

**SECTION 16500
BASIC MATERIALS AND METHODS**

PART 1 - GENERAL

1.1 MATERIALS

- A. All materials shall be new, as specified or approved, and in original packaging.
- B. Contractor shall schedule delivery and provide for receipt, handling, storage and protection of material.
- C. Contractor shall replace any material which is damaged due to delivery, handling, storage or lack of protection.
- D. Catalog numbers specified shall be verified with vendors prior to ordering material.
- E. All materials shall be UL labeled unless special fabrication of material is required.
- F. Special fabricated material shall be fabricated using UL labeled components and procedures.
- G. Material provided shall be in accordance with local code requirements.
- H. Where the word "provide" is used, it shall require the contractor to furnish and install material complete to a workable system.

1.2 WORKMANSHIP

- A. Provide for all labor and materials necessary for complete installation of wiring system for lighting and power.
- B. All work shall be installed complete and left in operating condition.
- C. Provide minor items which are necessary to complete work and even though they are not specified, such items as bolts, nuts, washers, anchors, brackets, sleeves, etc.
- D. Installation of equipment shall conform to applicable published standards.

1.3 CODES AND FEES

- A. Work and materials shall be in full accordance with the latest adopted and enforced edition of the following codes:
 - 1. National Electrical Code
 - 2. State and Local Electrical Installation Codes and Ordinances
 - 3. State and Local Building Codes and Ordinances
 - 4. State and Local Fire Codes and Ordinances
- B. Provide all necessary permits and licenses. Procure certificates as required for work installed.
- C. Provide for inspections by regulating agencies.
- D. Submit final inspection certificate signed by the local Electrical Inspector to Owner's Representative completion.

1.4 TESTS

- A. All work shall be tested in accordance with industry accepted standards.
- B. Before testing, a thorough visual inspection shall be made to detect connection problems, damaged components, poor workmanship, inappropriate overcurrent protection, debris, etc.
- C. Testing apparatus shall be certified or demonstrated to be accurate within reasonable limits.

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- D. Competent personnel familiar with the test equipment shall perform all tests.
- E. If testing procedures employed are not satisfactory to the Owner, outside testing will be done at the Contractor's expense.
- F. Document the test results and provide the Owner's Representative with the following:
 - 1. Date of Test
 - 2. Test Type
 - 3. Test Instruments Used
 - 4. Readings
 - 5. Failures, If Any
 - 6. Corrective Measures Taken
- G. Tests Required (As Applicable)
 - 3. Systems - Factory representative's letter certifying proper operation of systems as per Contract Documents.
 - 4. Lighting Control - Same as "Systems" test.

1.5 WORK PROGRESS

- A. Contractor to provide tools, material, manpower and equipment, as required, to keep up with the scheduled progress of the project.
- B. Problems shall be brought to the attention of the Owner's Representative immediately.

1.6 PEOPLE PROTECTION

- A. Contractor shall be legally responsible for all means and methods used throughout construction.
- B. Contractor shall install guards and barriers at electrical equipment to limit the approach of unauthorized personnel.
- C. No work shall be done on energized equipment.
- D. Contractor shall provide protective padding for any equipment mounted less than +6'-0" in walking areas.

1.7 SLEEVES, OPENINGS, CUTTING, PATCHING AND DRILLING

- A. Contractor is responsible for all openings, cutting, patching and drilling.
- B. Sleeve openings shall be with rigid pipe and set 1" minimum above finish floor.
- C. Penetrations through existing structural floors and walls shall be made with core drill.
- D. Exact locations of penetrations shall be verified with structural engineer such that structural integrity is maintained.
- E. Cutting and patching in finished spaces shall be such that the surface is restored to original condition.

1.7 FIRE STOPPING

- A. Seal all penetrations and sleeves through fire rated walls and floors with Chase Technology CTC PR-855 fire stop, 3M Brand Fire Barrier Penetration System, or Nelson Flameseal System.

1.8 MOUNTING HEIGHT OF DEVICES

- A. Unless otherwise shown or noted, position devices in structural course work such that a minimum of course work is cut.

1.9 HANGERS AND SUPPORTS

- A. Provide all hangers and supports such that they are suitable in strength and anchorage

for load imposed.

- B. Anchorage shall be by cast-in-place concrete type equal to UNISTRUT where possible.
 - 1. Expanding type masonry anchors are acceptable when cast-in-place cannot be used.
 - 2. Other anchor methods must be approved by Owner's Representative.
- C. Conduit banks shall be supported as follows:
 - 1. Structural channel as appropriate for load equal to UNISTRUT.
 - 2. 3/8" minimum rod support.
 - 3. 1" conduit and smaller - supports shall occur 7'-0" on center.
 - 4. Conduit over 1" - supports shall occur 10'-0" on center.
 - 5. All conduit to be strapped to channel.
- D. In all areas where supports and hangers are subjected to vibration, spring type lock washers shall be used.
- E. Individual conduit runs shall be supported by steel fasteners, such as caddy clips, suspended ring hangers or as application dictates.
- F. Twisted bailing wire will not be acceptable.
- G. Support for panelboards, terminal cabinets, transformers and other similar equipment shall be made by providing adequate interior wall studs or exterior structural channel equal to UNISTRUT.

1.10 IDENTIFICATION OF ELECTRICAL ITEMS

- A. Contractor to identify all electrical equipment with stenciled 1/4" white letters on black micarta plates as follows:
 - 1. Main service equipment
 - 2. Panelboards (in finished areas, plate shall be behind door).
 - 3. Disconnects, power distribution pull boxes, terminal cabinets, systems control cabinets, motor switches and starters.
 - 4. Any equipment which falls under the general intent of this section.
- B. In finished spaces, where specified, lighting switches, receptacles, motor controls, etc. shall be identified by their plates being engraved with 1/8" letters and filled with black paint.
- C. All conduit shall be color coded by colored bands 2" wide applied at panel and junction box locations within each room and 50' on centers within an area.
 - 1. Color Banding as follows:
 - a. 120/208 Volt - Gray
 - b. Fire Alarm - Red
 - c. Telephone - Blue
 - d. Sound - Yellow
 - e. Security - Green
 - f. Other colors as need dictates
- D. All low voltage cables shall be bundled and labeled as to their function.
- E. Provide typed electrical, communication and special system cabinet directories on the inside covers.

1.11 BRANCH CIRCUIT NUMBERS

- A. Branch circuitry shall match circuit numbers as shown on the drawings and as scheduled. Any required deviation shall be indicated on the as-built drawings.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

A. Laying Out work:

1. Carefully lay out all work in advance of installation using data and measurements from the site, the appropriate architectural and structural drawings, and shop drawings. Confirm code required clearances. Do not infringe upon space required for operation, maintenance, or clearance for items installed by other contractors.
2. Prior to installation of any work, make certain the location does not conflict with other items in or near the same location. If the layouts so prepared indicate that the required conditions cannot be met in the space provided, inform the Architect/Engineer prior to installation and request clarification.
3. Failure to properly coordinate and lay out work will require correction by the Contractor at the Contractor's expense.

- B. Data and Measurements: Data given herein and on the drawings is as accurate as could be secured; absolute accuracy is not guaranteed. Obtain exact locations, measurements, levels, etc., at the site and adapt work to actual conditions. Examine the general construction, mechanical, electrical, and other applicable drawings and the specifications. Plans and specifications are available for examination at the office of the Architect/Engineer. Utilize only architectural drawings, structural drawings, and site measurements in calculations. Mechanical and electrical drawings are diagrammatic or schematic.

3.2 ELECTRICAL SUPPORTING DEVICE APPLICATION

- A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.
- B. Dry Locations: Steel materials.
- C. Selection of Supports: Comply with manufacturer's written instructions.
- D. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four.

3.3 SUPPORT INSTALLATION

- A. Install support devices to securely and permanently fasten and support electrical components.
- B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.
- C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
- D. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

- E. Install 1/4-inch- diameter or larger threaded steel hanger rods, unless otherwise indicated.
- F. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.
- G. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.
- H. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches from the box.
- I. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.
- J. Mount electrical equipment located on exterior walls or other damp locations on U-channel system components.
- K. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves during erection of concrete and masonry walls. Extend sleeves 1 inch above floor in mechanical spaces and unfinished spaces. Seal sleeves through exterior walls with watertight caulking after installation of conduit. Space sleeves a minimum of three sleeve diameters on center.
- L. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:
 - 1. Wood: Fasten with wood screws or screw-type nails.
 - 2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
 - 3. New Concrete: Concrete inserts with machine screws and bolts.
 - 4. Existing Concrete: Expansion bolts.
 - 5. Steel: Welded threaded studs or spring-tension clamps on steel.
 - a. Field Welding: Comply with AWS D1.1.
 - 6. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
 - 7. Light Steel: Sheet-metal screws.
 - 8. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.5 EQUIPMENT CONNECTION

- A. General:
 - 3. Verify all control wiring requirements with manufacturer certified shop drawings for each piece of equipment or control system and install accordingly. Install control wiring in conduit.

3.9 WORK IN EXISTING BUILDINGS

- A. General: Execute work in the existing building, indicated on the drawings or specified herein, with a minimum amount of interference with the normal activities of the occupants of the building.

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Schedule work in advance with the Owner and proceed only with the Owner's written approval.

- B. Utilities: Do not interrupt utilities without the Owner's prior written approval regarding the time and duration of such interruptions. Do not disconnect utilities to existing facilities until new or temporary facilities are installed except for short periods of interruption which are necessary for the performance of the new work and which are approved by the Owner.
- E. Noisy Operations: Schedule noisy operations, such as those involving use of air hammers, etc., in demolition or cutting of openings, with the Owner.
- F. Occupancy: The Owner will continue to occupy the building and carry on normal activity. Protect the occupied areas from dust, smoke, etc., by a method reviewed by the Architect/Engineer.
- G. Owner's Right to Direct Work: The Owner shall have the right to direct the places of beginning work, its prosecution, and the manner in which all work under this contract is to be conducted, insofar as may be necessary to secure the safe and proper progress and quality of the work.
- H. Existing Conduits or Electrical Equipment: Remove or relocate, as required, or as directed by the Architect/Engineer, existing conduit or electrical equipment which would interfere with the proper installation of new work. Modify existing work in conformance with these specifications. Use the same materials as for new work unless otherwise specified.

