SECTION 230002

BUILDING MECHANICAL SYSTEMS

NOTE: It is the intent of this section of specifications to provide assistance in the design and preliminary pricing of this project. This information is based around Module 14 and 15 from the Marriot Hotel Design Standards dated January 2010 and and Module 14 and 15 from the Autograph Design Standards dated January 2010 and is subject to revision per operator choice and subsequent design changes and is not to be included as a part of any lease nor contractual agreement.

I. Project Description

A. The project scope consists of mechanical systems for a hotel. The basic building description is as follows:

1. The building consists of 325-room (keys), 12 floors (ground floor plus 11 guest levels), full service hotel including a three-meal kitchen / dining area with lobby bar, outdoor pool, fitness center, conference rooms and associated support spaces (office and back-of-house). Also, there will be a 550 space, open, free standing parking deck as depicted on the architectural drawings.
2. The total building area is approximately 268,000 sq. ft. (hotel and conference center only)
3. Reference the architectural plans for building configuration and schematic floor plan information.
4. This outline narrative is preliminary and is based on a number of assumptions. Load calculations are estimates only for basis of providing a common pricing baseline. Equipment arrangement is pending coordination of space based on the building configuration.
5. Refer to Marriott's operator's design standards for additional requirements related to the hotel systems. All requirements shall be met unless pre-approved as a deviation.
6. Provide all required interface including but not limited to test and balance, control sequence of operation and verification, testing, etc. for the MEP systems to be commissioned by a third party. All systems shall be set up and verified to function at maximum efficiency, minimizing energy consumption and operating cost.

II. The heating, ventilating and air conditioning (HVAC) system for the building shall be designed as follows and consist of the following major elements:

A. HVAC Design Criteria

1. The basic building block load shall include heat gain and losses per design conditions and include lighting based on actual light levels. Occupancy load shall be per Marriott Design Standards.
2. Design Conditions
   The HVAC equipment shall maintain the following indoor conditions maintained to plus or minus 2 degrees F., based upon the local conditions specified in the 2005 edition of ASHRAE HANDBOOK OF FUNDAMENTALS:
   a. Summer indoor shall be 72 degrees F.D.B. and 50% maximum relative humidity. The mechanical systems shall be designed and sized accordingly.

b. Summer outdoor shall be the ASHRAE 1% coincident weather data.
c. Winter indoor shall be 70 degrees F.D.B. The mechanical systems shall be designed and sized accordingly.
d. Winter outdoor shall be the ASHRAE 99.6% weather data.
e. Outside air amounts shall be based on the requirements of the International Mechanical Code and Marriott Design Standards.

3. U-factors shall be per the 2009 International Energy Code with GA Amendments.

C. The main central plant shall be located on the ground floor at the rear of the property. The system included in the central plant/mechanical room and service yard outside shall consist of the following:

1. Two (2) 400 ton electric air cooled centrifugal chillers piped in parallel located on grade within the mechanical room as depicted on the architectural drawings. Each chiller shall be selected for 42 degree discharge water temperature at 12 degree temperature difference. Chillers shall be manufactured by Trane or approved equal. Chillers shall utilize R123 or R134a refrigerant. Chiller shall not exceed 1.12 kW/ton at full load.
2. Three (3) centrifugal base-mounted, end suction primary chilled water pumps; one primary pump for each chiller and one standby pump; Bell & Gossett, Aurora, Peerless or equal. Pumps shall be variable speed, sized to match each chiller.
3. Four (4) centrifugal base-mounted, end suction secondary chilled water pumps; one primary and one stand-by for the common area air handling units and one primary and one stand-by for the guestroom fan coil units; Bell & Gossett, Aurora, Peerless or equal. Pumps shall be variable volume, sized to match the load served.
4. Provide all necessary accessories (air separator, expansion tank, etc.) for a complete piping system.
5. Provide one (1) nominal 7.5 Ton split systems with electric heat for conditioning of the central plant. Provide outside air to these split systems.
6. One (1) in-line exhaust fan for mechanical space ventilation. Provide two storm proof louvers for fan exhaust and intake. On the intake louver, provide a filter rack for make-up air intake. All openings shall have motor operated dampers; Greenheck or approved equal. Provide refrigerant monitoring and interlocks to the exhaust fan.
7. Provide chemical treatment for open and closed piping systems.
8. Multi-port refrigerant monitor with alarms and interlocks compliant with ASHRAE -15 and local code.

D. The chilled water distribution system shall be a primary secondary system. Secondary chilled water pumps shall be provided as described above for the hotel floors and common areas in separate piping systems. Distribution shall be variable volume flow based on differential pump/system pressure. All chilled water piping shall be welded schedule 40 steel. Piping on the service level shall be provided with vibration isolation hangars to decouple the system piping from the building structure.

E. Chilled water risers shall distribute water to each hotel room cooling unit and common area air handling systems. In addition, provide a dedicated chilled water loop for all water cooled refrigeration equipment including coolers, freezers and ice machines with its own closed circuit cooling tower. Isolation valves shall be provided at the base of each riser and throughout the common area distribution system for maintenance isolation. All chilled water coils shall be 2-way modulating type, except for equipment on the top level, which shall be provided with three-way modulating valves with full bypass.

F. Hotel system ventilation equipment shall be as follows:

1. Outside air shall be provided to deliver outside air to the hotel floors. The system shall be selected to fully condition and dehumidify outside air for direct delivery to hotel rooms and corridors. Discharge air temperature shall be adjustable from 53 degrees F to 75 degrees F. The outside air units shall be located on the roof. All ductwork shall be routed on the roof and shall be insulated with one layer of 2" thick Polyisocyanurate insulation and MFM Flexclad 400. Provide manufactured ductwork supports. The Outside Air units shall be as manufactured by Munters, DesertAire, or approved equal.
2. Outside air risers shall distribute from the unit described above to each hotel room. See architectural plans for riser locations. Outside air shall be ducted from the riser to a supply grill in the hotel room. A fire/smoke damper shall be provided at each shaft penetration. Sound baffles shall be provided between grilles on risers serving back-to back rooms. The smoke damper shall be interlocked to the fire alarm system. Outside air shall be provided at a rate of 55 CFM to each room.
3. In addition to the hotel room risers, one riser shall be provided at the center of the main corridor with horizontal distribution to provide fresh air and pressurization to the corridor. Outside air shall be ducted from the riser to supply grills in the corridor. A fire/smoke damper shall be provided at each shaft penetration if not utilized as part of the smoke control system. The smoke damper shall be interlocked to the fire alarm system. Outside air shall be provided at a rate of 2 air changes per hour to each floor corridor.
4. Outside air to common area air handling units shall be via sidewall louvers or roof hoods located near each unit or equipment room. These systems shall be fan forced or passive based on the proximity of the intake to the air handling unit. Outside air to each system shall be provided with a motor operated damper for isolation and a heating coil shall be provided where not included in the associated air handling unit to temper the outside air. These outside air duct systems shall be sized to accommodate 100% outside air economizer.

G. Hotel system exhaust equipment shall be as follows:

1. Toilet exhaust risers shall be provided to ventilate the hotel restroom spaces and routed to an exhaust fan on the roof. Fan shall be Greenheck G series or approved equal. A ceiling mounted approved exhaust fan interlocked with the light switch and sub-ducted into the vertical sheet metal exhaust riser to the roof mounted fans. A sub duct shall be installed and rise 22 inches (minimum) in the riser duct. No fire damper is required if this system is approved by the local code officials. See architectural plans for riser locations. Toilet exhaust shall be provided at a rate of 50 cfm for each restroom
2. An exhaust riser shall be provided to ventilate the Housekeeping / Service Elevator Lobby/Vending spaces, Linen, Electric Rooms on each floor. Exhaust shall be provided at a rate of 500-800 cfm per floor.
3. Toilet exhaust fans systems shall be provided for each restroom area in the common areas. Fans shall be constant volume sized based on the associated restroom configuration.

H. Hotel rooms shall be conditioned via vertical stacking fan coil units. Fan coil units shall be International model MPY or approved equal. Each system shall be complete with 3 row cooling coil, electric heating coil, and remote mounted thermostats. All units shall be UL listed with a one hour fire rating. Systems shall be designed for operation at medium fan speed. Each typical hotel room shall be provided with a system sized to deliver 0.75 tons of

total cooling capacity. Larger Suites shall be provided with a unit sized to deliver 1.5 tons of total cooling capacity. The Fitness Room shall each be provided with two units sized to deliver 2.0 tons of cooling capacity each. Chilled water coils shall be sized for a 14 degree F temperature difference with chilled water entering temperature of 42 degrees F. Supply air shall be discharged at the face of the unit enclosure.

I. Typical Elevator Lobbies on each hotel room level shall be conditioned via vertical stacking fan coil units as described for hotel rooms. Each unit shall be sized at 1.0 tons of total cooling capacity.

J. All areas in the common areas shall be conditioned via chilled water air handling units with electric heating coils. The systems shall be variable air volume (VAV) with zoned terminal units unless noted otherwise below. Terminal units shall be provided per zone by space function and exterior exposure. As a minimum, provide a separate air handling unit system for the following:

1. Conference, Meeting and Pre-function Areas (4 units)
2. Balance of lobby level (business center, service areas, lobby, etc.)
3. Housekeeping and Back of House
4. Kitchen (Chilled water taps only)
5. Restaurant (chilled water taps only)

Note that the above is a general guide to demonstrate system zoning. All areas shall be provided with complete systems based on the final architectural plan. Each air handling unit shall include a mixing box section with motor operated dampers on the return and outside air ductwork. These dampers shall be controlled with an active air monitoring station to maintain required outside air under all system operating conditions. Each system shall include CO2 monitoring sensors to provide active control of the outside air based on occupancy. Air handling units shall be Trane Performance Climate Changer or approved equal.

K. For each air handling system on the lobby, provide a series fan powered terminal unit for each space indicated on the architectural plans.

L. All AHU's shall be of double wall construction with closed cell insulation and stainless steel drain pan.

M. All air distribution shall be via an engineered sheet metal duct system sized at 0.08" loss per 100 ft for low pressure systems. All ductwork shall be fabricated and installed in compliance with the requirements of SMACNA. For VAV systems, the primary conditioned air shall be distributed to terminal units through a medium-pressure, rectangular and round, spiral galvanized sheet metal duct system. Lined rectangular ductwork shall be provided directly downstream of each air handling unit for a minimum of 25 feet or through the first elbow (whichever is longer). All other ductwork which is not lined shall be insulated with duct wrap.

N. All diffusers in hard ceilings in the common areas shall be linear slot diffusers with mud-in finish (no visible flange) – Titus Flowbar or approved equal.

O. In the conference areas, provide linear slots in ceiling and return down low.

P. The kitchen shall be provided with 16 gauge black steel exhaust systems for all grease exhaust hoods. Exhaust ductwork shall be wrapped with 2 hour fire insulation to allow zero

clearance from combustible materials. Ventilation rates shall be determined by the kitchen consultant. Exhaust shall be via a scrubber. Separate systems shall be provided for each hood unless they are intended for common operation. Make-up air to the hoods shall be via a dedicated air handling unit with chilled water coil and electric heating coil. All make-up air shall be heated or cooled prior to delivery to the hood.

Q. The kitchen dishwashing system shall be provided with stainless steel exhaust ductwork and fans. These systems shall be routed to outdoors and discharged via a louver in the building exterior.

R. Provide lined return air boots in all walls to structure or rated walls to allow for a return air path to the mechanical room on each floor. Return air boots shall be sized at 500 fpm. Provide fire dampers in all boots in rated walls.

S. All ducts penetrating vertical shafts shall be provided with a combination fire smoke damper as required by code. Smoke detectors shall be installed downstream of each fire/smoke damper. Detectors shall be provided by Division 16 and installed by Division 15. Smoke/fire dampers shall not be provided for risers that are part of the smoke control system.

T. All exterior louvers shall be storm proof and drainable. Louvers shall be sized peT manufacturers data to avoid water intake. Any inactive sections of louver shall be backed by sheet metal and shall be sealed air and water-tight. Louvers shall be by Ruskin or approved equal

U. The building elevator machine rooms shall have chilled water, cooling only fan coil units with electric heat. Quantities and capacity shall be as follows: one (1) 7.5-ton unit with 15 kW of electric heat serving each Service Elevator machine room, and two (2) 7.5-ton unit serving the Hotel Elevator machine room. In addition, for each elevator machine room, provide a back-up DX split system to match the capacity of the primary system. The indoor unit shall be mounted in the space. The condensing units shall be located on the roof or loading dock area. The units shall be provided with low ambient controls to minus 10 degrees F, and shall be controlled by a thermostat located in the machine room. Provide all necessary ductwork, diffusers, chilled water piping and refrigerant piping for a complete system.

