be load rated by the manufacturer based upon testing and analysis in conformance with ASME B31.1, MSS SP-58, MSS SP-69 and MSS SP-89.
 - d. Support Type: Manufacturer's recommendations, hanger style and load shall determine support type.
 - e. Insulated Piping Supports: Where insulated piping with continuous vapor barrier or where exposed to view in finished areas is specified, install hard maple wood insulation shields (Elcen Fig. 216) or steel pipe covering protection shields (MSS type 39) at each hanger.

C. Pipe Support:

1. Vertical Spacing: Support at base, at equivalent of every floor height (maximum 10' as required by Code) and just below roof line.
2. Screwed or Welded Steel or Copper Piping: Maximum hanger spacing shall be as follows:

	<u>Steel</u>	<u>Copper</u>
1-1/4" and smaller	7' span	6' span
1-1/2" pipe	9' span	6' span
2" pipe	10' span	10' span
2-1/2" & larger	12' span	10' span
3. Polyvinyl Chloride, Polypropylene and Other Plastic Pipe: Maximum hanger spacing and minimum rod diameters as follows:
 - a. Continuous support 1/2" to 4" pipe size Fee & Mason No. 109 channels with Fee & Mason No. 108 hanger. Lay pipe directly into the channel with fittings or couplings placed in spaces between channel sections. Secure piping to the channel at intervals between hangers with a few turns of vinyl electrical tape.
 - b. Non-Continuous Support: Maximum 4' spans or shorter if required by manufacturer for temperatures and pipe schedule.
 - c. Arrange supports to allow free movement, but restrict upward movement of lateral runs so as not to create reverse grade on drainage pipe. Use double bolt clamp or band hanger with restraint (Tolco fig. 25).
4. Install additional hangers or supports at concentrated loads such as pumps, valves, etc. to maintain alignment and prevent sagging.

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5. Support Rod: Hanger support rods sized as follows:

<u>Pipe and Tube Size</u>		<u>Rod Size</u>	
<u>Inches</u>	<u>mm</u>	<u>Inches</u>	<u>mm</u>
1/2" to 4"	12.7 to 101.6	3/8"	9.5
5" to 8"	127.0 to 203.2	1/2"	12.7
10" to 12"	254.0 to 304.8	5/8"	15.9

- D. Adjust hangers and supports to bring piping to proper levels and elevations.
- E. Provide all necessary structural attachments such as anchors, beam clamps, hanger flanges and brackets in accordance with MSS SP-69. Attachments to beams wherever possible. Supports suspended from other piping, equipment, metal decking, etc., are not acceptable.
- F. Horizontal banks of piping may be supported on common steel channel member spaced not more than the shortest allowable span required on the individual pipe. Maintain piping at its relative lateral position using clamps or clips. Allow lines subject to thermal expansion to roll axially or slide. Size channel struts for piping weights.
- G. Installation of drilled-in concrete anchors shall comply with the manufacturer's instructions for working load, depth of embedment, and spacing between anchors and from the edge of the slab. Use only wedge-style anchors.
- H. Seismic Restraints: Install restraints where recommended in SMACNA "Seismic Restraint Manual" and as required by code. Show analysis of supporting structure, anchorages, and restraints in accordance with OSSC Section 1613 and reference ASCE standard. Seismic restraint system components shall be approved by the California Office of Statewide Health Planning and Development (OSHDP). Acceptable Manufacturers: Amber/Booth, Mason Industries, Tolco, or approved.

3.06 HVAC SYSTEM IDENTIFICATION

- A. Piping System: Indicate each pipe system by its generic name (abbreviated) as shown/scheduled/specified. Comply with ANSI A13.1 for marker locations, letter sizes, and colors. Include arrows to show direction of flow and "Electric Traced" signs to identify heat cable wrapped piping. Locate pipe labels in accessible areas as follows:
 - 1. Near each valve, meter, gauge, or control device.
 - 2. Near equipment such as pumps, heat exchangers, water heaters, etc.
 - 3. At piping branch connections.
 - 4. At penetrations (each side) of walls, ceilings, and floors.
 - 5. At access panels and doors.
 - 6. At 25 foot maximum intervals. Provide a minimum of one label above each room where lift-out ceiling is installed. Reduce intervals in congested areas such as mechanical rooms.
- B. Valve Identification: Tag all valves with brass disc and chain. Prepare valve charts indicating valve number, size, location, function and normal position. Use no duplicate numbers in Plumbing and Heating systems. Mount glazed frames containing one set of valve charts in the building mechanical room.
- C. Equipment: Provide engraved plastic-laminate signs at locations of major equipment such as heat exchangers, pumps, etc. Identify equipment in field same as on drawings. Permanently mount in an appropriate and effective location.
- D. Operation Tags: Where needed for proper and adequate information on operation and maintenance of mechanical systems, provide tags of plasticized card stock, either pre-printed or hand printed to convey the message; example: "DO NOT CLOSE THIS VALVE EXCEPT WHEN THE PUMP IS OFF."