3.10 DEMOLITION AND REMODEL

- A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
- C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.
- D. Remove demolished material from Project site.
- E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.
- F. Remove all existing lights, receptacles, switches, etc., indicated on plans or which are not indicated but must be removed to accommodate demolition or new remodeling.
- G. Where existing walls are indicated to be removed, disconnect power to electrical devices and associated appurtenances relating to the walls. Maintain circuit continuity up and down stream from removed outlets. Extend circuiting to up and downstream devices and reconnect as required. Where existing site lighting fixtures are removed, verify the routing of existing circuits. Maintain circuit continuity between existing fixtures which remain.
- H. In areas which are remodeled, replace existing wire with new wire. No existing wire is permitted to remain unless noted. Existing concealed conduit and boxes may be reused.
- I. Verify existing conditions in field prior to bid date.

3.11 CUTTING AND PATCHING

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- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

3.12 FIELD QUALITY CONTROL

- A. Inspect installed components for damage and faulty work, including the following:
 - 1. Raceways.
 - 2. Building wire and connectors.
 - 3. Supporting devices for electrical components.
 - 4. Concrete bases.
 - 5. Electrical demolition.
 - 6. Cutting and patching for electrical construction.
 - 7. Touchup painting.

3.13 CLEANING AND PROTECTION

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, AND finishes are without damage or deterioration at time of Substantial Completion.

END OF SECTION

**SECTION 02 41 00
DEMOLITION**

PART 1 GENERAL

1.1 SECTION INCLUDES

- 1.A. Removal and disposal of existing equipment, structures, and associated work.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 PREPARATION

1.A. Site Inspection:

- 1.A.1.a. Prior to all work of this section, carefully inspect entire site and work areas, and all objects designated to be removed and to be preserved.
- 1.A.1.b. Contractor is responsible for determining actual site conditions, extent to which demolition is required, and method of demolition.
 - 1.A.1.b.1) Demolition work shown on Drawings is intended to represent general intent only. Demolition shall be complete and adequate for intended purpose and all necessary work, in addition to work indicated on plans and specifications, shall be included.
- 1.A.2. Locate all existing equipment and determine extents and requirements for removal.
- 1.A.3. Locate all existing utilities and determine all requirements for disconnecting and capping.

1.B. Clarification:

- 1.B.1. Drawings do not purport to show all objects existing on the site or work areas. Review Work shown on Drawings and sections and verify that conditions as indicated are representative of in-place construction.

- 1.C. Disconnect, remove, and cap designated utility services within demolition areas shown on Drawings.

- 1.D. Mark location of disconnected utilities.

3.2 PROTECTION

- 2.A. Exercise extreme caution if it is necessary to remove any adjoining construction, walls, structure and framing so as to preserve the structural integrity, finish and appearance of the existing construction or wall shown to remain. Any required structural removal to accomplish demolition and removal of existing equipment is to be replaced as part of the equipment reinstallation process. Surfaces replaced are to match existing.
- 2.B. Protect Work from injury by keeping all piping capped and plugged or otherwise protected. This includes damage by freezing and/or stoppage from building materials, sand, dirt, or concrete.
- 2.C. Protect all equipment from damage during project; provide all tarpaulins, drop cloths, barricades, or auxiliary equipment.
- 2.D. Provide temporary shoring, bracing, and staging as may be required to ensure stability of construction and adjoining structures shown to remain.
- 2.E. Provide, erect, and maintain temporary enclosures, barriers and security devices.
- 2.F. Contractor shall be repair damage(s) to surfaces not identified to be demolished to match existing at no cost to Owner.

3.3 TIME SEQUENCE COORDINATION

- 3.A. In general, coordinate removals with replacement Work such as to coordinate with Owner's occupancy and construction phases, maintain security at building openings, fire exit requirements, etc.
- 3.B. Coordinate removal of items from exterior walls with installation of permanent or temporary replacement materials such that the buildings are maintained weather tight at the end of each day.

3.4 REMOVAL OF PORTIONS OF EXISTING CONSTRUCTION

- 4.A. Cutting of structural support members shall not be permitted without prior approval of Owner.
- 4.B. General: Following verification that active utilities serving work areas have been disconnected or rerouted, remove all designated existing construction as indicated, including all mechanical and electrical equipment, piping, etc., except for elements required to remain.
- 4.C. Demolish in an orderly and careful manner. Protect existing foundation, supporting structural members, and construction.
- 4.D. Completely remove items of construction so shown or specified to be completely removed. Where not shown to be completely removed, remove existing construction as necessary to clear new construction and properly receive or member with new construction in a neat and finished manner.
- 4.E. Relics, antiques, and similar objects remain Owner's property. Notify the Owner in writing prior to removal and obtain written acceptance regarding removal method.
- 4.F. All existing piping and equipment which interferes with the new work shall be removed and relocated.
- 4.G. Where existing mechanical equipment, devices, control valves, piping, etc. interferes with any work, it shall be removed and relocated to another location where required. All existing equipment relocated shall be left in good operating condition.
- 4.H. Existing piping in remodeled areas which are required to be extended, altered, or reconnected, shall be left in proper working order. Where existing pipes are required to be revised or which will be essential to the functioning of a particular system are cut or exposed due to construction changes, new connections shall be made in the most expeditious manner as required. Attention is called to the fact that all new piping and apparatus shall be connected to the existing systems so as to function as complete systems. Maintain continuity of all systems which pass through the construction areas and serve loads in other areas of building.
- 4.I. Where existing piping is shown on the drawings, it is shown for reference only and exact routing of existing piping shall be determined on the job site by Contractor.

3.5 DISPOSITION OF MATERIAL

- 5.A. All items of material removed, except those to be reused or turned over to Owner are to be removed from site.
- 5.B. Remove demolished materials from site as work progresses. Site shall remain thoroughly clean of all rubble, debris, unused material, and left in good order. Upon completion of work, leave areas in clean condition.
- 5.C. Remove and promptly dispose of contaminated, vermin infested, or dangerous materials encountered.

5.D. No burning or burying of materials on site will be permitted.

5.E. Disposal shall be in accordance with all applicable requirements for disposal of construction waste.

3.6 REPAIRS AND PATCHING

6.A. Provide repairs, patching, and patch painting of existing structure as required for installation of Work.

6.B. Patching shall match adjacent materials and surfaces and shall be performed by skilled craftsmen in respective craft.

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**SECTION 23 05 00
COMMON WORK RESULTS FOR HEATING, VENTILATING & AIR CONDITIONING**

PART 1 GENERAL

1.1 SECTION INCLUDES

1.A. Work to be performed under this Division shall include all labor, materials, equipment, transportation, construction plant and facilities necessary to provide a complete and satisfactory system ready to use. Examine all drawings and all sections of specifications to ascertain to what extent other contracts affect work.

1.2 QUALITY ASSURANCE

2.A. Qualifications of contractor: All materials and equipment shall be new and all work shall be executed with maximum speed consistent with current accepted trade practices. Furnish materials and equipment promptly after authorization to proceed, and proceed with work in progress with contractor on project. Perform all work included in contract in a manner that will not cause interferences or delays to, or interfere with, progress of contractor.

2.B. Requirements of regulatory agencies:

2.B.1. Permits: Arrange and pay for all permits, inspections and utility connections required.

2.B.2. Referenced standards:

2.B.2.a. Comply with specified codes and standards. If conflict exists between codes or standards and drawings, project manual or addenda requirements, request clarification from Architect/Engineer.

2.B.2.b. Conform to installation rules and regulations of standards listed including all subsequently published amendments thereto issued prior to date of bidding documents.

2.B.2.c. Conform to requirements of all local, state and federal agencies, which have authority over this project. Include all items of labor and material required to meet such requirements regardless of failure to specify in project manual or indicate on drawings each individual item.

2.B.2.d. All equipment, apparatus and systems shall be rated, tested, fabricated and installed with applicable industry standards.

2.B.2.e. Applicable portions of latest editions of following standards form a part of this project manual to same force and effect as if repeated herein.

2.B.2.e.1) American Gas Association, Inc. (AGA)

2.B.2.e.2) American Society for Testing Materials (ASTM)

2.B.2.e.3) American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

2.B.2.e.4) American Society of Mechanical Engineers (ASME)

2.B.2.e.5) American Water Works Association (AWWA)

2.B.2.e.6) National Electrical Code (NEC)

2.B.2.e.7) National Electric Manufacturers Association (NEMA)

2.B.2.e.8) National Fire Protection Association (NFPA)

2.B.2.e.9) Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)

2.B.2.e.10) Underwriters Laboratories, Inc. (UL)

2.B.2.e.11) Environmental Protection Agency (EPA)

2.B.2.e.12) Department of Public Health (DPH)

1.3 COORDINATION & SUBMITTALS

3.A. Contractor shall resolve all conflicts before actual installation begins. Order of space preference throughout building shall be:

3.A.1. Duct work

3.A.2. Soil, waste, vent and storm piping

3.A.3. Hydronic water piping

- 3.A.4. Sprinkler piping
- 3.A.5. Electrical conduit
- 3.A.6. Exception: Electrical conduit above or below switchgear, panel boards and control panels shall have precedence over all other work. Do not install any fluid conveying piping over electrical or elevator equipment.
- 3.A.7. Submit following Certifications:
 - 3.A.7.a. Welding
 - 3.A.7.b. Insulation
 - 3.A.7.c. Air & Water Balance

1.4 **STARTING, TESTING, ADJUSTING & BALANCING**

- 4.A. See sections 23 05 93 Testing, Adjusting, and Balancing

1.5 **WARRANTY**

- 5.A. Guarantee all work including labor, material and equipment for this project for a period of one (1) year from date of acceptance by Owner.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 **EXISTING CONDITIONS**

- 1.A. In order to become familiar with scope of work involved, visit existing site, before submitting bid, and carefully examine existing condition in order to have full knowledge and understanding of conditions and restrictions affecting performance of work required. Include in bid all work which is reasonably inferred by contract drawings and specifications, whether specifically shown or not, as a result of existing conditions, construction, irregularities and interferences which may affect work. No additional compensation will be considered for misunderstanding conditions to be met.
- 1.B. Layout shown on drawings is necessarily diagrammatic but shall be followed as closely as other work will permit. Changes from these drawings required to make this work conform to building construction shall be made only with prior written approval of Architect/Engineer. All proposed changes shall be shown on shop drawings. All measurements shall be verified by actual observation and all work shall fit in place meeting approval of Architect/Engineer.
- 1.C. Contractor shall provide openings required in new and existing construction that may be necessary for installation of mechanical work and all patching and workmen competent in trade required, at expense of contractor shall do repairing. Contractor shall be responsible for arranging work so that minimum cutting will be required. All rubbish and excess materials involved in such cutting shall be promptly removed from site and disposed of by contractor. Cutting through floor or roof systems or load bearing walls shall be done only with prior written approval of Architect/Engineer so as to avoid damaging structural system.
- 1.D. Sequencing, scheduling:
 - 1.D.1. Confer with contractor regarding location and size of pipes, equipment, ducts, openings and special architectural treatments in order that there may be no interferences between installation or progress of work of contractor on project. Order of space preference shall be as listed above.
 - 1.D.2. In case of interconnection of work of two or more contractors, verify at site or on shop drawings all dimensions relating to such work. All errors due to failure to so verify any such dimensions shall be promptly rectified.
 - 1.D.3. All line voltage wiring and final connections to complete mechanical systems shall be provided by Electrical Contractor. All electrical conduit, wire, and connections relating to mechanical equipment controls and all wiring associated with starter holding coils, shall be responsibility of contractor installing mechanical equipment unless otherwise indicated on drawings. Contractor installing mechanical equipment shall be responsible for magnetic

motor starters where such starters are part of control package of equipment supplied. All other starters shall be furnished and installed by Electrical Contractor. Contractor installing starters that are part of a control package shall coordinate starter requirements with Division 26 of specifications.