V. The main telephone room shall be provided with a nominal 5 ton chilled water cooling only fan coil unit. In addition, provide a matching DX split system for back-up. The condensing units shall be located outside. Provide all necessary ductwork, diffusers and refrigerant piping for a complete system.

W. Provide dedicated HVAC systems for IT closets, MDF and IDF rooms with a chilled water cooling only fan coil unit. In addition, provide a matching DX split system for back-up. The condensing units shall be located in loading dock area. Provide all necessary ductwork, diffusers and refrigerant piping for a complete system.

X. The main electrical transformer and switchgear room shall each be provided with an exhaust fan, ductwork to exhaust to the loading deck area through a storm proof louver, and intake air louver. Fan shall be a Greenheck CSP or approved equal.

Y. Each core telephone and electrical room shall be ventilated with an exhaust fan and transfer air ducts. Fan shall be a Greenheck CSP or approved equal. Provide lined transfer ducts sized at 500.

Z. Provided dedicated exhaust fans for the following areas. Exhaust fans to be located sidewall or on the roof:
1. Employee Cafeteria
2. Restaurant
3. Coffee / Bar
4. Engineering Shop
5. Pool Equipment Room
6. Chemical storage rooms

AA. Miscellaneous ventilation fan systems and unit heaters shall be provided to properly condition all service areas, pump rooms, etc. and for freeze protection.

BB. Provide stairwell pressurization systems at each stairwell consisting of utility set supply fans on the roof and relief hood/louver. Supply air shall be ducted to every other floor and discharged in each stairwell. The relief hood/louver shall include counter balanced back draft damper and motor operated isolation damper. Damper shall be balanced to maintain pressure within code required limits.

CC. The HVAC systems shall be balanced per AABC standards under direct, separate contract to the General Contractor. All air and water systems shall be balanced.

DD. Smoke Control System
1. Provide a complete engineered smoke control system (minimum of 8 air changes per hour), for the building. Provide smoke exhaust fans, located on the low roof, for each of the following areas:
   a. Lobby
   b. Pre-Function Area
   c. Guestroom Corridors (fan on high roof)

2. Provide a smoke control panel with Hand-Off-Automatic (HOA) and pilot lights (one switch for each AHU, fan and damper) for manual control of all equipment that is a part of the smoke control system. Panel to be located in the Fire Control Room as depicted on the architectural drawings. Public Spaces shall consist of hard ducted smoke exhaust fans from each required smoke zone. In zones where makeup air for the smoke exhaust is readily available from adjacent zones, the HVAC system serving the exhaust zone is turned off. When makeup air is not readily available, the HVAC system serving the smoke exhaust zone closes the return air damper and supplies 100% outside air to provide positive air flow to the smoke exhaust fans. Supply, return and exhaust fans in other zones remain in normal operation. When utilizing VAV systems, the air handling unit supply fan and VAV boxes switch to 100% open. Guest Corridors shall consist of vertically ducted , dedicated smoke exhaust risers with normally closed dampers on each floor. Fans shall be sized to serve corridors of three(3) floors simultaneously.
3. Duct smoke detectors shall be provided in all AHUs.
4. The smoke control system shall be connected to the Fire Alarm system.

EE. Provide air curtains at all doors opening to the loading dock.

III. HVAC Controls

1. Provide a complete DDC controls system for the building. System shall be by Trane, or

approved equal. System shall include the following:

a. Maintain comfort and minimize energy consumption
b. Entire system to be provided by the same manufacturer
c. Include equipment and flow diagram graphics for computer workstation
d. Include a computer station with laptop, monitor, keyboard and mouse to be located in the engineering office
e. Provide full control of primary and secondary mechanical equipment, including guestroom fan coil units.
f. For Public Areas, provide individual wall mounted thermostats. In other areas, provide wall mounted sensors with remote control type thermostats (button sensors).
g. BMS shall be designed for expandability by using plug-in modules for future installation by Marriott.
h. System shall be capable of trend logs and custom reports
i. Provide all control points required to meet operators parameters.
j. Include lighting controls points – six (6) points per floor and three (3) additional points on the first floor for site lighting controls
k. Provide all necessary interlocks, hardware, software, etc. for a complete system.
l. CO2 sensors interlocked for audible/visual and EMS system alarm shall be provided for all spaces with gas burning equipment.

2. The guest units shall be provided with an Intelligent Hotel Guest Room Control System capable of triggering an “occupied” room state. The sensors shall detect occupancy and set thermostats back automatically to reduce energy. Provide a front end for hotel employees to access all required interface. Basis of Design, Inncom as set forth by Marriott guidelines.

IV. The plumbing system for the building shall be designed as follows and consist of the following major elements:

A. The system shall include all sanitary, vent, hot and cold water piping, risers, floor drains, janitors sinks, roof drains, hose bibbs and all associated piping to all commercial plumbing fixtures and kitchen equipment indicated on the architectural drawings. Utilities shall be routed to 5'-0" from the building for continuation by the civil/site contractor. The building backflow preventers shall be located on site. Fire and domestic water shall enter the building on the First Floor. The building meter shall be located by the civil engineer on the site.

B. The hotel rooms shall utilize cast iron pipe and fittings for all storm and sanitary sewer systems. Sovent may be considered if the entire design is approved in writing by the manufacturer and the contractor is a certified installer.

C. All FCUs condensate shall be via a riser for each group of fan coil units in the guestrooms. Pipe to nearest indirect drain.

D. Storm piping from all roof drains shall be routed down through the building in the core and piped to 5'-0" from the building for continuation by the civil/site contractor. Storm piping and drains shall be sized based on a rainfall rate of as required by code. The secondary storm system shall consist of scuppers as shown on architectural plans.

E. Storm piping from all area drains within the parking garage shall be routed down through the deck and piped to 5'-0" from the building for continuation by the civil/site contractor. Storm piping and drains shall be sized based on a rainfall rate of as required by code. The secondary storm system shall consist of leaders/scuppers as shown on architectural plans.

F. Hot water for the hotel areas shall be provided via a two temperature, gas fired central heating system. This system shall distribute 140 degree F water to the kitchen spaces and 110 degree F water to guest rooms and common area plumbing fixtures. The water heaters shall be located in the mechanical/boiler room. The system shall consist of two water heaters and a large storage tank with Leonard high-low mixing valve for the 110 degree F system. All distribution piping shall be continuously re-circulated. Separate hot water mixing valves/zones shall be provided with independent distribution between common area/back-of-house and guestrooms.

G. Provide a complete hot water return throughout the entire system with balancing valves not less than 10 feet from the end of every branch or riser. At a minimum, circulate 1.0 GPM through each hot water riser or branch line. Provide two (2) centrifugal in-line bronze hot water recirculation pumps in parallel (one standby) and thermal mixing valves for each distribution zone; Bell & Gossett, Armstrong, or equal.

H. Provide non-freeze wall hydrants at the loading dock, main building entrance and penthouse.

I. Provide a packaged domestic water booster pump located in the Mechanical/Boiler Room to serve the hotel areas. Bladder type expansion tank and pressure controls shall be located next to the pump. Booster pump shall be manufactured by Synchroflo or approved equal. The building shall be separated into two (2) zones. Each zone shall be provided with a pressure reducing valve and distribution piping.

J. Provide two three thousand gallon in-ground grease traps for the hotel kitchen. The grease traps shall be located adjacent to the kitchen and shall be installed in series. Route grease waste piping to all fixtures in the kitchen space and restaurant space.

K. Provide one three thousand gallon in-ground grease trap for the conference center food service areas. The grease trap shall be located in the loading dock. Route grease waste piping to all food prep fixtures in these conference areas.

L. Provide heat trace and insulation on all exposed domestic water piping outside of conditioned building.

M. Provide a can wash at the loading dock with hot and cold water service. Route the can wash drain to the grease waste line.

N. Prior to occupancy, all domestic water systems shall be flushed and disinfected.

O. See Marriott's Design Standards for plumbing fixture specifications.

P. Provide a hydrotherapy bath in any of the suites as per design narrative.

Q. Provide all miscellaneous plumbing / fixtures as depicted on the architectural drawings throughout the facility.

R. Provide a chilled water system for the ice makers on each guestroom level.

S. Provide eye wash stations within the following areas: Pool Chemical Room, Mechanical Room, other locations where chemicals are mixed, dispensed or handled in a concentrated

form.

III. The Fire protection system for the building shall be designed as follows and consist of the following major elements:

A. The building shall be completely protected by sprinklers, fire pump and standpipes in accordance with NFPA 13, 14, 20, 88A and 24.

B. All areas shall be provided with flush type concealed heads in coordination with the architectural plans. In the service and back of house areas, semi-recessed heads may be used where lay-in ceiling tile is installed.

C. System standpipe shall be looped on each floor for dual feed of each zone. Zoning shall be as required by Marriott criteria.

D. Provide dry standpipes in the parking deck.

END OF SECTION 230002

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SECTION 230100

MECHANICAL GENERAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Division 21, 22, 23 and 25 and the accompanying drawings cover the provision of all labor, equipment, appliances, and materials and performing all operations in connection with the construction of the air conditioning, ventilating, heating, fire suppression and plumbing systems as specified herein and as shown.

B. The General Provisions and Division 01, including the general, supplementary and other conditions and other Divisions, as appropriate, apply to work specified in this Division.

1.2 INTENT OF DRAWINGS AND SPECIFICATIONS

A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable standards for materials, equipment and workmanship, and to provide operable mechanical systems complete in every respect.

B. The engineering drawings are diagrammatic, intended to show general arrangement and sizes of system components, and shall not be scaled. Rather, the architectural and structural drawings shall govern space constraints, dimensions and finishes. All offsets and fittings which will be necessary to accomplish the finished installation shall be provided at no additional cost or increase in the Contract.

1.3 SPACE PRIORITY

A. Ensure optimum use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below except as otherwise detailed. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
   1. Gravity flow piping systems
   2. Vent piping systems
   3. Recessed lighting fixtures
   4. Concealed HVAC terminals and equipment
   5. Air duct systems
   6. Sprinkler piping systems
   7. Pressurized piping systems
   8. Electrical conduit, wiring, control air tubing

B. Order of space priority does not dictate installation sequence. Installation sequence shall be as required to install all affected trades.

C. The work of Division 21, 22, 23 and 25 shall not obstruct access for installation, operation and maintenance of the work of any other Division.

D. All major items of equipment shall be arranged so as to provide a minimum of 28" clear aisle space. Additional space shall be provided between and around equipment for maintenance and proper operation as shown in the equipment manufacturer's literature.

1.4 COORDINATION

A. Coordinate all work under Division 21, 22, 23 and 25 with work under all other Divisions, providing adjustment as necessary.

B. Coordination of space requirements with respect to Division 26 shall be performed such that:
   1. No equipment, piping or ductwork, other than electrical, shall be installed within 42" of switchboards or panelboards.
   2. No piping or ductwork which ever operates at a temperature in excess of 120 degrees F. shall be installed within 3" of any electrical conductor.

C. All items mounted in or below the ceiling, and all items penetrating the ceiling, shall be coordinated with the architectural reflected ceiling plans. If any items are not shown on these plans, or any items need to be relocated for coordination purposes, prepare a reflected ceiling plan and submit it to the Architect for approval.

1.5 CODE COMPLIANCE

A. All workmanship and materials provided under Division 21, 22, 23 and 25 shall comply with all laws, ordinances, codes and regulations of all Federal, State and Local Authorities having jurisdiction.

B. All fire suppression, plumbing, heating, ventilating, and air conditioning materials and workmanship shall comply with all applicable codes and standards as minimum requirements.

C. Secure and pay all fees associated with all permits and licenses required for execution of the Contract. Arrange for all inspections required by city, county, state and other authorities having jurisdiction, and deliver certificates of approval to the Architect.

D. The code requirements are strictly a minimum and shall be met without incurring additions to the Contract. Where requirements of the drawings or specifications exceed the code requirements, the work shall be provided in accordance with these drawings or specifications. In the event of conflict or ambiguity between the various codes, the most stringent requirement shall govern.

1.6 ELECTRICAL REQUIREMENTS AND INTERFACE

A. All electrical equipment and wiring provided under Division 21, 22, 23 and 25 shall comply with the electrical system characteristics indicated on the electrical drawings and specified in Division 26.