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3.07 EQUIPMENT CONNECTIONS

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- A. Provide complete connections for all items of equipment requiring such connections, including incidental piping, fittings, trim and labor necessary for a finished working installation.
- B. Verify the rough-in and finish requirements for all equipment provided under other Divisions of the work and requiring HVAC piping or duct connections with equipment supplier and installer prior to rough-in.

3.08 PROTECTION

- A. Protect all work and materials against loss or damage. Close all pipe openings with caps or plugs. At final completion, thoroughly clean and deliver all work and equipment in an unblemished new condition. Keep all motors and bearings in watertight and dustproof covers during entire course of installation.
- B. Protect floors, walls, framing and sheathing where pipe cutting and threading operations are conducted with plastic sheeting under plywood sheets. Extend plastic sheeting beyond the plywood. Clean-up metal cuttings, oil, etc., daily or as necessary to prevent debris from being tracked beyond the protected area. Damages, as determined by the Architect, due to the pipe cutting/threading operation shall be repaired by the responsible trade.

3.09 PIPE PENETRATION FIRE STOPPING

- A. Install as recommended by manufacturer and in accordance with the product's UL listing. Below are the minimum installation requirements.
 - 1. Install specified penetrating item(s) with required annular spacing in proper size wall or floor opening. Support penetrating item(s) adequately on both sides of construction.
 - 2. Clean all opening and penetrating item surfaces in penetration area to remove loose debris, dirt, oil, wax, grease, old caulking, etc.
 - 3. If needed or required for gypsum or concrete block walls, install specified galvanized steel wire mesh or sleeve recessed and centered inside wall around penetrating item(s) so that it is snug against perimeter of opening.
 - 4. When required, install specified type and depth of backing material in annular space, recessed to required fill depth of fire stopping caulking.
 - 5. Gun, trowel, and/or pump fire stopping sealant to specified depth in annular space around penetrating item(s). Trowel sealant surfaces flush with wall or floor surfaces to a smooth, defect-free finish. Where required, apply specified size caulking bead around penetrating item(s) at zero annular contact areas and tool smooth.

3.10 MECHANICAL PAINTING

- A. Minimum Requirements: All mechanical equipment, piping, insulation, etc., exposed in finished areas, storage rooms and other locations except mechanical equipment rooms will be painted under Section 09 90 00.
- B. Painting Materials: Materials shall comply with Section 09 90 00, Painting and shall be compatible with the material to be painted.
- C. Uninsulated Piping: Paint black or galvanized uninsulated piping located buried in ground, in concrete or masonry one (1) coat acid-resisting black paint. Paint black or galvanized uninsulated piping exposed to weather one (1) coat black asphaltum varnish.
- D. Iron Work: Paint hangers, rods, anchors, guides, threads of galvanized pipe, bases, supports, uncoated sheet metal and other iron work without factory finish, exposed to weather, one coat acid-resisting black paint. Apply one (1) coat Dixon's Aluminum Graphite No. 209 paint over the (1) coat

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primer as recommended by paint manufacturer to all hot metal surfaces.

- E. Piping in Mechanical Room: All insulated and uninsulated piping exposed in mechanical equipment rooms shall be painted. Painting is not required for cast iron, plastic, or glass waste piping, or for stainless steel piping, PEX tubing and soft copper tubing. Contractor shall submit proposed colors for approval. In lieu of painting, insulated piping may be covered with colored PVC insulation jacketing as specified in Section 23 07 00, HVAC Insulation.
- F. Insulated Piping and Other Insulated Surfaces: Paint insulated piping in half-round, split tile, or other inaccessible locations, one (1) coat asphalt emulsion.

3.11 HVAC WORK CLOSEOUT

- A. General: Refer to the Division 1 sections for general closeout requirements. Calibrate all equipment requiring same. Complete each system as shown or specified herein and place in operation except where only roughing-in or partial systems are called for. Each system shall be tested and left in proper operation free of leaks, obstructions, or contamination.
- B. Record Drawings: Submit record set of drawings as previously specified in this Section.
- C. Closeout Equipment/Systems Operations: Sequence operations properly so that work of project will not be damaged or endangered. Coordinate with seasonal requirements. Operate each item of equipment and each system in a test run of appropriate duration with the Architect present, and with the Owner's operating personnel present, to demonstrate sustained, satisfactory performance. Adjust and correct operations as required for proper performance. Clean and lubricate each system and replace dirty filters, excessively worn parts and similar expendable items of the work.
- D. Operating Instructions: Conduct a walk-through instruction seminar for the Owner's personnel who are to be involved in the continued operation and maintenance of the HVAC equipment and systems. Provide written instructions outlining and explaining the identification system, operational diagrams, emergency and alarm provisions, sequencing requirements, seasonal provisions, security, safety, efficiency and similar features of the systems.

END OF SECTION