- 1.D.4. Items of equipment may be specified in singular however, provide and install number of items of equipment as indicated on drawings and as required for a complete system.
- 1.D.5. Equipment and devices furnished and installed by mechanical contractors, which have factory prime coat, or final surface finish shall be replaced, repaired or refinished if defective or damaged during installation.
- 1.D.6. Arrange all work so a minimum period of interruption or outages will occur in temporary or permanent transfer of services as required for all mechanical revisions. Not less than 48 hours notification to Owner shall be required before approval will be granted for any disruption of gas, water, or sanitary services. Outage request shall include extent of work to be done, length of outage time required, and time at which outage is to begin. No allowance will be made for extra payment as a result of scheduling "overtime" work necessary to perform before or after normal or regular working hours to accomplish work intended.
- 1.D.7. Submit a "Sequence of Work Schedule" in respect to all temporary and permanent utility and service cutovers after final determination. This schedule shall be submitted for approval to Architect/Engineer. Submittal shall designate priority order, service or utility affected, date of cutover, and time of day to start and finish.

3.2 CLEANING

- 2.A. Upon completion of contract all remaining materials and rubbish shall be removed from building and premises and work areas shall be left clean and free from stains, mortar, paint spots, etc.
- 2.B. All switches, controls, and safety devices shall be clearly and permanently marked with embossed or printed plates as to purpose and as to operation and shall be tested in presence of Owner's designated representative to insure that their function and purpose is understood.
- 2.C. Upon completion of work, put systems into service maintaining responsibility for equipment during all testing operations including lubricating and turning on and off of such apparatus.

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**SECTION 22 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC**

PART 1 GENERAL

1.1 SECTION INCLUDES

- 1.A. Single phase electric motors.
- 1.B. Three phase electric motors.

1.2 REFERENCE STANDARDS

- 2.A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; American Bearing Manufacturers Association, Inc.; 1990 (R2000).
- 2.B. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; Institute of Electrical and Electronic Engineers; 2004.
- 2.C. NEMA MG 1 - Motors and Generators; National Electrical Manufacturers Association; 2006.
- 2.D. NFPA 70 - National Electrical Code; National Fire Protection Association; 2008.

1.3 SUBMITTALS

- 3.A. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- 3.B. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 1/2 horsepower.
- 3.C. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.
- 3.D. Operation Data: Include instructions for safe operating procedures.
- 3.E. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.4 QUALITY ASSURANCE

- 4.A. Conform to NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

- 5.A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

PART 2 PRODUCTS

2.1 GENERAL CONSTRUCTION AND REQUIREMENTS

- 1.A. Electrical Service:
 - 1.A.1. Motors 1/2 HP and Smaller: 115 volts, single phase, 60 Hz.
 - 1.A.2. Motors 3/4 horsepower and larger or motors used in outdoor application (regardless of horsepower) shall be three phase, 60 Hertz.

- 1.A.3. Motors configured in duplex applications shall have an individual electrical circuit to each motor.
- 1.A.4. Motor starter coils and control circuits shall be powered by 120 volt control transformers located within the motor started enclosure. Refer to Project Manual Section ----
-Motor Starters".
- 1.B. Open drip-proof except where specifically noted otherwise.
- 1.C. Motors shall be of cast-iron construction.
- 1.D. Motors: Design for continuous operation in 40 Centigrade environment.
- 1.E. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
- 1.F. All motors furnished shall be the manufacturer's premium efficiency design. The nominal efficiency and the minimum guaranteed efficiency shall be stamped on the nameplate of the motor. All efficiency testing and labeling shall be done in accordance with the NEMA MG 1 standard.
- 1.G. All three phase motors shall be "Inverter Approved" or "VFD Approved".
- 1.H. Explosion-proof motors must be UL approved and labeled for hazard classification, with over temperature protection.
- 1.I. Visible nameplates must be stainless steel, indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, and efficiency.
- 1.J. Wiring Terminations
- 1.K. Motor leads shall be stranded copper and shall be permanently identified and brought out into the motor terminal box through a neoprene gasket. Conduit opening suitable for locknut type connector. Include UL listed ground lug in terminal enclosure.
- 1.L. For fractional horsepower motors where connection is made directly, provide conduit opening suitable for locknut type fitting in end frame.

2.2 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- 2.A. Starting Torque: Less than 150 percent of full load torque.
- 2.B. Starting Current: Up to seven times full load current.
- 2.C. Breakdown Torque: Approximately 200 percent of full load torque.
- 2.D. Drip-proof Enclosure: Class A (50°C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
- 2.E. Enclosed Motors: Class A (50°C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.3 SINGLE PHASE POWER - CAPACITOR START MOTORS

- 3.A. Starting Torque: Three times full load torque.
- 3.B. Starting Current: Less than five times full load current.
- 3.C. Pull-up Torque: Up to 350 percent of full load torque.

- 3.D. Breakdown Torque: Approximately 250 percent of full load torque.
- 3.E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- 3.F. Drip-proof Enclosure: Class A (50°C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.

2.4 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- 4.A. Starting Torque: Between 1 and 1-1/2 times full load torque.
- 4.B. Starting Current: Six times full load current.
- 4.C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- 4.D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
- 4.E. Insulation System: NEMA Class B or better.
- 4.F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- 4.G. Motor Frames: NEMA Standard T-Frames. Stator frame and end brackets shall be a minimum of grade 25 cast iron construction.
- 4.H. Motors shall be 1800 rpm unless indicated otherwise. Enclosures shall be totally enclosed, unless otherwise noted. Motors rated two horsepower and larger shall be fan cooled, premium efficiency design.
- 4.I. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter.
- 4.J. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 100,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- 4.K. Sound Power Levels: To NEMA MG 1.
- 4.L. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
- 4.M. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.
- 4.N. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

2.5 THREE PHASE POWER - MOTOR STARTERS

- 5.A. Motor starters shall be in accordance with Project Manual Div 26.

2.6 ACCEPTABLE MANUFACTURERS:

- 6.A. Marathon-Blue Max, Siemens-PE21 Plus, Toshiba-EQP 111.

PART 3 EXECUTION

3.1 APPLICATION

- 1.A. Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.
- 1.B. Three phase motors for exterior mounted fans.
- 1.C. Motors located in exterior locations: Totally closed type.

3.2 INSTALLATION

- 2.A. Install in accordance with manufacturer's instructions.
- 2.B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- 2.C. Check line voltage and phase and ensure agreement with nameplate.

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR MECHANICAL SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- 1.A. Nameplates.
- 1.B. Tags.
- 1.C. Pipe Markers.

1.2 REFERENCE STANDARDS

- 2.A. ASME A13.1 - Scheme for the Identification of Piping Systems; The American Society of Mechanical Engineers; 2007.

1.3 SUBMITTALS

- 3.A. AHU Nameplate: Submit list of wording.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- 1.A. Air Handling Units: Nameplates.
- 1.B. Automatic Controls: Tags. Key to control schematic.
- 1.C. Ductwork: Nameplates with gauge.
- 1.D. Instrumentation: Tags.
- 1.E. Major Components: Nameplates.
- 1.F. Piping: Tags printed with service and direction of flow.

2.2 MANUFACTURERS

- 2.A. Brady Corporation
- 2.B. Champion America, Inc
- 2.C. Seton Identification Products.
- 2.D. Brimar.

2.3 NAMEPLATES

- 3.A. Description: Laminated three-layer plastic with engraved letters.
 - 3.A.1. Letter Color: White.
 - 3.A.2. Letter Height: 1/4 inch.
 - 3.A.3. Background Color: Black.

2.4 TAGS

- 4.A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- 4.B. Metal Tags: Brass with stamped letters; tag size minimum 1 1/2 inch diameter with smooth edges.

2.5 PIPE MARKERS

5.A. All piping systems will be labeled, color coded with the type of service, (for refrigerant piping, indicate the type) and the direction of flow. Labels to be factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Lettering will be placed at intervals of approximately 20' on straight runs of piping including risers and drops, adjacent to each valve and fitting, and at each side of penetrations of structure or enclosure. Lettering will be visible from the floor. For pipes $\frac{3}{4}$ " and smaller, permanent phenolic tags will be used. Insulated piping will be labeled as "non asbestos." Schedule for banding and labeling of pipe and conduit will conform to ANSI A13.1

5.B. Acceptable manufacturers: Seton Name Plate Corporation, W.H. Brady Company or Westline Products Company.

PART 3 EXECUTION

3.1 PREPARATION

1.A. Degrease and clean surfaces to receive adhesive for identification materials.

1.B. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

3.2 INSTALLATION

2.A. Placement - Provide Identification Markers:

2.A.1. On all exposed covered and uncovered pipes at 20 foot intervals.

2.A.2. At changes of flow direction.

2.A.3. On each riser at a point 5 feet above floor or platform.

2.B. Markers shall be applied so they can be read from the floor.