B. Electric controls, contactors, starters, pilot lights, push buttons, etc., shall be provided complete as part of the motor, heater or other equipment which it operates. All electrical components shall be in conformance with the requirements of the National Electrical Code and Division 26. Reference Division 26 and the electrical engineering drawings for those motor starters provided under that Division 26. All starters not shown shall be provided under this Division 21, 22, 23 and 25. Unless specified otherwise under other individual equipment Sections, motor starters shall conform to the following minimum requirements:
   1. Starters for motors 1/3 horsepower or smaller shall be manual unless remote or automatic starting is required, in which case the starters shall be magnetic, full

voltage, non-reversing, single-speed, unless otherwise indicated. All other starters shall be magnetic.

2. Each starter for a three-phase motor shall be furnished with three (3) overload relays sized for the full load running current of the motor actually provided. Provide an external "HAND-OFF-AUTO" selector switch with red "RUNNING" light. Provide a green pilot light to indicate motor "STOPPED". Each pilot light shall have a legend plate indicating reason for signal.
3. Each overload relay shall have a normally open alarm contact which will close only when actuated by an overload (not to be confused with N.O. or N.C. auxiliary contacts). These contacts shall be properly wired to their respective blue pilot light provided on the starter front cover and having a "TRIPPED" legend plate.
4. Individually mounted motor starters shall be in a NEMA Type 1 general purpose enclosure in unfinished areas and shall be flush mounted in all finished areas. All starters mounted in exterior areas shall have a NEMA 3R enclosure. Each starter shall have a laminated nameplate to indicate equipment unit number, function and circuit number.
5. All motor starters, push buttons and pilot lights shall be of the same manufacturer as the switchboard and shall be General Electric, Square D, Siemens I.T.E., or Westinghouse.

C. Motor starters for the following equipment shall be provided under this Division 21, 22 and 23 by the manufacturer of the equipment:
1. Packaged air conditioning equipment
2. Water chillers
3. Cooling Towers
4. Fire pumps
5. Packaged booster pump systems
6. Fans
7. Other equipment hereinafter specified in other Sections to be provided with integral starters and as shown on the drawings.

D. Unless otherwise noted or specified in individual Sections, all 3-phase motors shall be standard NEMA continuous duty "B" type, with Class B insulation, open drip-proof frame for indoor service, TEFC for outdoor service and a service factor of 1.15. All motors 5 HP and larger shall be U.S. Motors Hi-Efficiency Model or Reliance XE Hi-Efficiency Model.

E. All power wiring and final connections to equipment shall be provided under Division 26.

F. Control components, all interlocks (motor-operated dampers, fire alarm motors, etc.) and control wiring (120 volt, single phase and less) shall be provided under this Division 21, 22, 23 and 25 as required to achieve the specified control sequences.

G. All control wiring over 30 volts shall be installed by a licensed electrician working under this Division 21, 22, 23 and 25.

H. All power to control panels and devices shall be provided under this Division 21, 22, 23 and 25.

1.7 SLEEVES, SEALS AND ESCUTCHEONS

A. Sleeves shall be provided through all pipe penetrations of concrete or masonry walls, etc.

B. Sleeves shall be fabricated from Schedule 40 steel pipe through 10" and Standard Wall steel pipe for sleeve sizes 12" and larger. All sleeves penetrating exterior walls, underground walls, pit or vault walls shall be provided with a 3" x 3/8" thick waterstop ring welded completely to the midpoint of the sleeve. Crete sleeves are acceptable for use in poured slabs.

C. All sleeves penetrating exterior walls, underground walls, pit or vault walls and elevated floors shall be packed and sealed watertight.

D. Sleeves through roofs shall extend above the roof surface and be flashed watertight.

E. Sleeves through walls shall be cut and finished flush with each surface of the wall in which they are installed.

F. Sleeves shall be sized to provide a minimum of 1/2" clearance between the inside surface of the sleeve and the outside finished surface of the pipe plus any insulation specified.

G. Fire-stops shall be provided as specified herein. All annular spaces between piping and sleeves, which do not require fire-stops, shall be packed with mineral wool and caulked.

H. Provide round, chrome-plated escutcheons on all exposed piping penetrations passing through walls, floors, partitions and ceilings.

1.8 FIRE-STOPS

A. Where ductwork, piping, conduit, etc. pass through fire partitions, fire walls and floors, a fire-stop shall be provided that will ensure an effective barrier against the spread of fire, smoke and gases. Fire-stop material shall be packed tight and completely fill gaps between the ductwork, piping, conduit, etc. and the perimeter of their rough openings.

B. Fire-stopping material shall maintain its dimensions and integrity while preventing the passage of flame, smoke and gases under conditions of installation and use when exposed to the ASTM E119 time-temperature curve for a time period equivalent to the rating of the assembly penetrated. Fire-stopping material shall be noncombustible as defined by ASTM E136; and, for insulation materials, melt point shall be a minimum of 1700 degrees F. for 1-hour protection and 1850 degrees F. for 2-hour protection. Fire-stopping material shall be Dow-Corning RTV Foam or 3M Fire Barrier Products or Sohio Carborundum Fyre Putty.

C. See Section 224000 for fire stopping of PVC piping.

1.9 CORE DRILLING

A. Cutting of holes through concrete and masonry shall be by diamond core or concrete saw. Pneumatic hammer, impact electric and hand or manual hammer type drills will not be allowed, except as permitted by the Architect where required by limited working space. Locate holes such that they will not affect structural sections such as ribs or beams. Holes shall be laid out well in advance of the installation. These layout locations shall be approved by the Architect prior to drilling.

1.10 OWNER STANDARDS

A. All products and installation shall comply with the latest edition of the Marriott Autograph

Collection Design Standards. The contractor shall obtain a copy of the standards. The contractor shall indicate any conflict between the design documents and the standards for resolution.

1.11 SOUND CHARACTERISTICS

A. All equipment and installations shall comply with the Marriott Autograph Collection Design Standards required sound levels, or as specified, whichever is the most conservative. The contractor shall submit sound data with all submittals indicating compliance with these standards.

PART 2 - PRODUCTS

2.1 BID BASIS AND SUBSTITUTION PROCEDURES

A. Manufacturers names, series and model numbers, as noted or specified, are for the purpose of describing type, capacity, and quality of equipment, materials and products to be used. Unless "or equal" is specifically stated, bids shall be based only on the specified "basis of design" manufacturer. The listing of a particular manufacturer as an "equal" or "acceptable substitute" manufacturer shall not be misconstrued as approving nor allowing the substitution of that manufacturer's standard product in place of the basis of design. No consideration will be given to a product, which would require dimensional, spatial or aesthetic changes to the project. "Acceptable substitute" and "equal" manufacturers shall only bid those products, which exactly match the size and other characteristics of the specified basis of design. Any changes to other disciplines and trades of work required by an "or equal" or "substitute" product shall be duly considered and priced accordingly prior to bidding or pricing. The decision as to whether or not a proposed substitute or "equal" product is actually equal to that specified shall rest solely with the Architect.

B. Requests to provide "equal" products in lieu of those specified shall be submitted to the Architect in writing at least ten (10) days prior to final pricing and execution of the Contract. No consideration will be given to substitute products after final pricing and execution of the Contract.

C. Any "or equal" product or proposed product substitution which will cause a change in the appearance, dimensions or design of any part of the building, it structure, electrical system or any other engineered systems shall be accompanied by a scaled drawing and written description of the required change(s) for approval by the Architect. If deemed necessary by the Architect, design changes shall be signed and sealed by a registered Professional Engineer, currently licensed in this State.

2.2 MINIMUM STANDARDS

A. Every piece of energy consuming equipment, all fire suppression products and life safety equipment shall comply with the following standards as applicable; especially in regard to prevailing codes:
   1. Factory Mutual Laboratories (FM)
   2. Industrial Risk Insurers (IRI)
   3. Underwriters Laboratories, Inc. (UL)
   4. ADC: Air Diffusion Council
   5. AGA: American Gas Association
   6. AMCA: Air Moving and Conditioning Association, Inc.
   7. ANSI: American National Standards Institute

8. API: American Petroleum Institute
9. ARI: American Refrigeration Institute
10. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers
11. ASME: American Society of Mechanical Engineers
12. ASTM: American Society of Testing and Materials
13. AWWA: American Water Works Association
14. IBR: Institute of Boiler and Radiator Manufacturers
15. MSS: Manufacturers Standardization Society
16. NBBPVI: National Board of Boiler and Pressure Vessel Inspectors
17. NEMA: National Electrical Manufacturer's Association
18. OSHA: Occupational Safety & Health Administration
19. PDI: Plumbing Drainage Institute
20. PPI: Plastic Pipe Institute
21. SMACNA: Sheet Metal and Air Conditioning Contractors National Association, Inc.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Before preparing submittals, study all Contract Drawings and specifications in detail, obtain manufacturer's recommended instructions, and have submittals prepared based on specific equipment and material proposed for installation. An officer of the contracting firm shall sign all shop drawings (certifying conformance with plans and specifications) before submitting to the Architect or releasing to the field.

B. The submittal process shall not be utilized as an avenue to substitute products after the execution of the contract. Should an unspecified or unequal product be submitted, it will be rejected. If a second attempt at substitution is made during the resubmittal of the same product, then no more reviews of that product will be performed without direct compensation to the Engineer being paid for the additional services required for the third review and any further reviews.

C. Electronic submittals are preferred. If hard copies are submitted, no more than four (4) copies of submittal data will be reviewed. Any additional copies will be returned unmarked. The responsibility of copying review comments on any additional copies will rest solely with the Contractor.

D. Submittals will not be accepted for review unless they:
1. Comply with the requirements of Division 01.
2. Include complete information pertaining to all appurtenances and accessories.
3. Are submitted as complete packages which pertain to all related items in Division 21, 22, 23 and 25. Separate packages shall be submitted as follows:
   a. All HVAC equipment and components
   b. All plumbing equipment, fixtures and components
   c. The fire suppression system
   d. The automatic controls and EMS
4. Are properly marked with equipment, service or function identification as related to the project and are marked with pertinent specification paragraph number.

E. Submit catalog information, factory assembly drawings, field installation drawings and certifications as required for complete explanation and description of all items of

equipment. The submittal data shall provide ample, unquestionable compliance with the Contract Documents.

F. Review of submittals shall not be construed as authorizing any deviations from the plans and specifications unless such deviations are clearly identified and separately submitted in the form of a letter that is enclosed with the submittals.

G. Submittals are required on all manufactured equipment, especially energy consuming equipment. Submittals shall include, but are not limited to, the following items of equipment:

1. Chillers
2. Pumps
3. Boilers
4. Piping Specialties
5. Insulation
6. Heat Exchangers
7. Heat Tracing
8. Water Heaters
9. Plumbing Fixtures
10. Fire Protection System (entire system, equipment and plans)
11. Packaged Domestic Water Booster System
12. Air-Handling Units
13. Variable Frequency Drives
14. Starters
15. Electric Duct Heaters
16. Terminal Units
17. Split Systems
18. Fans
19. Piping Shop Drawings
20. Sheet Metal Shop Drawings
21. Air Distribution Devices
22. Ductwork Accessories
23. Louvers and Hoods

3.2 EXCAVATION, TRENCHING AND BACKFILLING

A. Perform all excavation, trenching and backfilling for underground work under Division 21, 22, 23 and 25. During excavation, the excavated material shall be piled back from the banks of the trench to avoid overloading, slides or cave-ins. Do not exceed the angle of repose unless written approval is obtained in advance from the Architect for shoring, bracing or other alternate excavation methods. All excavated material not used for backfilling shall be removed from the building and disposed of as indicated or directed by the Architect. Take measures to prevent surface water from flowing into trenches and other excavations and any water accumulating therein shall be removed by pumping. All excavation shall be made by open cut. Tunneling shall not be allowed.

B. The bottom of all trenches shall be evenly graded to provide firm support and an even bearing surface. Pipe shall be laid on firm soil, laid in straight lines and on uniform grades. Provide bell holes so that the barrel of the pipe rests evenly on the bottom of the trench along the entire length of the pipe.

C. Pipe shall be inspected and tested prior to backfilling. Trench shall be handfilled to a minimum of 12" above the top of pipe with suitable earth (free of rocks, trash, large clods

and organic material) and compacted to a minimum 95% proctor. After the first layer is completed, subsequent layers shall be filled and compacted the same as the first layer. Settling the backfill with water shall not be permitted.

3.3 INSTALLATION REQUIREMENTS

A. All equipment shall be installed in strict conformance with the recommendations of the equipment manufacturer, as indicated on the Drawings and as specified.

B. Provide installation manuals for each piece of equipment. Submit in separately bound volumes after review of submittals.

C. Provide supplementary steel framing and welded steel equipment support stands as required for proper hanging and support of the mechanical systems. Steel angles, channels and tubing utilized for such framing shall be selected for a maximum deflection of 1/360th of the span.

D. All roof curbs shall be a minimum of 12" high and selected for the various roof pitches. Curbs installed on roofs having pitches of not more than 1/4" per foot may be standard curbs shimmed level with steel channels or Zs to provide suitable support and flashing surfaces.

3.4 CLEANING, LUBRICATION AND ADJUSTMENT

A. The exterior surfaces of all mechanical equipment, piping, ductwork, conduit, etc., shall be cleaned and free of all dirt, grease, oil, paint splatter, and other construction debris.

B. Ducts, plenums, and air unit casings shall be cleaned of all debris and either vacuumed or blown free of all rubbish, dirt, and dust before installing grilles, registers or diffusers.

C. Bearings that require lubrication shall be lubricated in strict accordance with the manufacturer’s recommendations.

D. All control equipment shall be adjusted to the settings required for the performance specified.

E. Fans shall be adjusted to the speed indicated by the manufacturer to meet the installed final system pressure at the airflows indicated. Any additional sheaves and belts required for final adjustments shall be provided with no increase in the Contract amount.

F. Any fans operated during construction shall have temporary filters. Temporary filters shall be changed regularly to minimize contamination of the equipment and duct systems. Permanent filters shall be installed prior to final inspection.

G. All coils shall be thoroughly cleaned and combed prior to final inspection.

3.5 PAINTING

A. All uncoated and uninsulated steel surfaces exposed to sight inside the building, such as piping, equipment hangers and supports which are not provided with factory prime coat or galvanizing, shall be cleaned and painted with one coat of rust inhibiting primer. In addition, all surfaces in finished spaces shall also be painted with two coats of finish paint in a color selected by the Architect. Any paint or coating that is applied on site and used

within the building weatherproofing system shall comply with VOC content limits identified in Section 018113 Sustainable Design Requirements.

B. All ductwork surfaces visible through grilles, registers and diffusers in finished areas shall be painted flat black.

C. Steel items exposed outside the building, such as equipment supports, uninsulated piping and hangers, which are not factory painted or galvanized, shall be cleaned and painted with one coat of rust inhibiting primer and two coats of asphaltic base aluminum paint. Insulated steel pipes outside the building shall be cleaned and painted with one coat of rust inhibiting primer before installing insulation.

D. Factory painted equipment that has been scratched or marred shall be repainted to match the original factory color.

3.6 DUCTWORK AND PIPING LEAK TESTING

A. Underground, concealed and insulated ductwork and piping shall be tested for leaks in place before backfilling, concealing or covering. Tests shall be conducted in the presence of the Architect or his designated representative.

B. All low pressure ductwork (design operating pressure of 1.0" W.C. E.S.P. or less) shall be tested by the operation of the system to which it is connected.

C. All medium and high pressure ductwork (operating pressure of more than 1.0" W.C. E.S.P.) shall be tested at 1.5 times the design operating pressure of the system to which it is connected, or at the total fan pressure at shut-off, whichever is greater. Sample testing per SMACNA recommendations is acceptable.

D. All visible and audible air leaks from the ductwork systems shall be repaired.

E. Soil, waste, storm and vent piping shall be tested with water before installing fixtures. Water test shall be applied to the system either in its entirety or to the individual sections. Each opening except the highest opening of the section under test shall be plugged, and the section shall be filled with water and tested with a head of water of at least ten (10) feet above the highest point in the system. The water shall be kept in the portion under test, for at least thirty (30) minutes; no drop in the water level will be acceptable.

F. The water piping systems shall be tested at a minimum pressure of 125 psi and proved tight at this pressure for not less than thirty (30) minutes or longer if required to permit inspection of all joints. No loss in pressure will be permitted.

G. All gas piping shall be tested pneumatically and proved tight at a pressure of not less than 100 psi for a period of not less than two (2) hours. No loss in pressure will be permitted.

H. All compressed air piping shall be tested pneumatically and proved tight at a pressure of not less than 100 psi for a period of not less than two (2) hours. No loss in pressure will be permitted.

I. Chilled water, condenser water and hot water supply and return piping shall be hydrostatically tested at a pressure of 100 psig (60 psig for PVC piping) for a minimum of one hour. No loss in pressure shall be permitted.

J. All refrigerant piping shall be 100% tested with a halide torch leak detector.

K. All leaks shall be repaired by tightening, remaking joints, or replacing pipe and fittings. Caulking of joints shall not be permitted.

3.7 RECORD (AS-BUILT) DRAWINGS

A. At the completion of the project, provide a set of reproducible PDF files to the Architect which reflect all changes, deviations and revisions made to the original design documents. Locations of all underground piping and utilities shall be clearly shown and dimensioned from permanent reference points such as building column lines.

3.8 OPERATING AND MAINTENANCE MANUALS AND INSTRUCTIONS

A. Complete operating and maintenance manuals shall be provided to the Owner. Four copies shall be provided. Each copy shall be bound in a separate 3-ring, loose-leaf notebook. Operating instructions shall be provided for each mechanical system, and shall each include a brief system description, a simple schematic and a sequence of operation. Operating and maintenance instructions shall be provided for each piece of equipment. A control system wiring diagram shall be included in each operating and maintenance manual.

B. Prior to final acceptance or beneficial occupancy, provide the services of a competent technician for not less than two (2) days to instruct the Owner in the operation of the mechanical systems.

3.9 TESTING AND BALANCING

A. Testing and balancing of the HVAC system shall be performed as specified in Section 23 04 30. Note that this work is to be performed under a separate Contract directly under the General Contractor. Submit four (4) copies of the test and balance report directly to the Architect.

3.10 WARRANTY

A. All work provided under Division 21, 22, 23 and 25 shall be subject to a minimum one year warranty. The warranty shall include prompt repair or replacement of equipment or system failures and shall include all parts and labor. In addition, all reciprocating air conditioning compressors shall carry an additional four-year parts-only warranty. Extended warranties shall be provided on all other equipment so specified in other Sections.

END OF SECTION 230100

SECTION 230430

HVAC TEST & BALANCE

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 230430 and the accompanying drawings cover the provision of all labor, equipment, appliances, and materials and performing all operations in connection with the testing and balancing (T&B) of the heating, ventilating and air conditioning (HVAC) systems as specified herein and as shown. These systems include, but are not limited to, the following:

1. Supply distribution systems
2. Return and exhaust air systems
3. Heating, ventilating and air conditioning equipment (all scheduled equipment as a minimum) airside and waterside.
4. HVAC hydronic systems.
5. Plumbing water distribution systems.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide a complete operable and balanced HVAC system as shown and specified which is reasonably airtight, comfortable and free of objectionable noise and vibration.

1.3 SCOPE OF WORK

A. HVAC test and balance shall be performed by an independent agency certified by the Associated Air Balance Council (AABC) under direct contract to the General Contractor. All work performed by this agency shall be performed by qualified technicians under the direct supervision of an AABC certified test and balance engineer. The agency shall be independent and shall not be associated in any way with the installing HVAC subcontractor.

B. HVAC test and balance shall be performed in accordance with the 4th edition of the AABC National Standards, 1982 for Total System Balance.

C. The final T&B report shall serve to substantiate compliance with the intent of the Contract Documents, specifically the HVAC systems.

D. HVAC test and balance shall not begin until the systems are substantially complete.

E. Upon the completion of the T&B work, the Agency shall submit four copies of the complete HVAC Test and Balance Report directly to the Architect.

F. The Agency, as a part of its contract with the General Contractor, shall act as an authorized inspection agency, responsible to the General Contractor and the Architect and shall, during the test and balance, list those items which require correction or have not been installed in accordance with the Contract Documents.

G. The Agency shall plainly mark the settings of all valves, dampers and other adjustable devices. If a balancing device is provided with a memory stop, it shall be set, locked and marked.

1.4 SUBMITTALS

A. The name and certification of the Agency, along with the name and certification of the Certified Test and Balance Engineer, shall be submitted to the Architect for review within 30 days after the award of the general contract.

B. The selected Agency shall submit to the Owner:
1. Procedural Manual
2. Report Forms
3. AABC Performance Guaranty
4. Instrument List and Calibration Dates
5. Schedule

C. A reviewed copy of each of the above shall be returned to the Agency before the HVAC Test and Balance begins.

D. If a complete submittal in accordance with these requirements is not received within 60 days from award of the general contract, then the Architect reserves the right to select the Agency.

PART 2 - PRODUCTS

2.1 (Not applicable)

PART 3 - EXECUTION

3.1 GENERAL CONTRACTOR'S DUTIES

A. The General Contractor shall provide the following, within 10 days after his receipt, to the Agency:
1. Contract drawings
2. Contract applicable specification division 15 (others as applicable)
3. Addenda
4. Change orders
5. Reviewed submittals

B. The General Contractor shall start-up and maintain the HVAC systems and shall continue the operation of the HVAC systems during each day of testing and balancing. Start-up and operation shall include, as a minimum, the following:
1. All equipment operable and in safe condition.
2. Temperature control system complete.
3. Proper thermal overload protection in place for electrical equipment.
4. Ductwork leakage rates not exceeding those specified and all duct systems clean of debris.
5. Air transfer systems shall have:
   a. Correct fan rotation and RPM.
   b. Coil fins cleaned and combed.
   c. Filters matching design efficiency, clean and in place.
   d. Access doors closed.

e. All dampers in place and open.
f. All grilles, registers and diffusers installed.

C. Provide sufficient time before final completion date so that testing and balancing can be accomplished. Coordinate the submitted T&B schedule.

D. Provide immediate labor and tools to make required corrections and repairs without undue delay.

E. The General Contractor and his subcontractors shall cooperate fully with the Agency to provide the following:
1. Access to HVAC system components.
2. The right to adjust the systems.

F. Any conditions which prevent a proper HVAC Test and Balance shall be reported by the Agency to the General Contractor and Architect within 7 days of their discovery.

G. If it is determined by the Agency and confirmed by the Architect that drive changes or additional balancing dampers are required, the Contractor shall obtain and install all necessary components.

H. The Agency shall cooperate with the Architect and the Contractor and all his subcontractors to perform the work in such a manner as to meet the job schedule.

I. The Agency shall verify that all system components are in place and in proper working order prior to leaving the project.

J. All reported, recorded data shall represent true measured conditions.

3.2 SCOPE OF WORK

A. All HVAC air and waterside systems shall be fully balanced to flow rates shown on the drawings. Airside components shall be balanced to within 10% of design; waterside components shall be balanced to within 5% of design.

B. Plumbing recirculated hot water system risers shall be balanced to flow rates shown on drawings.

END OF SECTION 230430

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SECTION 230600

HVAC PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 230600 and the accompanying drawings cover the provisions of all labor, equipment, appliances, and materials and performing all operations in connection with the construction of the piping systems as specified herein and as shown for the heating, ventilating and air conditioning (HVAC) systems. These piping systems include, but are not limited to, the following:
1. Chilled water supply and return (CHWS&R)
2. Condenser water supply and return (CWS&R)
3. Hot water supply and return (HWS&R)
4. Refrigerant suction and liquid (RS&RL)
5. Refrigerant relief and pressure relief (RR&PR)
6. Drains (DR)

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete and operable piping systems as shown and specified which are free of leaks, properly vented, free of noise, vibration and sweating, and fabricated so as to fit the space allotted and to exhibit a minimum resistance to fluid flow.

B. The word "piping" is defined to mean all piping, fittings, joints, hangers, coatings, valves, cocks, test and sensor wells and accessories necessary for the HVAC piping systems described, shown and specified.

1.3 GENERAL REQUIREMENTS

A. Provide all reducing fittings, flanges, couplings and unions of the size and type of material to match the piping to each piece of equipment, valve and accessory.

B. Union joints or flanges shall be provided in each pipeline connected to each piece of equipment and elsewhere as indicated and specified. Unions shall match the piping system in which they are installed.
1. Unions or flanges shall be provided between all copper to steel connections in water-carrying piping. These unions shall be dielectric, insulating type.

C. All changes in direction and branches shall be made with manufactured fittings.

D. In all water piping systems, changes in horizontal pipeline sizes shall be made with eccentric reducers installed flat on top for proper air venting. Reducing tees, reducing elbows and concentric reducers shall only be allowed for changing pipe sizes in vertical risers and for making connections to equipment and accessories from vertical risers.

E. In refrigerant, drain, steam and condensate piping systems, eccentric reducers shall be installed with the flat side on bottom to maintain the bottom of the pipe flush for proper condensate and oil drainage. Reducing tees, reducing elbows and concentric reducers shall only be allowed for changing pipe sizes in vertical risers and for making connections to equipment and accessories from vertical risers.