2.C. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

2.D. After applying each marker, wrap one turn of pipe banding tape completely around the circumference of the pipe at each end of the marker. Overlap ends of marker with the tape and overlap the tape upon itself a minimum of 1-inch. The pipe banding tape shall match the background color of the marker.

2.E. Install plastic pipe markers in accordance with manufacturer's instructions.

2.F. Identify control panels and major control components outside panels with plastic nameplates.

2.G. Identify valves in main and branch piping with tags.

2.H. Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping $\frac{3}{4}$ inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

2.I. Install ductwork with plastic nameplates. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

2.J. Where a service is indicated on the drawings as a circulating system, the pipe marker legend for the particular service shall be followed by either the word "supply" or "return" to clarify the line function. An arrow designating direction of flow shall follow the legend on each marker.

2.K. Flow Indicators:

2.K.1. Provide an arrow marker at each identification marker, with arrow pointed away from legend in the direction of flow. When flow may be both ways, provide double-headed arrows.

2.L. Equipment Schedule: Tag and number each and every piece of equipment for every service included in this contract.

END OF SECTION

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SECTION 23 05 93
TESTING ADJUSTING AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

1.A. Testing, adjustment, and balancing of air systems.

1.2 REFERENCE STANDARDS

2.A. ASHRAE Std 111 - Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 1988, with 1997 Errata.

2.B. NEBB (TAB) - Procedural Standards for Testing Adjusting Balancing of Environmental Systems; National Environmental Balancing Bureau; 2005, Seventh Edition.

2.C. SMACNA (TAB) - HVAC Systems Testing, Adjusting, and Balancing; Sheet Metal and Air Conditioning Contractors' National Association; 2002.

2.D. AABC - Associated Air Balance Council; Test and Balance Procedure.

2.E. AABC - Associated Air Balance Council; National Standards for Total System Balance.

1.3 SUBMITTALS

3.A. TAB Plan: Submit written plan indicating testing, adjusting, and balancing standard to be followed and specific approach for each system and component.

3.A.1. Include at least the following in the plan:

3.A.1.a. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.

3.A.1.b. Discussion of what notations and markings will be made on the duct and piping drawings during the process.

3.A.1.c. Final test report forms to be used.

3.A.1.d. Details of how TOTAL flow will be determined.

3.A.1.e. Specific procedures that will ensure that air side are operating at the lowest possible pressures and methods to verify this.

3.A.1.f. Procedures for formal deficiency reports, including scope, frequency and distribution.

3.B. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

1.A.1. Revise TAB plan to reflect actual procedures and submit as part of final report.

1.A.2. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer and for inclusion in operating and maintenance manuals.

1.A.3. Include actual instrument list, with manufacturer name, serial number, and date of calibration.

1.A.4. Form of Test Reports: Where TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.

1.A.5. Units of Measure: Report data in I-P (inch-pound) units only.

1.A.6. Include following on the title page of each report:

1.A.6.a. Name of Testing, Adjusting, and Balancing Agency.

1.A.6.b. Address of Testing, Adjusting, and Balancing Agency.

1.A.6.c. Telephone number of Testing, Adjusting, and Balancing Agency.

1.A.6.d. Project name.

1.A.6.e. Project location.

1.A.6.f. Report date.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

- 1.A. Perform system balance in accordance with one of following:
 - 1.A.1. AABC MN-1, AABC National Standards for Total System Balance.
 - 1.A.2. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
 - 1.A.3. SMACNA HVAC Systems Testing, Adjusting, and Balancing.
 - 1.A.4. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of project.
 - 1.A.5. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with authorities having jurisdiction.
 - 1.A.6. TAB Agency Qualifications:
 - 1.A.6.a. Company specializing in testing, adjusting, and balancing of systems specified in this section.
 - 1.A.6.b. Certified by one of following:
 - 1.A.6.b.1) AABC, Associated Air Balance Council: www.aabchq.com; upon completion submit AABC National Performance Guaranty.
 - 1.A.6.b.2) TABB, Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org.
 - 1.A.6.c. TAB Supervisor Qualifications: Professional Engineer licensed in Iowa.

3.2 EXAMINATION

- 2.A. Verify that systems are complete and operable before commencing work. Ensure following conditions:
 - 2.A.1. Systems are started and operating in a safe and normal condition.
 - 2.A.2. Temperature control systems are installed complete and operable.
 - 2.A.3. Proper thermal overload protection is in place for electrical equipment.
 - 2.A.4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 2.A.5. Fans are rotating correctly.
 - 2.A.6. Outdoor air dampers are in place and operating properly.
 - 2.A.7. Air outlets are installed and connected.
 - 2.A.8. Duct system leakage is minimized.
- 2.B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- 2.C. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

- 3.A. Conduct pre-balancing meeting at least one week prior to starting TAB work.
 - 3.A.1. Require attendance by all installers whose work will be tested, adjusted, or balanced.
 - 3.A.2. Provide additional balancing devices, as required.

3.4 RECORDING AND ADJUSTING

- 4.A. Field Logs: Maintain written logs including:
 - 4.A.1. Running log of events and issues.
 - 4.A.2. Discrepancies, deficient or uncompleted work by others.
 - 4.A.3. Contract interpretation requests.
 - 4.A.4. Lists of completed tests.
 - 4.A.5. Ensure recorded data represents actual measured or observed conditions.

- 4.A.6. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- 4.A.7. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- 4.A.8. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.5 AIR SYSTEM PROCEDURE

- 5.A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- 5.B. Measure air quantities at air inlets and outlets.
- 5.C. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- 5.D. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- 5.E. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across fan.

3.6 SCOPE

- 6.A. Test, adjust, and balance following:
 - 6.A.1. West Rooftop Air Handling Unit (RTU).
 - 6.A.2. Air Inlets and Outlets.

3.7 MINIMUM DATA TO BE REPORTED

- 7.A. Dehumidification Unit:
 - 7.A.1. Location
 - 7.A.2. Manufacturer
 - 7.A.3. Model number
 - 7.A.4. Serial number
 - 7.A.5. Arrangement/Class/Discharge
 - 7.A.6. Air flow, design and actual
 - 7.A.7. Entering air temperature, design and actual
 - 7.A.8. Leaving air temperature, design and actual
 - 7.A.9. Air pressure drop, design and actual
 - 7.A.10. Sheave Make/Size/Bore
 - 7.A.11. Number of Belts/Make/Size
 - 7.A.12. Fan RPM

END OF SECTION

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SECTION 230713 – DUCTWORK INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Ductwork insulation.

1.2 REFERENCE STANDARDS

- A. ASTM International:
1. ASTM C553 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
 2. ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation
 3. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
- B. Code of Federal Regulations 29 CFR 1910.7 Definitions and Requirements for a A nationally Recognized Testing Laboratory (NRTL)
- C. NFPA - National Fire Protection Association:
1. NFPA 255 Surface Burning Characteristics of Building Materials
- D. Underwriters Laboratory (UL):
1. UL Building Materials List
 2. UL 723 Surface Burning Characteristics of Building Materials

1.3 INSULATION WORK REQUIREMENTS

- A. Insulate HVAC ductwork as follows:
1. Unless indicated otherwise, new HVAC supply and return air ductwork shall be externally insulated.
 - a. Insulate cold room supply and exhaust ducts.
 2. If ducts are internally insulated, they are not externally insulated unless specifically directed.
 3. Transfer and exhaust ducts are internally insulated only if specifically directed.
 4. Install an insulation jacket on externally-insulated HVAC ductwork located outdoors; and indoors except in mechanical rooms and above ceilings.
 5. Insulate outside air intake ducts if located in non-mechanical room indoors space.

1.4 SUBMITTALS

- A. Product Data: Include product description, list of materials, coating sample, and thickness for each service, manufacturer's installation instructions, and locations.

1.5 QUALITY ASSURANCE

- A. Applicator: Assure that applicator is a company specializing in ductwork insulation application with 3 years relevant experience.

- B. Materials: Listed by a nationally recognized testing laboratory (NRTL) recognized under 29 CFR 1910.7; flame-spread/fuel-contributed/smoke-developed ratings of 25/50/50 in accordance with UL 723.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Knauf, Manville Corporation, Owens-Corning, Casco, Circliner, or equal.
- B. Substitutions: Under provisions Division 01 Section "General Requirements - Materials and Equipment".

2.2 DUCT LINER

- A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 - 1. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.1 PREPARATION

- A. Install materials after ductwork has been tested and approved.
- B. Clean surfaces for adhesives.
- C. Install materials in accordance with manufacturer's instructions.
- D. Internal Insulation Application:
 - 1. Insulate all ducts where shown as new on the Drawings, on the inside.
 - 2. Coat interior duct surfaces with adhesive prior to installation.
 - 3. Insert liner sections into straight ducts and fittings, achieving a tight fit.
 - 4. Treat factory, shop, and field cut edges with high density spray-on and/or brush-on mastic to lock in fibers and keep the liner from tearing.
 - 5. Repair damaged liner prior to installing ductwork.
 - 6. All adhesive and insulation material shall be fire-retardant and U.L. listed.
 - 7. Submit duct sample of liner, its attachment, and edge treatment.

END OF SECTION 230713

**SECTION 23 07 19
PIPING INSULATION**

PART 1 GENERAL

1.1 SECTION INCLUDES

- 1.A.Piping insulation.
- 1.B.Jackets and accessories.

1.2 REFERENCE STANDARDS

- 2.A.ASTM B 209/B 209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2007.
- 2.B.ASTM C 177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus; 2004.
- 2.C. ASTM C 518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2004.
- 2.D. ASTM C 534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2007a.
- 2.E.ASTM C 547 - Standard Specification for Mineral Fiber Pipe Insulation; 2007.
- 2.F.ASTM C 585 - Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System); 1990 (Reapproved 2004).
- 2.G. ASTM C 591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation; 2007.
- 2.H. ASTM C 795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2003.
- 2.I. ASTM D 2842 - Standard Test Method for Water Absorption of Rigid Cellular Plastics; 2006.
- 2.J. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2008.
- 2.K.ASTM E 96/E 96M - Standard Test Methods for Water Vapor Transmission of Materials; 2005.
- 2.L. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials; National Fire Protection Association; 2006.
- 2.M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Underwriters Laboratories Inc.; 2003.

1.3 SUBMITTALS

- 3.A.Insulation Schedule: Provide insulation schedule indicating insulation material, thickness, and jacket material for each service, and locations.
- 3.B.Product Data: Provide product description and thermal characteristics:
 - 3.B.1. Insulation.
 - 3.B.2. Insulation Vapor Barriers.