F. All pipe joints shall be cut square and all burrs shall be removed.

G. All butt-weld pipe elbows shall be long radius type.

H. Fabrication of a bullhead tee connection is strictly prohibited.

I. Each pump shall be provided with a straight run of piping into the suction of a length not less than five (5) times the suction pipe size indicated. Where space is limited, suction diffusers provided by the pump manufacturer may be reused.

J. Open ends of pipelines not currently being handled shall be plugged during installation to keep dirt, water and foreign material out of the system.

K. Horizontal water supply and return piping shall be installed level or, where space permits, slope up in the direction of flow at 1/2 to 1 percent of the run.

L. Horizontal refrigerant and drain piping shall slope down in the direction of flow at a minimum slope of 1/8" per foot of run.

M. All welders employed at this project shall be qualified under the requirements of ANSI Specification B31.1.0, Section 127.5. Evidence of welders' qualifications shall be submitted before any welds are made.

N. Welding procedures should be in accordance with ASME B31.1-2007 and ASME B31.9-2004, for the service involves welds that shall be full penetration type, accomplished by proper beveling and space pipe ends.

1.4 FIRE-STOPS

A. Where pipes pass through fire partitions, firewalls and floors, install a fire-stop that shall provide an effective barrier against the spread of fire, smoke and gases. Fire-stop material shall be packed tight and completely fill clearances between pipes and openings. Fire-stop material shall conform to the following:

1. Fire-stopping material shall maintain its dimensions and integrity while preventing the passage of flame, smoke and gases under conditions of installation and use when exposed to the ASTM E119 time-temperature curve for a time period equivalent to the rating of the assembly penetrated. Fire-stopping material shall be noncombustible as defined by ASTM E136; and in addition for insulation materials melt point shall be a minimum of 1700 degrees F. for 1-hour protection and 1850 degrees F. for 2-hour protection. Fire-stopping material shall be Dow-Corning RTV Foam or an approved equal.

1.5 IDENTIFICATION OF PIPING

A. All aboveground HVAC piping sized 3/4" and larger which is installed in accessible

locations (including piping above removable ceilings and behind access panels) shall be identified in strict conformance with the "Scheme for the Identification of Piping Systems" (ANSI A13.1-1996).

B. Each identification marker shall include to the following:
1. Proper color-coded background
2. Proper color of legend in relation to background color
3. Proper legend letter size
4. Proper marker length.
5. Direction of flow arrows shall be included on each marker.

C. Locations for pipe markers shall be as follows:
1. Adjacent to each valve and fitting
2. At each branch and riser take off
3. At each pipe passage through walls, floors or ceilings
4. On all straight pipe runs every 25 feet

D. Identification markers may be stenciled or shall be Setmark Pipe Markers, as manufactured by Seton Name Plate Corporation.

E. All valves shall be identified with the appropriate service designation and valve number with brass valve tags. Each valve tag shall be 19 gauge brass with 1/4" black-filled letters over 1/2" black-filled numbers. Tags shall be fastened to valves with brass "S" hooks or brass jack chain. Brass tags and fasteners shall be as manufactured by Seton Name Plate Corporation.

F. Provide charts of all valves. Valve charts shall include the following items:
1. Valve identification Number
2. Location
3. Purpose/Material

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. All pipe and fittings shall be products of a domestic manufacturer.

B. Pipe and fittings shall be as listed and outlined below:

	SERVICE	MATERIAL TYPE	SIZES
1.	Chilled Water Supply & Return	1	(2 1/2" & Larger)
2.	Chilled Water Supply & Return	2 or 5	(2" & Smaller)
3.	Condenser Water Supply & Return	1	(2 1/2" & Larger)
4.	Condenser Water Supply & Return	5	(2" & Smaller)
5.	Hot Water Supply & Return	1	(2 1/2" & Larger)
6.	Hot Water Supply & Return	5	(2" and Smaller)
7.	Refrigerant Suction and Liquid	4	All
8.	Refrigerant and Pressure Relief and Vents	1	All
9.	Drains*	6	All

*Note: As an option, on cooling coil condensate drains (which are not installed in a plenum) and all outdoor cooling tower drains only, the drain piping may be schedule 40 PVC with solvent joints; subject to advance approval by the Local Authorities. Fittings shall meet ASTM D2466 and solvent shall meet ASTM D2564.

C. The pipe, fittings and joints shall be as outlined below:
   1. Material Type 1:
      a. Pipe - Black steel, schedule 40 (standard weight for 12" and larger sizes), meeting ASTM A-106 and ANSI B36.10.
      b. Fittings - Carbon steel selected to match adjacent pipe per ANSI B36.10. Fittings shall meet ASTM A106 Grade B, ASTM A234 and ANSI B16.9.
      c. Flanges - Carbon steel meeting A105 Class 150, selected to match adjacent equipment, pipe, valves, fittings, etc. Flanges shall meet ANSI B16.5. Gasket faces shall be raised and meet ANSI B46.1 modified spiral serrated surface finish requirements.
      d. Joints - Beveled, butt-welded.
   2. Material Type 2:
      a. Pipe - Black steel, Schedule 40 meeting ASTM A120 standards.
      b. Fittings - 150 lb. class black malleable iron meeting ASME B16.3.
      c. Joints - Screwed with tapered threads per ASME B1.20.1 standards with Teflon pipe joint compound applied to male threads only.
   3. Material Type 3:
      a. Pipe -Same as Type 1, except schedule 80 (extra strong on 10" and larger).
      b. Fittings - Same as Type 1.
      c. Flanges - Same as Type 1, except extra strong bore.
      d. Joints - Same as Type 1.
   4. Material Type 4:
      a. Pipe - Type L hard drawn copper tubing meeting ASTM B88 or ASTM B280.
      b. Fittings - Wrought copper meeting ANSI B16.22.
      c. Joints - Silver brazed with sil-fos or silver solder.
   5. Material Type 5:
      a. Pipe - Same as Type 4.
      b. Fittings - Same as Type 4.
      c. Joints - Same as Type 4, except that a solder meeting ASTM B32 may be utilized in a soldered joint suitable for 150 lb. service.
   6. Material Type 6:
      a. Pipe - Copper drainage tube DWV meeting ASTM B306.
      b. Fittings - Wrought copper solder-joint drainage fittings meeting ANSI B16.29.
      c. Joints - Soldered with a solder meeting ASTM B32.

2.2 PIPE HANGERS AND SUPPORTS

A. Pipe hangers, trapeze hangers, upper attachments, rods and other supports shall be selected based on pipe size and material contained therein. Provide all hangers, rods, turnbuckles, angles, channels and other supports to securely support the piping systems from the building structure.

B. All materials utilized for the hanging and support of the piping systems shall be

manufactured products, which are specifically intended for the purpose of hanging piping systems. The use of wire, steel straps, plastic ties, etc. is strictly prohibited.

C. Supports and hangers shall be selected to fit around the pipe (and insulation unless otherwise specified herein) and provide adequate movement for expansion of the piping systems. Anchors shall be provided to restrict and control such movement within offsets and expansion loops.

D. All hangers and supports shall be selected at a minimum factor of safety of five based on the ultimate tensile strength of the material.

E. Intermediate pipe supports shall be provided between building structural members so as not to exceed maximum support spacing specified and shall be structural steel angles (minimum 2 1/2" x 2 1/2" x 1/4"). In steel construction, intermediate supports shall be securely clamped to steel beams and to steel joists, and in no case shall supports be attached to roof decks.

F. For suspending pipes from concrete beams, upper attachments shall be side beam bracket utilizing bolts in sleeves set in top portions of the beams. Where sleeves are not used, provide expansion shields or power-actuated fasteners.

G. Hanger rods for pipe hangers shall be as follows:

HANGER ROD SIZE	NOMINAL PIPE SIZE
3/8"	2" and Smaller
1/2"	2 1/2" and 3"
5/8"	4" and 5"
3/4"	6"
7/8"	8" thru 16"

H. Pipe hangers selected for supporting horizontal insulated piping shall be sized to fit around the outside of the pipe insulation except for the following services, which shall be sized to fit around the pipe and under the insulation:
1. Hot water supply and return piping, steam, condensate return and related piping sized 2" and smaller.

I. Provide pipe saddles, inserts and shields on all insulated piping as outlined below:
1. Hot water supply and return piping and associated steam and condensate return piping over 2" shall be supported by steel saddles welded to pipe. Insulation shall be continuous through the saddle.
2. All other insulated piping shall be supported on Foamglas insulation inserts and galvanized shields, except that no inserts are required on piping sized less than 2". Foamglas inserts shall extend at least 2" past each end of the pipe shields.
   a. Shields shall be as follows:
      1) Pipes 2" and smaller: 18 gauge x 12" long.
      2) Pipes 2 1/2" and larger: 16 gauge x 18" long.
   b. Shields and inserts shall be 180 degrees around the lower half of the pipe at all pipe hangers, except that on trapeze hangers, pipe racks and floor supported horizontal pipes, shields shall be 360 degrees around the entire pipe.

J. Provide riser clamps at all floor penetrations. Provide vibration isolation at all riser clamps with two (2) pad-type mountings consisting of a minimum 3/8" thick ribbed or waffled elastomeric pads bonded between minimum 16-gauge galvanized steel separator plates. Pads shall be sized for a deflection of 0.12" to 0.16". Pads shall be minimum 3" x 3" square.

2.3 VALVES

A. All valves shall have the manufacturer's name or trademark and the working pressure cast or stamped on the valve body.

B. All valves utilizing packing shall be designed and constructed to allow repacking while under pressure.

C. Gate valves for water services shall be as follows:
1. Non-rising stem type:
a. Valves 2" and smaller shall be bronze construction screwed bonnet with threaded end connections meeting MSS-SP80. Valves shall be rated for 125 W.S.P., 200 lb. (minimum) W.O.G Stems shall be bronze ASTM B-62 or silicon bronze ASTM B-371 with malleable iron handwheels. Valves shall be Hammond, Milwaukee, Stockham or Nibco.
b. Valves 2 1/2" and larger shall be iron body with bolted bonnet, inside screw, bronze trim, wedge disc and flanged end connections. Valves shall be rated for 125 W.S.P., 200 lb. (minimum) W.O.G. Meeting MSS-SP70. Valve shall be Hammond, Nibco, Milwaukee or Stockham.
2. Rising stem type:
a. Valves 2" and smaller shall be bronze construction with screwed bonnet with threaded end connections, wedge disc and screwed end connections Meeting MSS-SP80. Valves shall be rated for 125 W.S.P., 200 lb. (minimum) W.O.G. Stems shall be bronze ASTM B-62 or silicon bronze ASTM B-371 with malleable iron handwheels. Valves shall be Hammond, Stockham, Milwaukee, Nibco.
b. Valves 2 1/2" and larger shall be iron body with bolted bonnet, outside screw and yoke, bronze trim, wedge disc and flanged end connections. Valves shall be rated for 125 W.S.P., 200 lb. (minimum) W.O.G. meeting MSS-SP70. Valves shall be Hammond, Stockham, Milwaukee or Nibco.

D. Globe valves for water service shall be as follows:
1. Globe valves 2" and smaller shall be bronze with union bonnet, replaceable TFE disc and threaded end connections meeting MSS-SP80. Valves shall be rated for 150 W.S.P., 300 pounds (minimum) W.O.G. Stems shall be bronze ASTM B-62 or silicon bronze ASTM B-371, with malleable iron handwheels. Valves shall be Hammond, Milwaukee, Stockham or Nibco.
2. Valves 2 1/2" and larger shall be iron body with bronze trim, yoke bonnet, solid disc and flanged end connections. Valves shall be rated for 125 W.S.P. 200 pounds (minimum) W.O.G. Valves shall be Hammond, Milwaukee, Stockham or Nibco.

E. Ball Valves 2 inch and smaller for chilled water:
1. Ball valves shall be two piece bronze body, large port with solid, smooth bore chrome plated brass ball, meeting MSS-SP110. Seats shall be reinforced TFE

with Teflon packing ring and threaded adjustable packing nut. Valves on insulated lines will be provided with stem extensions to provide clearance for two inches of pipe insulation. Valves to be Apollo 70, Hammond 8501 or Watts B-6000.

F. Butterfly valves for use in chilled and condenser water only shall be as follows:

1. Butterfly valves shall be tapped full lug type designed to hold the valve against the upstream pipe flange independently of the downstream pipe flange meeting MSS-SP67. Valves shall be designed for use in systems with continuous operating temperatures between 40 degrees F. and 120 degrees F. Valves sized 6" and smaller shall be provided with memory-stop manual lever type handles with locking quadrant; valves 8" and larger shall have worm-gear operators with cast or malleable iron handwheels. All valves shall be equipped with position indicator plates. Automatic control valves shall be provided with pneumatic**electric** operators which shall provide full modulation from closed to open and positive closure. Valves shall be 150 lb. (minimum) W.O.G. valves with cast iron body, bronze alloy disc, stainless steel stem, EPDM (EPT) replaceable seat liner and shall have extended neck to allow for insulation in those piping services specified to be insulated. The valve liner design shall be such that it shall serve as a flanged seal and no separate gasket shall be required. Valves shall be Hammond, Mission, Demco, Keystone, Grinnell or Center Line. Butterfly valves shall not be utilized in hot water piping systems.