1.4 QUALITY ASSURANCE

- 4.A.Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum 3 years of experience.

1.5 DELIVERY, STORAGE, AND HANDLING

- 5.A.Deliver material to site in factory fabricated containers with manufacturer's stamp or label, showing fire and smoke hazard ratings of products.
- 5.B.Accept materials on site, labeled with manufacturer's identification, product density, and thickness.
- 5.C. Store material in original wrappings and protect from weather and construction traffic.
- 5.D. Protect against sun, dirt, water, chemical and mechanical damage.
- 5.E.Remove damaged insulation from project site. Do not install.

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR ALL PRODUCTS OF THIS SECTION

- 1.A.Surface Burning Characteristics: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.

2.2 TYPE DC-1: GLASS FIBER

2.A.Acceptable Manufacturers:

- 2.A.1. Knauf Insulation
2.A.2. Johns Manville Corporation
2.A.3. Owens Corning Corp
2.A.4. CertainTeed Corporation

2.B.Insulation: ASTM C 547 and ASTM C 795; rigid molded, noncombustible.

- 2.B.1. 'K' value: ASTM C 177, 0.22 at 75°F.
2.B.2. Maximum service temperature: 850°F.
2.B.3. Maximum moisture absorption: 0.2 percent by volume.

2.C. Vapor Barrier Jacket:

- 2.C.1. Kraft paper with glass fiber yarn and bonded to aluminized film.
2.C.2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E 96/E 96M.
2.C.3. Secure with pressure sensitive tape.
2.C.4. Thickness: 0.016 inch sheet.
2.C.5. Finish: Smooth.
2.C.6. Pipe Joining: Longitudinal slip joints and 2 inch laps.
2.C.7. Fittings: 0.016 inch thick die shaped pre-molded fitting covers with factory attached protective liner.
2.C.8. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
2.C.9. Provide with 3-mil moisture barrier heat and pressure bonded to interior surface.

PART 3 EXECUTION

3.1 EXAMINATION

- 1.A. Verify piping has been tested before applying insulation materials.
- 1.B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- 2.A. Install in accordance with manufacturer's instructions.
- 2.B. Install in accordance with NAIMA National Insulation Standards.
- 2.C. Exposed Piping: Locate insulation and cover seams in least visible locations.
- 2.D. Insulation: Continuous through inside walls and at all hangers; pack insulation around pipes with fireproof self-supporting mineral wool insulation material, fully sealed.
 - 2.D.1. Install adhesives at ambient and equipment temperatures recommended by adhesive manufacturer.
- 2.E. Fittings:
 - 2.E.1. Hot Piping:
 - 2.E.1.a. Do not insulate unions, flanges, strainers, valves, flexible connections, or expansion joints.
 - 2.E.1.b. Terminate insulation neatly with mastic material troweled on bevel.
 - 2.E.1.c. Finish insulation neatly at hangers, supports and other protrusions or interruptions.
 - 2.E.1.d. Ensure hangers and cradles are properly installed to avoid crushing insulation.
 - 2.E.1.e. Locate insulation or cover seams in least visible locations.
- 2.F. Glass fiber insulated pipes conveying fluids above ambient temperature:
 - 2.F.1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
 - 2.F.2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- 2.G. Install protective metal saddles and insulated inserts to prevent insulation compression.
- 2.H. Inserts and Shields:
 - 2.H.1. Application: Piping 1-1/2 inches diameter or larger.
 - 2.H.2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - 2.H.3. Insert location: Between support shield and piping and under the finish jacket.

- 2.H.4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
- 2.H.5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- 2.I. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions.
- 2.J. Insulate all condensate drains from equipment.
- 2.K. Piping exposed to finish areas and in Finished Spaces: Provide with white PVC jacket covers.
- 2.L. Piping exposed to finish areas and in Mechanical Rooms (less than 10 feet above finished floor): Provide with aluminum jacket covers.

3.3 SCHEDULES

Service	Type	Thickness (Inches)	Jacket
Heating Hot Water	DC-1	1-1/2"	None required (Mech. Room Only)

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**SECTION 23 31 01
HVAC DUCTS – FABRIC**

PART 1 GENERAL

1.1 SECTION INCLUDES

- 1.A. Fabric ductwork. (Fabric air dispersion systems).
- 1.B. Fabric ductwork hangers.

1.2 REFERENCE STANDARDS

- 2.A. Products must be classified in accordance with the 25/50 smoke/flame spread development requirements of UL723 - "Standard for Test for Surface Burning Characteristics of Building Materials" as required by UL2518 - "Outline of Investigation for Air Dispersion System Materials".
- 2.B. Product must be treated with an EPA approved and listed antimicrobial agent.

1.3 QUALITY ASSURANCE

- 3.A. Manufacturer Qualifications: Company specializing in manufacturing type of products specified in this section, with minimum three years of documented experience.
- 3.B. Installer Qualifications: Company specializing in performing type of work specified in this section, with minimum 3 years of documented experience.

1.4 SUBMITTALS

- 4.A. Submit copy of UL/ULC Registered Firm certificate and ISO 9001 certificate from production facility.
- 4.B. Submit UL file number under which product is Classified by Underwriter's Laboratories to UL2518 (as required by NFPA 90A) or ULC-S102.2 for Canada.
- 4.C. Submit UL file number under which product is Classified by Underwriter's Laboratories to UL2518 (as required by NFPA 90A) or ULC-S102.2 for Canada.
- 4.D. Antimicrobial treated duct: submit documentation for EPA registration.
- 4.E. Submit manufacturer's drawings indicating size and placement of dispersion units, and installation instructions.
- 4.F. Submit manufacturer's technical product data for fabric dispersion units.
- 4.G. Submit manufacturer's performance data for each fabric duct system including airflow rate, design static pressure, inlet velocity, and isothermal throw.
- 4.H. Submit manufacturer's maintenance data.

1.5 WARRANTY

- a. Manufacturer shall provide a 10 year non-prorated warranty, unless otherwise mentioned. Prorated warranties will not be accepted.

1.6 DELIVERY, STORAGE, AND HANDLING

- a. Protect fabric duct systems from damage during shipping, storage, and handling.
- b. Product shall be protected from the elements at all times.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

a. Manufacturer must comply with all previous described requirements. Approved manufacturers:

1. FabricAir, Inc. (Basis of design)
2. Approved equivalent.

2.2 MATERIALS

a. FABRIC AIR DISPERSION SYSTEM

1. Round fabric air dispersion system shall be constructed of a woven fire retardant and permeable fabric complying with the following characteristics:
 - a. Duct Shape: Round
 - b. Fabric: 100% Flame Retardant Polyester
 - c. Weight: 7.67 oz./yd² per ASTM D3776
 - d. Shrinkage: Max. 0.5% per EN ISO 5077
 - e. Color: To be selected by Owner
 - f. Temperature Range: -40°F and +284°F
 - g. Base Permeability @ 0.5" WG: 2.28 CFM/SQFT per ASTM D737, Shall be verified by the Frazier Permeability Test
 - h. Fire Retardancy: Shall meet the requirements of NFPA 90-A, ICC AC167 and UL 2518
 - i. Manufacturer shall provide a 5 year non-prorated warranty. Prorated warranties will not be accepted.

b. SYSTEM FABRICATION REQUIREMENTS

1. Air dispersion shall be accomplished with linear arrays of laser cut orifices. Orifices shall be from 0.12" to 0.55" diameter. Due to exact throw requirements and NC requirements alternative flow models are not acceptable.
2. Number, spacing, and size of linear arrays of laser cut orifices shall be determined by the manufacturer.
3. Fabric system shall include connectors to attach to suspension system listed below.
4. Provide system in sections optimized for maintenance, connected by zippers. Zippers shall provide closure completely around the circumference to prevent leakage. Required number of zippers shall be specified by the manufacturer.
5. Each section to have a unique tag including information about manufacturer's order number, position, diameter of section, length of section, maintenance instruction, code compliance and contact details for spare parts.

c. DESIGN PARAMETERS

1. Use fabric air diffusers only for positive pressure air distribution.
2. Do not use fabric air diffusers in concealed locations.
3. Fabric diffusers shall be designed to a maximum of 3" water gauge, with 0.5" being the standard.
4. Design temperatures shall be between -40°F and +284°F
5. Manufacturer shall approve all technical design parameters.

d. HANGERS AND SUPPORTS

1. 2x1 (10" – 48"), two rows H-rail/curved rods system located 1.5" above 3 and 9 o'clock of fabric air distribution system. Hardware to include H-rail joint, end cap H-rail, curved rods, fastener ceiling/H-rail, tie down strap, cable, cable locks and H-rail as required. Fabric duct system to be attached to hardware using two rows of plastic sliders located 3 and 9 o'clock spaced 20 inches.

Hardware

Anodized Aluminum H-Rails - With PVC coated Galvanized Steel suspension cable. Suspension cable clamps, H-rail suspension eyebolts, and all other factory supplied metal components shall be Galvanized Steel.

PVC Coated Stainless Steel Tensioning and Suspension Cable - Cable clamps, cable tensioners, and all other factory supplied metal components shall be Stainless Steel.

2. Mounting system to be provided by fabric duct manufacturer.

3. Alternate mounting systems are subject to Engineer's and Owner's approval.

2.3 AIR HANDLER REQUIREMENTS

- a. Provide adequate pre-filtering prior to the fabric duct system, all according to manufacturer's specifications.
- b. Air handler filters shall be changed per unit manufacturer's requirements. Failure to maintain clean filters may result in a voided warranty.
- c. Provide fans capable of delivering the specified air volume at the specified static pressure.

PART 3 EXECUTION

3.1 INSTALLATION

- a. Examine area and conditions under which the fabric air distribution systems are to be installed. Do not continue any installation until unsatisfactory conditions have been corrected.
- b. Install chosen suspension system in accordance with the requirements of the manufacturer. Installation instructions shall be provided by the manufacturer with product.
- c. Coordinate layout with suspended ceiling, lighting layouts, and all other trades that may interfere with the installation of the fabric air distribution system.

3.2 CLEANING

- a. Clean air handling unit and other ductwork upstream of the fabric air distribution system as it is installed. Ensure that all construction debris, including dust, is removed from the air handling unit and other ductwork before connecting the fabric distribution system.
- b. If the fabric air distribution system becomes soiled during the installation, it should be removed and cleaned following the manufacturers cleaning instructions.