G. Check valves shall be as follows:

1. Check valves shall be non-slam type with iron body, globe-type silent checks with bronze trim, stainless steel spring and flanged end connections. Flow area through the valve shall exceed the cross sectional area of the pipe in which the valve is installed by not less than 10%. Valves shall be Mueller Steam Specialty Co., APCO, Metra-flex Globe Style Silent Check Valve Hammond IR 9354, or TRW Mission. All check valves on pump discharges shall be non-slam type.

H. Balancing valves:

1. Balancing valves shall have a cast iron body, bronze trim and bronze disc. Valve shall be suitable for 125 psig working pressure and provide positive shut-off. Each balancing valve shall be equipped with two gauge taps with check valves and drip caps. Provide preformed insulation to encase valve assembly. Balancing valves shall be Bell and Gossett Circuit-Setter Plus or equal by Illinois or Armstrong. After the test and balance is complete, provide to the Owner a differential pressure gauge to match the balancing valves.

I. Plug valves shall be as follows:

1. Plug valves shall be semi-steel body with lubricated plug and TFE seals. All valves shall be wrench operated and one wrench shall be provided with each size valve. Each valve shall be provided with the manufacturer's sealant. Plug valves shall be as manufactured by Nordstrom, Powell or Resun.

J. Relief valves shall be sized to have the pressure and temperature relief capacities indicated by their service. Relief valves shall be ASME rated and labeled.

2.4 FLEXIBLE PIPE CONNECTIONS

A. Flexible pipe connections for refrigerant relief piping shall be of flexible stainless steel construction with a minimum length of 12". Inner hose shall be type 320 stainless steel surrounded by an outer braiding of type 321 stainless steel. Hose shall be designed for a minimum working pressure of 125 psi at 250 degrees F.

B. Flexible piping connections for chilled and condenser water service shall be suitable for 150 psi working pressure and shall be fabric-reinforced neoprene, flanged construction with a length not less than their pipe size diameter.

2.5 STRAINERS

A. Strainers shall be Y-type and rated for a minimum working pressure of 125 psi WOG. Strainers sized 2" and smaller shall have screwed end connections and be provided with 20 mesh monel screens. Strainers sized 2 1/2" and larger shall have flanged ends and be provided with 1/16" perforated, 24 gauge stainless steel baskets. All strainers shall be provided with a blow-down connection complete with a full-size gate valve with hose end connection.

B. Strainers shall be manufactured by Metraflex or Mueller.

2.6 AIR SEPARATORS

A. Air separators shall be combination centrifugal air separators with system strainer. Vessels shall be designed for collecting entrained air from the water flowing thru them. Each vessel shall be of welded steel construction complying with ASME codes for not less than 125 psi working pressure and shall be so stamped and labeled. Piping connections shall be flanged. Internal strainer shall be removable and have a free area of not less than 5 times the area of the connecting pipe. Separators shall be provided with a factory enamel finish.

B. Air separators shall be Bell & Gossett Rolairtrol, Armstrong or J. J. Finnigan.

2.7 EXPANSION TANKS

A. Expansion tanks shall be of welded steel construction for a minimum working pressure of 125 psi at 240 degrees F. Construction shall be in accordance with ASME codes and the tanks shall be so stamped and labeled.

B. Expansion tanks shall be Bell & Gossett or J. J. Finnigan.

C. Expansion tanks shall be a precharged bladder type of welded steel construction for a minimum working pressure of 125 psi at 240 degrees F. Construction shall be in accordance with ASME codes and the tanks shall be so stamped and labeled. The expansion tank shall be supplied with a heavy duty butyl replaceable bladder, ring base, lifting rings, NPT system connection, 3/4" NPT drain and an air charging valve connection to facilitate adjusting precharge pressure.

D. Expansion tanks shall be Amtrol or an approved equal.

2.8 AIR VENTS

A. Air vents shall be automatic type and provided with a gate valve or cock on their inlet. Outlets shall be provided with 1/4" copper tubing routed to the nearest sanitary drain.

B. Air vents shall be Hoffman No. 78 or an approved equal.

2.9 THERMOMETERS AND PRESSURE GAUGES

A. Thermometers and pressure gauges shall be products of Trerice, Weksler or Weiss. Select all devices to operate within 20% of the midpoint of their scales under normal operating conditions. Gauges provided on pumps shall be compound type.

2.10 PRESSURE AND TEMPERATURE (P&T) TEST PLUGS

A. Plugs shall be constructed of brass with two (2) self-closing Nordel cores and be complete with cap and gasket.

B. Plugs shall be as manufactured by Peterson or Lancaster.

C. Provide a complete test kit to the Owner at the time of final inspection. Test kit shall be complete with pressure gauge, thermometer, probes and carrying case.

PART 3 - EXECUTION

3.1 ARRANGEMENT

A. Follow the general piping layout, arrangement, schematics, and details. Provide all offsets, air vents, drains and connections necessary to accomplish the installation. Fabricate piping accurately to measurements established at the project site to avoid interference with ductwork, other piping, equipment, openings, electrical conduits and light fixtures. Make suitable provision for expansion and contraction with expansion loops and offsets.

3.2 MINIMUM HANGER SPACING

A. Pipe hangers or supports shall be provided within 18" of each horizontal fitting, equipment connection, valve, etc. and at not more than the following spacings along horizontal runs of straight, plain piping:

	Pipe Size	Maximum Span
1.	2" and smaller	8 ft.
2.	2 1/2" through 4"	12 ft.
3.	5" through 8"	16 ft.
4.	10" through 14"	22 ft.
5.	16" and 18"	26 ft.

B. Riser clamps shall be provided at each floor penetration.

3.3 UNDERGROUND PIPING

A. All underground piping shall have a minimum cover of 3'-0".

B. Provide concrete thrust blocks at all changes of direction and secure all joints.

C. All underground copper water lines shall be protected from corrosion with a continuous plastic sheathing or coating and wrapping. This sheathing or coating and wrapping shall be extended 6" to 12" above finished floor.

3.4 REFRIGERANT PIPING INSTALLATION

A. All refrigerant piping shall be sized in accordance with the air conditioning equipment manufacturers written instructions. Provide charging ports, solenoid valves, service valves, dryers, etc. at each piece of equipment.

B. All brazing shall be done while the line is being flushed with carbon dioxide, nitrogen or other inert gases.

C. The inside of all tubing shall be thoroughly cleaned and internally wiped with a lintless, dry cloth.

D. Suction lines shall drop below their coils before any horizontal run.

E. Provide oil traps at least every ten feet for extended vertical risers.

F. All oil traps shall be constructed from close-radius type fittings.

G. Dryer cores shall be installed to remove horizontally or downward.

H. Install external equalizer downstream of its expansion valve sensing bulb.

I. Install expansion sensing valve bulb on top centerline of piping up to 5/8" size; install 45 degrees down from the horizontal centerline on pipe sizes 7/8" and larger.

END OF SECTION 230600

SECTION 231410

CENTRIFUGAL PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 231410 and the accompanying drawings cover the provisions of all labor, equipment, appliances, and materials and performing all operations in connection with the construction and installation of the centrifugal pumps as specified herein and as shown. These pumps include, but are not limited to, the following:
1. In-line Pumps
2. End-suction Pumps

1.2 BASIS OF DESIGN

A. The basis of design is Bell and Gossett. Any proposed substitutions shall be proven equal in all respects to the equipment specified as the basis of design. Any modifications to piping, electrical work, controls, building structure, etc., that result from any substitution shall be coordinated with all trades. This coordination shall occur before delivery of equipment and any modifications shall be performed without incurring additions to the Contract.

1.3 ACCEPTABLE MANUFACTURERS

A. Acceptable substitute manufacturers are Aurora and Peerless, provided that their pumps, performance, appearance and physical characteristics are equal in all respects to the basis of design for this specific project.

PART 2 - PRODUCTS

2.1 IN-LINE PUMPS

A. Furnish and install pumps with capacities as shown. Pumps shall be in-line type, close-coupled, single-stage design, for installation in vertical or horizontal position, and capable of being serviced without disturbing piping connections.

B. Pump casing shall be of Class 30 cast iron. The impeller shall be of cast bronze, enclosed type, dynamically balanced and keyed to the shaft.

C. The liquid cavity shall be sealed off at the motor shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225 degrees F. A bronze shaft sleeve shall completely cover the wetted area under the seal.

D. Pumps shall be rated for a minimum of 175 psi working pressure. The pump case shall have gauge tappings at the suction and discharge nozzles and shall include vent and drain ports.

E. Motor shall be premium efficiency, shall have heavy-duty grease lubricated ball bearings and shall be selected for the maximum load for which the pump is designed.

F. Each pump shall be factory tested. It shall then be thoroughly cleaned and painted with at least one coat of high-grade machinery enamel prior to shipment.

2.2 END-SUCTION PUMPS

A. End-suction pumps shall be base-mounted, single-stage, flexible-coupled centrifugal pumps. Pumps shall be suitable for base-mounted installations, and shall be capable of being serviced without disturbing piping connections; back pull-out design.

B. Pump casing shall be of cast iron. The impeller shall be of cast bronze, enclosed type, dynamically balanced and keyed to the shaft. Motors shall be premium efficiency.

C. Impeller diameter shall not exceed 85% of the casing cut-water diameter. Bearings shall be grease lubricated, complete with grease fittings designed for a minimum life of 40,000 hours (L10).

D. The critical speed of each pump shall be at least 115% of the scheduled RPM.

E. The pumps shall be free of cavitation at all flow rates from 25% to 150% of design flow under the suction conditions indicated.

F. The liquid cavity shall be sealed off at the motor shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225 degrees F. An aluminum shaft sleeve shall completely cover the wetted area under the seal.

G. Pumps shall be rated for a minimum of 175 psi working pressure. The pump case shall have gauge tappings at the suction and discharge nozzles and shall include vent and drain ports.

H. Base shall be constructed of welded structural steel suitable for grouting to a concrete pad.

I. All chilled and condenser water pumps shall be provided with a drip pan under the pump casing. Drip pan shall have a threaded connection for field piping to the nearest floor drain.

J. Each pump shall be hydrostatically and run tested at the factory. It shall then be thoroughly cleaned and painted with at least one coat of high-grade machinery enamel prior to shipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The pumps and accessories shall be installed in strict accordance with the manufacturer's recommendations and the Contract Documents.

B. All base-mounted pumps shall be grouted level and secured to the structure with anchor bolts.

END OF SECTION 231410

SECTION 231720

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 231720 and the accompanying drawings cover the provisions of all labor, equipment, appliances, and materials and performing all operations in connection with the construction and installation of the variable frequency drives as specified herein and as shown. This work includes, but is not limited to, the following:
   1. The variable frequency drive (VFD) and all necessary controls as herein specified shall be supplied by the drive manufacturer.

1.2 STANDARDS

A. Institute of Electrical and Electronic Engineers (IEEE)
   1. Standard 519-1992, IEEE Guide for Harmonic Content and Control

B. Underwriters Laboratories
   1. UL508C

C. National Electrical Manufacturer's Association (NEMA)
   1. ICS 7.0, AC Adjustable Speed Drives

D. IEC 16800 Parts 1 and 2

1.3 TESTING

A. All VFD's shall be assembled and tested at the factory. Burn-in and testing shall be on a motor at full rated load.

B. Assemble VFD shall be UL listed.

1.4 HARMONIC ANALYSIS

A. The VFD manufacturer shall provide total harmonic voltage distortion (THD) calculations, specific to this job. The acceptance of this calculation must be completed prior to VFD installation.

B. If the THD exceeds 5%, the VFD manufacturer shall provide all necessary line filters (sized per manufacturer) to ensure compliance with IEEE Standard 519 (latest version).

1.5 BASIS OF DESIGN

A. The basis of design is Yaskawa, ABB, AC Technology Corporation. Any proposed substitutions shall be proven equal in all respects to the equipment specified as the basis of design.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES (VFD)

A. The variable frequency drives (VFD's) shall be solid state, with a Pulse Width Modulated (PWM) output. The VFD package as specified herein shall be enclosed in a NEMA 1 enclosure (enclosure shall be UL listed as a plenum rated device) or NEMA 3R enclosure (enclosure shall be UL listed as an outdoor device) completely assembled and tested by the manufacturer. See the drawing for VFD locations. The VFD shall employ a full wave rectifier (to prevent input line notching), Integral Line Reactor(s), Capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device.