END OF SECTION

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**SECTION 23 31 00
HVAC DUCTS - METAL**

PART 1 GENERAL

1.1 SECTION INCLUDES

- 1.A. Metal ductwork.
- 1.B. Miscellaneous Blankoff Panels

1.2 REFERENCE STANDARDS

- 1.A. ASHRAE Handbooks - Fundamentals, Applications, Systems, latest editions.
- 1.B. ASTM A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by Hot-Dip Process; 2007.
- 1.C. NFPA 90A - Standard for Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2009.
- 1.D. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; Sheet Metal and Air Conditioning Contractors' National Association; 1985, First Edition.
- 1.E. SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.
- 1.F. SMACNA - HVAC Systems - Duct Design.

1.2 PERFORMANCE REQUIREMENTS

- 2.A. Ducts shall have minimum internal dimensions indicated on drawings. Whenever necessary to change shape of duct, it shall be done gradually and full area retained in accordance with ASHRAE "Table of Equivalence Rectangular and Round Ducts."
- 2.B. Ductwork, unless otherwise shown on drawings, or specified herein, shall be G-90 galvanized steel sheets (F.S. QQ-S-775, Type 1, Class E) and joints shall be constructed so as not to trap condensed water.
- 2.C. Minimum construction standards for sound plenums, supply air plenums, return air plenums, outside air plenums, mixed air plenums shall be SMACNA design for four (4) inches water gauge. All remaining ductwork shall be per Schedule in 3.04B.
- 2.D. Where it is necessary that any portion of duct system be built around pipes, conduits, beams, or other obstructions, provide air stream deflectors for smooth flow at Contractor's cost. Maintain air stream velocity at obstruction; if required, enlarge duct to maintain this velocity at Contractor's cost.
- 2.E. Mitered elbows shall be furnished with turning vanes, unless noted otherwise, consisting of single thickness vanes, constructed to prevent vibration and eliminate air noise.
 - 2.E.1. Elbows with unequal dimensions in plane of turn shall have leading and trailing edges of vanes parallel to sides of duct.
 - 2.E.2. Use radius throat elbows where shown or noted on drawings; Contractor may elect to use radius throat elbows in lieu of square elbows with turning vanes as

shown. Where indicated on drawings large radius throat elbows shall be provided with radius air turn vanes.

1.3 QUALITY ASSURANCE

- 3.A. Manufacturer Qualifications: Company specializing in manufacturing type of products specified in this section, with minimum three years of documented experience.
- 3.B. Installer Qualifications: Company specializing in performing type of work specified in this section, with minimum 3 years of documented experience.

1.4 REGULATORY REQUIREMENTS

- 4.A. Construct ductwork to NFPA 90A standards.

1.5 FIELD CONDITIONS

- 5.A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- 5.B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 PRODUCTS

2.1 MATERIALS

- 1.A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A 653/A 653M FS Type B, with G90/Z275 coating.
- 1.B. Exposed Ductwork shall be constructed with metal conforming to Paint Grip A-601.
 - 1.B.1.a. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.

2.2 DUCTWORK FABRICATION

- 2.A. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and SMACNA HVAC Duct Construction Standards - Round Duct, and as indicated.
- 2.B. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- 2.C. Tees, bends, and elbows: Construct according to SMACNA (DCS).
- 2.D. Increase duct sizes gradually, not exceeding 15° divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45° convergence downstream.
- 2.E. Fabricate ductwork and fittings in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- 2.F. Provide standard 45° lateral wye takeoffs unless otherwise indicated where 90° conical tee connections may be used.

- 2.G. Where exhaust and relief air ductwork is connected to exterior wall louvers and duct outlet is smaller than louver frame, provide insulated metal blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct. Transition intake ductwork to full louver area.
- 2.H. Duct connectors as manufactured by Ductmate Industries may be used at Contractors option, but must meet all SMACNA requirements, including leakage class as specified.

2.3 ROUND AND RECTANGULAR DUCTWORK

- 3.A. Ductwork and fittings shall be factory manufactured or machine fabricated of galvanized steel with lock formed joints and seams.
- 3.A.1. Connect round to rectangular ductwork with job fabricated transitions; seal airtight with Hardcast Foil Grip or equal; brush on sealant of any kind is NOT considered an equal. Where drawings indicate 45 degree entry taps or 45 degree lateral fittings, conical lateral or like fittings shall be used.
- 3.A.2. Fittings shall be wall thickness not less than that specified for ductwork; mitered, pleated and adjustable elbows are not acceptable. Where drawings indicate 45 degree entry taps or lateral fittings, conical lateral or like fittings shall be used.
- 3.A.3. Snaplock ductwork is NOT acceptable.
- 3.A.3.a. Seal joints with Hardcast Aluma Grip AFT-701 or equal; brush on sealant of any kind is NOT considered an equal.

PART 3 EXECUTION

3.1 INSTALLATION

- 1.A. Install, support, and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. SMACNA seal class "A" for all operating pressures. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- 1.A.1. Duct sizes indicated are inside clear dimensions.
- 1.A.2. Install and seal metal and flexible ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- 1.A.3. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot 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.
- 1.A.4. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.
- 1.A.5. All ductwork seams shall be sealed with hard cast joint sealant compound or heat shrink plastic per SMACNA high pressure standards.
- 1.A.6. Ducts shall be of internal dimensions shown on drawings. In no case shall be indicated size of ductwork be changed without prior approval of Architect/Engineer. Wherever it is necessary to change shape of duct, it shall be done gradually and full area retained.
- 1.A.7. Ducts shall be constructed with easy elbow fittings except where square turns are specifically indicated on drawings or are approved by Architect/Engineer. throat radius elbows shall be 12 inches minimum except where space is not available in which case radius shall be as large as

possible, but not less than a radius ratio of 1.5. Turning vanes must be used in miter elbows.

- 1.A.8. Ducts shall be stiffened as necessary to prevent sagging or buckling and to provide a rigid installation and freedom from vibration and noise when fan is operating.
- 1.A.9. Means for expansion of long lengths of duct should be provided.
- 1.A.10. Use double nuts and lock washers on threaded rod supports.
- 1.A.11. As an option contractor can substitute double wall for rectangular ductwork in exposed areas.
 - 1.A.11.a. Ductwork delivered to jobsite shall be covered watertight, and not placed directly on ground or floor without being elevated by blocking to prevent water intrusion. No ductwork shall be installed without first having interior wiped clean and dry.
 - 1.A.11.b. NO DUCTWORK SHALL BE INSTALLED WITH DAMP INSULATION OR DUST/DIRT IN INTERIOR. Any ductwork found in this condition shall be removed from site immediately and replaced, all at contractor's expense.
 - 1.A.12. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system. NO DUCTWORK SHALL BE LEFT OPEN AT END OF A WORKDAY. Any ductwork found open at start of a workday shall be cleaned immediately or replaced, at contractor's expense.

3.2 HANGERS AND SUPPORTS FOR DUCTS

- 2.A. Horizontal ducts shall be supported with substantial angle and rod or strap iron trapeze hangers not less than 1/8 inch by 1 inch placed entirely around sides and bottoms of ducts and securely fastened to ducts and to construction above.
- 2.B. Attachments to steel beams shall be by "C" clamps. Rods shall be not less than 5/16 inch diameter with eye close to ceiling and matching bolt to attach trapeze duct hanger. Use double nuts and lock washers on threaded rod supports.
- 2.C. Horizontal duct supports shall be spaced not to exceed 8 feet apart and at least two trapeze supports per section of duct (this maximum spacing applies to both round and rectangular ducts).
- 2.D. Ducts 24 inches or greater in width, height or diameter shall be stiffened with galvanized structural angle reinforcing (round ducts shall be reinforced with prefabricated rings), not to exceed four feet on centers and on all four surfaces (entire circumference on round ducts), to prevent sagging or buckling and to provide a rigid installation and freedom from vibration and noise. Where angle cleats are made of same gauge metal as ducts (or heavier) angle cleats shall serve as reinforcing members on two surfaces of ducts at joints in ducts. Additional reinforcing angles shall be provided adjacent to branch duct connections, which are of less width or depth than surface of main duct at points of connection and at all other locations to make ductwork free from noise and vibration when fans are operating.

3.3 CLEANING PROCEDURE AFTER INSTALLATION

- 3.A. Initial Cleaning: Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half system at a time. Protect equipment that could be harmed by excessive dirt with temporary filters, or bypass during cleaning.

- 3.B. Intermediate Cleaning: Clean duct systems with high power HEPA vacuum machines. Protect equipment that could be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.
- 3.C. Final Cleaning: All ductwork and equipment that is accessible through access panels shall be hand wiped with oil-free tack rags.

3.4 SCHEDULES

- 4.A. Ductwork Material:
 - 4.A.1. All Supply: Steel.
 - 4.A.2. Return: Steel.
 - 4.A.3. Ductwork Pressure Class:
 - 4.A.3.a. Supply: 2 inch.
 - 4.A.3.b. Return: 2 inch.

3.5 LEAKAGE TESTING OF INSTALLED SYSTEM

- 5.A. Contractor shall perform a leak test all duct fabricated. Testing of duct system in sections is permissible provided that all sections are tested.
- 5.B. Conduct tests, in presence of Engineer, at static pressures equal to maximum design pressure of system or section being tested. Do not pressurize systems above maximum design operating pressure. Give seven (7) days advanced notice for testing.
- 5.C. Maximum Allowable Leakage: As described in SMACNA "HVAC Air Duct Leakage Test Manual." Comply with requirements for SMACNA Leakage Classification 3 for all pressure classes.
- 5.D. Leakage test procedures shall follow outlines and classifications in SMACNA "HVAC Duct Leakage Test Manual."
- 5.E. If specimen fails to meet allotted leakage level, contractor shall modify to bring it into compliance and shall retest it until acceptable leakage is demonstrated.
- 5.F. Tests and necessary repair shall be completed prior to insulation and/or concealment of ducts.

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**SECTION 23 37 00
AIR OUTLETS AND INLETS**

PART 1 GENERAL

1.1 SECTION INCLUDES

1.A.Louvers.

1.2 REFERENCE STANDARDS

2.A.AMCA 500-L - Laboratory Methods of Testing Louvers for Rating; Air Movement and Control Association International, Inc.; 2007.

2.B.ASHRAE Std 70 - Method of Testing for Rating Performance of Air Outlets and Inlets; American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.; 2006.

2.C. SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.3 SUBMITTALS

3.A.Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

3.B.Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission.

1.4 QUALITY ASSURANCE

4.A.Test and rate air outlet and inlet performance in accordance with AMCA-500-L and ASHRAE Std 70.

4.B.Manufacturer Qualifications: Company specializing in manufacturing type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.1 MANUFACTURERS

1.A.Diffusers, Registers, and Grilles:

1.A.1. United Enertech

1.A.2. Greenheck

1.A.3. Approved equivalent.

2.2 WALL LOUVERS

2.A.1. Type: As indicate on the drawings

2.A.2. Frame:As indicated on the drawings.

2.A.3. Fabrication: Aluminum extrusions, with factory off-white Kynar finish.

PART 3 EXECUTION

3.1 INSTALLATION

1.A.Install in accordance with manufacturer's instructions.

- 1.A.1. Check location of louvers and make necessary adjustments in position to conform with architectural features, symmetry, and structural features.
- 1.A.2. Install ductwork to louvers with air tight connection.
- 1.A.3. Fasteners exposed to chlorine environment, provide 316L stainless steel hardware.

3.2 SCHEDULES

- 2.A. See plan drawings for schedule.
- 2.B. Verify plan drawings for all duct connections and louver types prior to final selection.

END OF SECTION

SECTION 23 74 33
PACKAGED ROOFTOP AIR HANDLING UNIT

PART 1 GENERAL

1.1 SECTION INCLUDES

- 1.A. Packaged, dehumidification air handling unit complete with casings, fans, internal spring-type vibration isolation, insulation, drain pans, heat transfer coils, heat recovery unit, and filter frames with media.
- 1.B. Standard floor mounting rails.

1.2 QUALITY ASSURANCE

- 2.A.1. Packaged pool dehumidification units shall be UL listed and labeled in accordance with UL 1995/C 22.2.
- 2.B. Units shall have certified ratings complying with ARI Standards.
- 2.C. Prior to startup, complete manufacturer's startup checklist and provide a copy to Owner for review.

1.3 SUBMITTALS

3.A. Product Data:

- 3.A.1. Submit manufacturers catalog literature.
- 3.A.2. Fan performance curves.
- 3.A.3. Coil capacity.
- 3.A.4. Electrical requirements including horsepower and electrical characteristics.
- 3.A.5. Integrated digital unit controller.

3.B. Drawings: Submit drawings indicating dimensions, arrangement, required clearances, weights, and construction materials.

- 3.B.1. Pool dehumidification unit.
- 3.B.2. Standard floor mounting rails.

3.C. Wiring Diagrams:

- 3.C.1. Submit manufacturer's electrical requirements for power supply wiring.
- 3.C.2. Submit manufacturer's control wiring.
- 3.C.3. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between factory installed wiring and portions to be field installed.

3.D. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

3.E. Operation and Maintenance Manuals. Manuals will include electrical and control drawings and refrigeration piping drawings. Manufacturer's representative shall instruct owners/operators of the unit regarding its functions and sequence of operation.

1.4 TRAINING

- 4.A. Provide minimum 4 hours training to Owner's operation and maintenance personnel in cooperation with Owner's Representative. Provide competent, factory-authorized personnel for instruction concerning location, operation, and troubleshooting of installed systems.

1.5 WARRANTY

- 5.A. Provide one (1) year limited warranty on complete unit.

- 5.B. Provide five (5) year warranty on compressors.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

- 6.A.1. Handle units and associated components to prevent damage, breakage, denting, and scoring. Do not install damaged units or components. Replace with new.
- 6.A.2. Store units and associated components in clean, dry place.
- 6.A.3. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- 6.A.4. Comply with manufacturer's rigging and installation instructions for unloading packaged units, and moving into final location.

1.7 SPARE PARTS

- 7.A. Provide one complete set of filters for dehumidification unit.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- 1.A. DesertAir (basis of design)
- 1.B. Approved equivalent.

2.2 GENERAL

- 2.A. All units shall be factory fabricated, internally wired and fully charged with R-410a.
- 2.B. Factory Testing:
 - 2.B.1. Dehumidification operation.
 - 2.B.2. Supplemental heating operation.
 - 2.B.3. Fan and blower rotation.
 - 2.B.4. Heat recovery operation, water and air.
 - 2.B.5. Control sequence.

2.3 CASINGS

- 3.A. Unit casing shall be constructed as follows:
 - 3.A.1.a. Base rails and supports shall be 12-gauge galvanized steel channels; corner posts and side posts shall be formed of 16-gauge galvanized steel; top panels and removable side panels shall be 16-gauge galvanized steel. Removable panels with insert nut screw sites shall be provided to allow easy access to all internal parts and components. The electrical control box and switch panel shall be enclosed in a separate compartment, complete with a hinged door.
 - 3.A.1.b. All panels shall be fabricated of heavy gauge steel reinforced with steel angle framework, as required, for pressure rating.
 - 3.A.2. Casings shall be sectionalized with separate fan and coil sections.
 - 3.A.3. Provide full-sized, hinged access doors. All access shall be from same side of unit.
 - 3.A.3.a. Top of unit shall be one piece, if possible. If seams are necessary, double hem and gasket seal to prevent water leakage.
 - 3.A.3.b. Prior to painting, all metal parts shall be pretreated to remove oils and dirt and rinsed with an ionized solution. Painting shall be by a powder coat technique to assure positive adherence with a high impact finish. All sides of panels shall be painted after manufacturing. The paint shall be High Yield Polyester. The paint shall be rated to meet a minimum of 1,000-hour salt spray test (ASTM B117), have a minimum Direct Impact Resistance of 160 in-lbs (ASTM D2794), have a minimum flexibility of ¼" Mandrel (ASTM

D522, Method B) and a minimum 1000-hour Humidity Resistance (ASTM D2247). The unit color shall be light gray

3.B. Unit design shall allow unit to be installed indoors on existing concrete floor.

2.4 INSULATION

4.A. The thermal and sound insulation shall be engineered polymer closed-cell foam insulation (EPFI). Indoor units shall have 3/8" thick insulation and outdoor units shall have 3/4" thick insulation. The insulation shall meet the following requirements.

NFPA 255 Flame Spread – 25

NFPA 255 Smoke Developed – 50

NFPA 255 Fuel Contributed – 0

NFPA 90A (2-2.4.2) and 90B

ASTM C5118 (Thermal Resistance)

ASTM C411 (Hot Surface Performance)

ASTM C423 (Sound Absorption)

ASTM C665 (Fungi Resistance)

ASTM E90 (Airborne Sound Transmission Loss)

ASTM E96 (Water Vapor Transmission)

UL 94HBF (Horizontal Burn)

UL 181 (Air Erosion, Mold Growth, and Humidity)

ASTM C1136 (Mold, Mildew, and Moisture Resistance)

2.5 REFRIGERATION SYSTEM

5.A. The system's operating refrigerant shall be R-410A

5.B. Provide with direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps. The compressors shall be a dual circuit, tandem pair, heavy-duty scroll-type. The circuits shall be staged. The compressor shall be equipped with high- and low-pressure safety switches, with internal protection from overheating. The compressor shall be externally vibration isolated.

5.B.1. The unit shall include a refrigerant receiver with rotolock service valves. The receiver shall be sized for full-system refrigerant capacity to allow system pump down, and for operating at the highest efficiency over a wide range of load conditions.

5.C. Motor shall be suction gas-cooled with voltage utilization range of $\pm 10\%$ of nameplate voltage.

- 5.D. Provide with crankcase heaters, phase monitors, and low and high pressure control to allow operation down to -20 degrees F.
- 5.E. Provide anti-short cycle timing and time delay between compressors.

2.6 FANS

- 6.A.1. Supply fan to either be double inlet forward curve fan or double inlet air foil fan.
 - a. Double Inlet Forward Curve Fans: The fan housing shall be made of galvanized steel. The impeller is manufactured in galvanized steel with tab locked blades
 - b. Double Inlet Air Foil Fans: The fan housing shall be made of galvanized steel. The high performance impeller is manufactured in corrosion resistant steel, with backward curved, true airfoil shaped blades, welded into position. All wheels are coated with an anticorrosive primer and a final layer of synthetic paint.
- 6.A.2. Fan shall be die-formed with streamlined inlets and sidesheets.
- 6.A.3. Bearings shall be grease lubricated ball bearings selected for L-50 rating of 200,000 hours average life.
- 6.A.4. Fan motor(s) shall be permanently lubricated with built-in thermal overload protection.
- 6.A.5. Fan and motor assembly shall be internally isolated from unit casing with factory mounted spring isolators.
- 6.A.6. All fans are to be dynamically and statically balanced.
- 6.A.7. Fans motor sheave shall be variable pitch type adjusted to operate at design conditions without exceeding frequency drive speeds of 60 Hz. Settings requiring operation above 60 Hz are not acceptable.
- 6.A.8. Fan discharge is to be as shown on the drawings.
- 6.A.9. Exhaust fan The exhaust fan motor shall be variable speed via electronically commutated (EC) design for highest overall system efficiency. Motor to be permanent magnet brushless DC design with integral rectifier and electronics. Integral under/over voltage protection, motor protection, and status indication is required. Motor electronics to be encapsulated for shock, moisture and corrosion resistance. Fixed speed motors or AC motors with variable speed drives are not acceptable. Motors shall utilize permanently lubricated ball bearings with L10 life of 40,000 hours minimum
- 6.A.10. The exhaust fan venturi shall be constructed of heavy weight galvanized steel and have provisions for static pressure measurement via transducer at the inlet plenum and specific position at the venture throat. Qualified values of the venture static pressure coefficients to calculate airflow must be type tested in the application and programmed into the unit controller for display of flow rates.
- 6.A.11. The exhaust fan impeller is to be constructed of a high strength, low mass, corrosion-free composite material in a single shot injection molding process. The impeller blades are to be backwards-curved airflow type. Forward-curved or flat backwards-incline blades are not acceptable. The impeller shall be balanced with hub with admissible vibration severity less than 0.11 in/s.
- 6.A.12. The exhaust fan frame assembly shall be constructed of heavy gauge galvanized and shall support the fan and motor. When more than one fan is provided, each must be mounted on its own independent frame.