B. The VFD shall convert three-phase, 60 Hertz utility power to adjustable voltage and frequency, three-phase, AC power for motor speed control on variable torque loads with NEMA Design B motors.

C. The variable frequency control shall include transient voltage suppression to allow reliable operation on a typical industrial or commercial power distribution system. The VFD shall operate satisfactorily when other VFD's are operated from the same bus.

2.2 DRIVE FEATURES

A. The keypad of each VFD shall include an alphanumeric readout for all drive functions on a backlit, LCD display. The backlit LCD alphanumeric digital readout shall present all diagnostic messages and parameter values in English with standard engineering units. Codes are not an acceptable alternative.

B. The keypad of each VFD is to be used for local control, for setting all parameters, and for stepping through the displays and menus.

C. The keypad shall include Hand-Off Auto membrane selections. When in "Hand", the VFD will be started and the speed will be controlled from the up/down arrows. When in "Off", the VFD will be stopped. When in "Auto", the VFD will start via an external contact closure and the VFD speed will be controlled via an external speed reference. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Auto" and "Hand" modes and vice-versa.

D. The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable.

E. The VFD shall be equipped with an automatic extended control power loss ride-through circuit, which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and no inertia.

F. The VFD shall resume control of an rotating motor from an auto-restart command by matching frequency and accelerating or decelerating to set speed without tripping into a fault condition.

G. An overcurrent speed reduction shall be activated to avoid tripping the drive during transient overloads. The drive shall return to a set speed after the overload is removed. If the acceleration or deceleration rate is too rapid for the connected load, the drive shall automatically compensate to prevent a fault trip.

H. The VFD shall have two (2) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.

2.3 PROTECTIVE FEATURES AND CIRCUITS

A. The drive shall have the following protective features and circuits:
1. Overcurrent trip 350% instantaneous (170% RMS) of the VFD's variable torque current rating.
2. Overvoltage trip 130% of the VFD's rated voltage.
3. Undervoltage trip 65% of the VFD's rated voltage.
4. Heatsink overtemperature +90º C.
5. Ground fault either running or at start.
6. DC bus discharge circuit.
7. Input line noise suppression.
8. Phase loss protection – normal and bypass operation.
9. Isolated operator controls.

2.4 INPUT AND OUTPUTS

A. The VFD shall have as a minimum the following input and outputs:
1. Analog Outputs
   a. 0 to 10 VDC and 2 to 10 VDC proportional to speed and load.
   b. 24 VDC @ 50 made for powering remote devices.
2. Digital Outputs
   a. Three programmable Form C relay rated 2 Amps at 28 VDC or 120 VAC for; Run, Fault, Fault Lockout, At Speed, Above Set Speed, Current Limit, Follower Present, Auto Mode or Min/Max transducer level in PID mode.
3. Analog Inputs
   a. 4-20 ma speed.
   b. 0-10 VDC speed.
   c. Potentiometer speed.
4. Digital Inputs
   a. Two wire remote Start / Stop.
   b. Three wire remote Start / Stop.
   c. Local / Remote start and stop commands.
   d. Auto / Manual speed commands.
   e. Four Preset Speeds.
   f. Emergency / external fault stop from No or NC contact.
   g. Increase / Decrease speed or setpoint (floating point).
   h. Fault reset.
5. Serial Communication (three terminals) RS485
   a. Modbus or LON RTU Protocol
   b. PC Software available at no charge for direct access for:
      1) Monitor mode to duplicate keypad / display functions.
      2) Program upload and download mode.
      3) Control mode to duplicate keypad / display functions.
6. Drive shall be compatible with building control system.

2.5 DRIVE BYPASS

A. Three (3) Contactor Bypass
1. Integral NEMA 1 steel enclosure, with VFD module and three (3) contactor bypass module shall be independently enclosed and completely isolated from

each other when the bypass door is opened. All power and control terminations shall be brought from the VFD module to terminals within the bypass module.

2. A door interlocked disconnect switch with through-the-door handle and padlock facility in the OFF position, to provide positive disconnect of incoming AC power.
3. A three (3) contactor bypass is required to be provided to allow the motor to run across the line in the event of VFD shutdown. The transfer from the VFD to the line shall be accomplished manually by means of a BYPASS / OFF / DRIVE switch. The bypass shall include a mechanically inter-locked VFD output contactor, full-voltage motor starting contactor and a VFD input contactor for drive isolation and test. A thermal overload relay to provide motor protection, fused motor bypass and a fused control power transformer. A HAND/OFF/AUTO switch, TEST/OFF/DRIVE switch, BYPASS/OFF/DRIVE switch, POWER ON pilot light, BYPASS ON pilot light, DRIVE ON pilot light and SAFETY CIRCUIT TRIPPED pilot light (with reset) shall be mounted on the front of the bypass enclosure.

B. Two (2) Contactor Bypass
1. Integral NEMA 1 steel enclosure, with VFD module and two (2) contactor bypass module shall be independently enclosed and completely isolated from each other when the bypass door is opened. All power and control terminations shall be brought from the VFD module to terminals within the bypass module.
2. A door interlocked disconnect switch with through-the-door handle and padlock facility in the OFF position, to provide positive disconnect of incoming AC power.
3. A two (2) contactor bypass shall be provided with a fast acting semi-conductor fuse which will allow the VFD to disconnect from the line downstream of bypass branch circuit, which will allow bypass to maintain capability. The contactor on the bypass shall be mechanically interlocked to the contactor on the VFD output.

C. A dedicated terminal strip in the bypass control shall be included for 120 V (or 24 V) customer connections. These shall include terminals for external fault conditions, Start/Stop, Smoke Purge (that forces either the VFD or bypass to Run), the bypass contactor interlock (to prevent bypass operation). This terminal strip shall contain all VFD control terminals. Transfer to line bypass will require manual switching unless automatic transfer is specified. Provisions for an automatic transfer, after automatic restart attempts have failed to start the VFD, shall include a bypass lockout that can be activated to prevent unsafe bypass operation.

D. A spare drive may be provided in lieu of maintenance bypass if approved.

2.6 OUTDOOR INSTALLATION (Optional)

A. All drives installed outside of building shall be supplied with the following options.
1. NEMA 3R enclosure.
2. Electric heater in enclosure to prevent condensation.
3. Ventilation fan.
4. Thermostats to control heater and ventilation fan.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as

outlined in the installation manual.

B. Power wiring shall be completed by the electrical contractor. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

C. Provide summary of drive type and if bypass or spare drive will be provided.

3.2 START-UP

A. Certified factory start-up shall be provided for each drive by a factory authorized technician. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

3.3 WARRANTY

A. Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of manufacturer. The warranty shall include all parts, labor, travel time and expenses.

END OF SECTION 231720

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SECTION 231810

HVAC PIPING AND EQUIPMENT INSULATION

PART 1 – GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 231810 and the accompanying drawings cover the provisions of all labor, equipment, appliances, and materials and performing all operations in connection with the insulation of the HVAC piping systems as specified herein and as shown for the heating, ventilating and air conditioning (HVAC) systems. These insulated piping systems include, but are not limited to, the following:
1. Chilled water supply and return (CHWS&R)
2. Condenser water supply and return (CWS&R)
3. Hot water supply and return (HWS&R)
4. Refrigerant
5. Condensate drains (COND DR) (indoors only)
6. Chilled water equipment and accessories

C. All insulation products installed indoors shall meet NFPA 90A, 90B and 255 requirements for Flame Spread Rating 25 and Smoke Developed Rating 50.

D. Inserts for all piping which is specified to have hangers outside the insulation shall be provided at such hangers and supports for all piping 2" and larger. Inserts shall be Foamglas insulation, and shall be at least 2" longer than the length of the associated pipe shields.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide a complete piping insulation system which is free of gaps and tears, properly fitted and finished, free of sweating, and fabricated so as to fit the space allotted and to exhibit a negligible heat transfer.

B. The word "piping" is defined to mean all piping, fittings, joints, hangers, coatings, valves, cocks, test and sensor wells and accessories necessary for the HVAC piping systems described, shown and specified.

1.3 ACCEPTABLE MANUFACTURERS

A. Insulation products shall be as manufactured by Owens Corning, Knauf, Manville, Certainteed, Dow or Armstrong.

PART 2 – PRODUCTS

2.1 PIPING INSULATION

A. Piping insulation installed inside the building, except for the refrigerant suction service, shall be fiberglass preformed pipe insulation with a white all-service jacket/vapor barrier. Insulation shall have a maximum K of 0.23 BTU/In/Hr/SF/deg. F., at a mean temperature of 70 degrees F. For pipe sizes ~~2" through 4"~~ 4" and smaller, 1-1/2" thick insulation shall be

used; for pipe sizes larger than 4", 2" thick insulation shall be used. All hot water piping over 1.5" shall be 2" thick.

B. Piping insulation installed outside the building, except for the refrigerant suction service, shall be prefabricated 2 lb./cu.ft. density polyisocyanurate insulation (Trymer 9501 or approved equal) with waterproof mastic and glass fiber jacket finished with an aluminum jacket with waterproof silicone caulk joints. Outside the building, insulation with a maximum K of 0.14 BTU/In/Hr/SF/deg. F. at a mean temperature of 70 degrees F., shall be used. Outdoor piping 4" and smaller shall be insulated with 1" thick insulation; outdoor piping 4" and larger shall be insulated with 1-1/2" thick insulation.

C. Closed-cell insulation shall be provided over all refrigerant piping and other services as specified or noted. Closed-cell piping insulation shall be 1/2" thick 25/50 compliant Armaflex or Rubatex. All glues and coatings shall be products of the same manufacturer as the insulation.

D. Closed-cell insulation shall be provided over chilled water equipment and accessory cold surfaces to avoid condensation. Blanket type closed-cell insulation shall be ¾" (minimum) thick 25/50 compliant Armaflex or Rubatex. All glues and coatings shall be products of the same manufacturer as the insulation. Insulation shall be 6 lb. density, k-factor 0.28 at 75°F.

E. Insulation shall be continuous over all valve bodies, fittings, and wall and floor penetrations. Do not insulate unions on hot water piping; nor instruments, gauges, valve handwheels, etc. on any piping.

F. All piping insulation covering water-carrying piping which is exposed to the weather and subject to bursting from freezing temperatures shall have oversized insulation to accommodate heating cable.

G. Provide a continuous watertight aluminum jacket and fitting covers for all polyisocyanurate insulation piping exposed to the weather.

PART 3 - EXECUTION

3.1 INSTALLATION OF PREFORMED PIPE INSULATION

A. Indoors
1. Preformed pipe insulation with all-service jackets shall have all longitudinal joints lapped by a minimum of 2" and sealed with fire retardant adhesive. Butt joints shall be sealed with 3" wide tape similar to the insulation vapor-barrier jacket and secured with adhesive.
2. All elbows shall be insulated with preformed fitted insulation equal to the thickness specified for the adjacent piping insulation. As an alternative, provide fitting covers meeting NFPA/UL 25/50 ratings; stuff all covers with fiberglass insulation having characteristics equal to adjacent pipe insulation.

B. Outdoors
1. Preformed pipe insulation for exterior water-carrying pipe shall have insulation secured on with copper wire with ends twisted and turned into the insulation. Over the insulation, apply mastic to a minimum 1/4" thickness and draw in, while mastic is wet, glass fiber cloth. Finish with aluminum jacket with waterproof silicone caulk joints.
2. All water-carrying piping shall have self-regulating electric heat tracing installed as

specified in Section 231900.

3.2 CLOSED-CELL PIPING INSULATION INSTALLATION

A. Insulation shall be provided on all refrigerant and condensate drain lines. The insulation shall be installed by the slip-on method; slitting of the insulation is prohibited and shall be cause for rejection. All elbows shall be mitered and all such joints and butt joints shall be tightly made and glued.

B. All insulation installed outdoors shall be coated with a glossy white, ultraviolet protective coating applied in two coats.

C. Blanket insulation shall be provided on chilled water pump casings, chiller cold surfaces, chilled water system accessories and trim. Insulation shall be neatly cut and formed to the shape of the equipment. All ends shall be sealed. Where access is required, the insulation shall be made removable or fiberglass board insulation shall be provided as an alternate to allow access.

D. Closed-cell insulation shall not be used where system surface temperatures exceed 180°F.

3.3 MISCELLANEOUS REQUIREMENTS

A. Where insulation is installed over pipe hangers, seal vapor barrier at all penetrations. Also seal all end joints at unions and points of termination by bevel cutting the end and drawing jacket over until secured at the pipe. Apply white mastic to all end seals over jacket.