2.7 COILS

7.A. Evaporator Dehumidifier Coils

7.A.1. Fins: Fins shall be die-formed, aluminum and shall be damage resistant. Extruded fin collars provide maximum heat transfer. Fin spacing shall be 10 FPI (fins per inch) maximum. The coil shall be a maximum of 38" in height to avoid water carryover to the reheat coil and re-evaporation into the air stream

7.A.2. Tubes: Coils shall be fabricated from seamless drawn copper. The tubes shall be hydraulically expanded into the fins to form a permanent metal-to-metal bond for maximum heat transfer and stability.

7.A.3. Each coil shall have its own drain pan

7.A.4. Testing: Coils shall be leak tested with 420 psig nitrogen

7.B. Air-Cooled Condenser (Reheat) Coils

7.B.1. The reheat coil shall be positioned with a minimum of 5" clearance from the DX coil to help prevent water re-evaporation

7.B.2. Fins shall be die-formed aluminum and shall be damage resistant. Fin spacing shall be 12 FPI (fins per inch) maximum

Coils shall be fabricated from seamless drawn copper. The tubes shall be hydraulically expanded into the fins to form a permanent metal-to-metal bond for maximum heat transfer and stability. The coil shall be a minimum of two (2) rows deep

7.B.3. Coils shall be fabricated from seamless drawn copper. The tubes shall be hydraulically expanded into the fins to form a permanent metal-to-metal bond for maximum heat transfer and stability. The coil shall be a minimum of two (2) rows deep

7.B.4. All air-side refrigerant heat exchangers shall be treated for enhanced corrosion resistance. Dry film thickness shall be 0.6-1.2 mils (15-25 μ m). Heat transfer coefficient loss shall be less than 1% after coating. Minimum salt spray resistance per ASTM B117-97 / DIN 53167 after coating shall be 6,000 hours. Phenol coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification

2.8 AUXILLIARY HEAT

8.A. The capacity shall be in accordance with the schedule. The heater shall be integral to the unit and wired to the unit as a single point power connection

8.B. The heater coils shall be constructed of High Grade Nickel-Chrome alloy and will be insulated by floating ceramic bushings from the galvanized steel frame. Coil terminal points shall be stainless steel insulated by means of non-rotating ceramic bushings.

8.C. The heater shall be equipped with fail-safe, automatic reset and manual reset disc-type thermal cut-outs.

The heater will include high limit cut-outs, magnetic contactors as required, a control transformer, and an airflow switch.

8.D. The heater will include high limit cut-outs, magnetic contactors as required, a control transformer, and an airflow switch.

2.9 HEAT RECOVERY

- 9.A.1. The unit will be supplied with an integral fresh air/exhaust air heat recovery system for the introduction of outside air, to comply with ASHRAE Ventilation Standards 62.1-2010 and local health codes.
- 9.A.2. The unit will include energy recovery for ventilation air and exhaust air with up to 25% of the supply air volume for ventilation air. Exact amount of ventilation and exhaust air is as listed on the specification schedule.
- 9.A.3. The internal control system will maintain the correct proportions of return air, supply air, exhaust air and ventilation air. The system will monitor the static pressure difference at three locations; the ventilation air intake, evaporator coil and the zone vs. ambient.
- 9.A.4. The control system will monitor the pressure differential across the ventilation air orifice plate, and the unit controller will modulate the ventilation air damper to ensure the correct amount of ventilation air during occupied times. The amount of ventilation air can be set through the unit controller.
- 9.A.5. The system will monitor the pressure differential across the evaporator coil and will modulate the evaporator bypass damper to ensure the proper amount of evaporator cfm therefore optimizing the moisture removal capacity of the system at all times
- 9.A.6. The system will monitor the pressure difference between the zone pressure and the ambient pressure once the initial air balance has been completed and setup values entered into the controller. This will vary the exhaust fan volume via the fan motor VFD to help guarantee the negative pressure within the space.
- 9.A.7. The dehumidifier's refrigerant circuit shall be equipped with a water cooled condenser that rejects heat to the pool/spa water loop. The condenser shall be tube-in-tube, cupronickel construction with CPVC stub-outs
- 9.A.8. Outdoor units shall have the condenser wrapped in insulation and heat traced. The heat tracing shall be wired back to the control panel for an independent 120V power connection.

2.10 FILTERS

- 10.A. The unit shall be provided with MERV 8 disposable filters consisting of 4" pleated filter.
- 10.B. The outdoor air shall be filtered by a 2" MERV 7 pleated filter.

2.11 ELECTRICAL CONTROL PANEL

- 11.A. The electrical control panel will be easily accessible on one side so that service can be performed from the side of the unit. It will be of adequate size so as to house all electrical controls and devices. The unit will be provided with single point power connection to serve controls, fans, electric auxiliary heater (if provided), and compressors, factory wired to the power connection lug set. The electrical controls will include low-voltage transformers to supply 24 VAC control power, clearly labeled high- and low-voltage terminal strips, high- and low-pressure control (with manual reset of the high-pressure cutout and automatic reset of low-pressure cutout), and an anti-short cycling timer to protect against compressor cycling.
- 11.B. Short Circuit Current Rating (SCCR): The complete unit shall be rated in compliance with NEC® 110.10 and UL 1995 at nameplate voltage maximum, when protected by Class J, Class T or Class RK1 fusing. Electrical markings on the unit shall include, but not limited to the MCA (Minimum Circuit Ampacity), the MOPD (Maximum Over-Current Protection Device) and the SCCR.

11.C. Disconnect: Provided with a factory mounted and wired disconnect switch.

2.12 CONTROL SYSTEM

- 12.A. A digital control system using a 16 bit microprocessor shall be used to accurately and precisely control the dehumidification system and the space environment. The controller will include three (3) levels of password protection and shall be provided by the same manufacturer as the dehumidification unit.
- 12.B. The controller will provide precise system control and feature an easy-to-read display which indicates actual operating and set points. The display will be remote mountable up to 1,640 feet from the unit. The controller will have a built-in occupancy timer.
- 12.C. The unit shall include a temperature sensor to be field-installed.
- 12.D. The unit shall include a relative humidity sensor to be field-installed.
- 12.E. The dehumidifier shall be provided with one aquastat per pool or spa water condenser. The aquastat shall be installed by the mechanical contractor in the main water loop upstream of the pool heater and dehumidifier, constant water flow required across the aquastat.
- 12.F. The unit's controller shall have the following BMS compatibility: BacNet MS/TP communication card.
- 12.G. The following Control Points will be available as read/write through the on board terminal or through the BMS system

Zone Air RH Setpoint

Zone Air RH Deadband

Zone Air Temperature Setpoint

Zone Cooling Deadband

Zone Cooling Stage Deadband

Zone Heating Deadband

Energy Recovery Deadband

Pool 1 Temperature Setpoint (optional)

Pool 1 Temperature Differential (optional)

Pool 1 Stage Deadband (optional)

Pool 2 Temperature Setpoint (optional)

Pool 2 Temperature Differential (optional)

Pool 2 Stage Deadband (optional)

Network Occupancy Command (optional)

Network Event Command (optional)

Network Purge Command (optional)

Network Off Command (optional)

Remote Reset

12.H. The controller will include the following alarms:

Low Suction Pressure Circuit A

Low Suction Pressure Circuit B

High Discharge Pressure Circuit A

High Discharge Pressure Circuit B

Supply Air Sensor Failure

Zone Air Sensor Failure

Supply Fan Overload

Compressor Circuit A Overload

Compressor Circuit B Overload

System Shutdown

Low Supply Air Temperature

Exhaust Fan Overload

Low Voltage (optional)

Low Air Flow

Freeze Stat (optional)

12.I. The dehumidifier shall be equipped with an airflow switch to prevent the compressors from starting or operating on loss of airflow.

12.J. The dehumidifier shall be equipped with one water flow switch per water condenser. A water flow switch shall prevent condenser operation in the event of loss of water flow. The unit shall be able to function normally in the dehumidification mode when water flow is not present.

2.13 REMOTE AIR-COOLED CONDENSER

13.A.1. The size and capacity shall be in accordance with the unit schedule. The system shall be able to reject all the recovered heat (T.H.R) from Circuit A to the outdoor condenser.

13.A.2. The unit shall be provided with a weatherproof electrical panel with factory mounted door interrupt disconnect switch.

- 13.A.3. The unit shall be provided with a weatherproof electrical panel with factory mounted door interrupt disconnect switch.
- 13.A.4. The cabinet shall be constructed of G90 galvanized steel. The sides shall be one-piece construction. The unit shall be provided with lifting eyes located on the fan discharge panel.
- 13.A.5. The coil shall be constructed of copper tubing in a staggered design. Tubes shall be hydraulically expanded into full-collared, plate-type aluminum fins. Coils shall be factory leak-tested and sealed with caps.
- 13.A.6. The fan motors shall be heavy-duty PSC or three-phase with permanently lubricated ball bearings and built-in overload protection. All motors shall be factory-wired and leads terminating in a weatherproof junction box located on the outside of the unit cabinet.
- 13.A.7. The fan diameter shall not exceed 30". All units shall have a dynamically balanced fan with aluminum blades.
- 13.A.8. The fans shall be cycled based on internal head pressure on multiple fan units
- 13.A.9. Fan guards shall be heavy-gauge, closed-mesh steel wire with vinyl coating. Guards shall be contoured for maximum rigidity.

PART 3 EXECUTION

3.1 INSTALLATION

- 1.A. Install units per manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.
- 1.B. Provide transitions to exactly match unit duct connection size.
- 1.C. Reconnect piping and duct connections to existing as indicated on the drawings.
- 1.D. Connect unit drain to nearest indirect waste connection. Extend condensate drain line to the nearest floor drain and elbow into drain.
 - 1.D.1. Condensate waste shall be trapped at drain pan, with screwed cleanout plug in low point of trap.
 - 1.D.2. Multiple condensate discharge shall be trapped separately, as close to the unit as possible.
 - 1.D.3. Effective trap seal shall be two (2) times suction pressure of fan in inches for draw through units, but not less than three (3) inches.
 - 1.D.4. Install control devices furnished by manufacturer to be field installed.
- 1.E. Provide equipment base rail or housekeeping pad as required to maintain required height for installation of all piping and ductwork connections to unit including condensate traps.
- 1.F. Provide factory startup of equipment to ensure unit is ready for balancing and controls work. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and/or equipment.
- 1.G. Install new filters at completion of air handling system construction, prior to testing, adjusting and balancing work.

END OF SECTION

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