B. Insulate chilled water pump casings and chilled water air separator with two (2) layers of 1/2" thick closed cell insulation. Cover with two 2-1/4" thick coats of insulating cement. Insulate pump in two sections, the top section of which shall be removable to service the pump. Provide a removable section of insulation for the air separator strainer pull.

END OF SECTION 231810

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SECTION 231900

ELECTRIC HEAT TRACING

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 231900 and the accompanying drawings cover the provisions of all labor, equipment, appliances and materials, and performing all operations in connection with furnishing and installing the electric heat tracing as specified herein and as shown. This work includes, but is not limited to, the following:

1. A complete UL listed system of heaters, components, and controls to prevent water-carrying outdoor piping from freezing.

C. Only one electrical power connection shall be required for each system.

D. Electric heat tracing shall be U.L. listed.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, fully wired electric heat tracing systems as shown and specified, which operate efficiently and automatically.

1.3 BASIS OF DESIGN

A. The basis of design is Raychem XL-Trace. Any proposed substitutions shall be submitted in accordance with the prior approval requirements.

PART 2 - PRODUCTS

2.1 ELECTRIC HEAT TRACING

A. The self-regulating heater shall consist of two (2) 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be crossed over itself without overheating, to be used directly on plastic pipe, and to be cut to length in the field. The heater shall be covered by a radiation cross-linked, modified polyolefin, dielectric jacket. Not for installation on plastic piping.

B. In order to provide energy conservation and to prevent overheating, the heater shall have a self-regulating factor of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control of the heater output going from 40 degrees F. pipe temperature operation to 150 degrees F. pipe temperature operation.

C. The heat tracing shall operate on the available line voltage indicated without the use of transformers.

D. The heater shall be sized according to the following table. The required heater output rating is in watts per foot at 50 degrees F.

Pipe Size	Minimum Ambient of -10 deg. F.
3 inch or less	5 watts
4 & 5 inch	5 watts
6 inch	8 watts
8 inch	2 strips of 5 watts
10 inch to 14 inch	2 strips of 8 watts

E. Provide all power connections, end seals, splices and tee kits.

F. The system shall be controlled by a bulb-sensing thermostat set at 40 degrees F. either directly or through an appropriate contactor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The electric heat tracing and associated controls shall be installed in strict accordance with the manufacturer's recommendations.

B. The thermostatic control system shall be completely wired under this Division 23. Wiring shall be in accordance with the NEC and shall meet all requirements for this installation.

C. Apply the heat tracing linearly on the pipe after piping has been successfully pressure tested. Secure the heater to the piping with cable ties or fiberglass tape.

D. Apply "ELECTRIC TRACED" signs to the outside of the piping insulation.

E. All piping outdoors, in the parking deck or otherwise subject to freezing, shall be provided with heat tracing. This applies to all system piping with the exception of fire protection.

3.2 TESTS

A. After installation and both before and after installing the piping insulation, subject heat tracing to testing using a 1000 VDC megger. Insulation resistance shall be 20 to 1000 megaohms regardless of length.

END OF SECTION 231900

SECTION 232500

WATER TREATMENT

PART 1 – GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 232500 and the accompanying drawings cover the provisions of all labor, equipment, appliances, chemicals and materials and performing all operations in connection with the construction and installation of the water treatment systems as specified herein and as shown. These systems include, but are not limited to, the following:
1. Condenser water treatment
2. Chilled water treatment
3. Heating hot water treatment

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete water treatment systems as shown and specified, which are installed neatly into the spaces allotted.

1.3 ACCEPTABLE WATER TREATMENT COMPANIES

A. All chemical treatment systems shall be provided by Nalco Company, Garratt - Callahan Co., Technical Specialties Co. or Superior Water Treatment.

1.4 WATER ANALYSIS TEST AND REPORT

A. Provide four (4) copies of the water analysis tests and the treatment company's conclusions for and recommendations for the particular chemicals proposed for each system.

1.5 CHEMICALS

A. All chemicals utilized for water treatment shall be non-polluting and conform to all government regulations. All chemicals shall be EPA registered and biodegradable. Material safety data sheets shall be submitted to the Owner prior to use.

1.6 INSURANCE

A. Water treatment company shall provide an insurance certificate to the Owner as proof of a minimum one million dollars ($1,000,000.00) in liability insurance on systems treated.

PART 2 - PRODUCTS

2.1 CONDENSER WATER SYSTEM CHEMICAL TREATMENT

A. System shall consist of chemical tanks, chemical feed pumps, and automatic feed and bleed equipment.

B. All chemical feed piping shall be chemical-resistant plastic tubing.

C. Injection nozzles for connecting the chemical feed tubing to the condenser water piping shall have threaded male connections.

D. Pumps shall be self-priming, resistant to the chemicals being utilized and complete with anti-siphon check valve and internal pressure relief by-pass valve.

E. Water meters shall be brass body and have a minimum working pressure of 125 psig. The meter registers shall be calibrated in gallons. A magnetic type contactor shall be provided between the makeup water meter body and register, which shall generate a pulse when a given volume of water passes through the meter.

F. Bleed valves shall be low-voltage solenoid pilot operated, globe-type and shall have a brass body with a minimum working pressure of 125 psig. Valve shall be fitted with a diaphragm, which provides an adjustable flow rate. The valve shall be serviceable without removing it from the system piping.

G. Chemical feed control panel shall be 120 volts, 1 phase, complete with cord and plug, an internal or external conductivity sensor and the following face-mounted devices:
1. Bleed "ON" pilot light
2. Feed "ON" pilot light
3. Total dissolved solids (TDS) meter
4. pH meter
5. Pilot light test button

H. Timers shall be 24-hour, seven-day, analog type with spring carryover for power failures.

I. Chemicals (note that the application and quantity of each chemical is a function of the water analysis, which shall be taken into account prior to bidding or pricing) shall be as follows:
1. Corrosion inhibitors shall be phosphate-free, with no heavy metal content, and be of the organic polymeric type. The inhibitor shall be effective in pH's of 7.0 - 9.0.
2. Biocides shall be non-foaming, operational in pH of 6.5 - 9.5. Chlorine shall not be acceptable as a biocide.
3. Provide, where dictated by the water analysis, pH control. The pH control treatment shall be an inhibited, powdered acid type. Muriatic acid shall not be acceptable.

2.2 CHILLED AND HOT WATER SYSTEMS

A. Chemicals
1. The chilled water (closed) systems treatment shall be the nitrite-borate type. The residual as nitrite shall be maintained at 800-1000 ppm in the chilled and loop water systems.

PART 3 – EXECUTION

3.1 FLUSHING AND CLEANOUT

A. All HVAC piping systems shall be thoroughly cleaned, flushed and tested until the system water quality equals the raw water makeup quality. If it does not, the system shall be flushed and cleaned until this quality of water is attained.

B. No HVAC equipment shall be operated until the associated piping system has been flushed, cleaned and the water quality established, and the chemicals/PPS have been added/activated.

3.2 CONDENSER WATER CHEMICAL TREATMENT (BLEED & FEED) SYSTEMS

A. The systems shall provide automatic bleed of the condenser water based on conductivity due to TDS.

B. Automatic make-up shall be provided to maintain the minimum cooling tower basin level as sensed by an electric sensor(s).

C. The conductivity sensor, together with its control panel, shall measure the total dissolved solids (TDS) in the water by conductivity. When the conductivity reaches the set point the solenoid bleed valve shall open. When the conductivity falls below the set point, the solenoid bleed valve shall close. Set points shall be adjustable.

D. Water meters with registers shall be installed in both the makeup water line and bleed line. The makeup meter shall also contain a magnetic type contactor, which generates an electric pulse after a given volume of water passes through the water meter. The pulse shall be received by the inhibitor pump controller, which in turn energizes the associated chemical feed pump for a preset (adjustable) period of time.

E. A programmable time clock shall be provided to inject the biocides into the system and interlocked with the automatic bleed to temporarily stop the bleed and permit circulation of the biocide.
1. There shall be two biocides provided and they shall be alternated monthly.

F. The bleed and feed systems shall be interlocked to the condenser water pumps such that no bleed-off or chemical feed occurs when these pumps are off.

G. Provide all interlock wiring required to accomplish the sequences outlined herein. The only power required shall be taken from the nearest 120 volt receptacle.

3.3 CLOSED SYSTEMS

A. These chemicals shall be manually fed into their systems through their air separators or bypass pot feeders.

3.4 FOLLOW-UP

A. Provide the first twelve months' supply of all chemicals. The instructions for handling, storage and mixing of the chemicals and dosage requirements for this specific installation shall also be provided. All chemicals shall be provided by the same water treatment company.

B. The water treatment company shall provide test kits, reagents and training for the owner's personnel to monitor the water treatment program. Log sheets shall also be provided. The systems will be operated at the optimum cycles of concentration to facilitate only the minimum amount of bleed and feed that is necessary.

C. The water treatment company shall have a qualified technician supervise the equipment installation startup and system cleanout. Provide service calls every two weeks for the

first two months, then no less than once per month during the remainder of the first year's operation. A written report shall be provided to the Owner to provide system status water quality and recommend any necessary changes in the program after each onsite analysis.

END OF SECTION 232500

SECTION 236720

PACKAGED AIR-COOLED ROTARY CHILLERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this section is governed by the Mechanical General Section 230100.

B. This Section 236720 and the accompanying drawings cover the provision of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the chillers as specified herein and as shown.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted chillers as shown and specified which are free of leaks, sweating, excessive cycling, noise, vibration and temperature fluctuations.

1.3 BASIS OF DESIGN

A. The basis of design is *Trane*Carrier* JCI/York. Any proposed substitutions shall be proven equal in all aspects to the equipment specified as the basis of design. Particular attention is called to the requirements of Section 230100.

1.4 ACCEPTABLE SUBSTITUTE MANUFACTURER

A. Acceptable substitute manufacturer is *JCI/York * Trane *Carrier.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Chiller ratings shall be certified in accordance with ARI Standard 550/590 and shall conform to ANSI/ASHRAE 15-78, Safety Code for Mechanical Refrigeration.

B. All electrical components shall meet the requirements of the National Electrical Code and be UL listed.

C. Chiller efficiency shall meet the requirements of ASHRAE 90.1 or locally enforced energy code, whichever is greater.

D. Selection of the chiller shall be based on a minimum fouling factor of 0.00010 in the evaporator tubes. Pressure drops through the evaporator and the power input at full load shall not exceed scheduled quantities.

E. Chiller shall be complete with motor, compressors, evaporators, air-cooled condensers, lubrication systems, capacity controller, purge system, instruments, disconnect, starters and microprocessor control panel, and all other items specified; all factory mounted and factory wired on the chiller.

F. Each chiller shall be a complete assembly consisting of condenser, evaporator,

compressors, piping controls, and weatherproof casing; factory assembled, tested, packaged, and charged ready for operation. Testing shall be performed with all specified options and accessories installed.

G. Provide capacity control system capable of reducing unit capacity to 10% of full load. Compressor shall start in unloaded condition. Application of factory installed hot gas bypass shall be acceptable as required to meet specified minimum load.

2.2 COMPRESSORS

A. Compressors: Shall be direct drive, 3,600 RPM, semi-hermetic, rotary twin-screw type, including: muffler, temperature actuated “off-cycle” heater, rain-tight terminal box, suction and discharge shut-off service valve, and precision machined cast iron housing. Design working pressure of entire compressor, suction to discharge, shall be 450 PSIG (31 bar). Compressor shall be U.L. recognized.

B. Compressors shall start unloaded and provide a minimum of six steps of capacity modulation.

C. Each chiller shall be equipped with a minimum of two compressors and a minimum of two matching, independent refrigerant circuits.

D. A cycle counter and hour meter, which records the number of compressor, starts and hours of operation shall be provided for each compressor.

2.3 EVAPORATOR

A. Evaporator shall be accessible shell-in-tube type covered with 3/4" thick, closed-cell, foam plastic, vapor barrier insulation, protected against freeze-up by a thermostatically controlled electric heater cable wrapped around the shell under the insulation. Fouling factor shall be 0.00010. Evaporator shall be designed, tested, and stamped in accordance with ASME Code for refrigerant side working pressure of 235 psig.

2.4 CONDENSER

A. Condenser shall be constructed of aluminum fins mechanically bonded to seamless copper tubes pressure tested at 425 psig minimum. Condenser fans shall be vertical discharge propeller type, statically and dynamically balanced, direct drive, 3-phase motors with permanently lubricated ball bearings. Motors shall be furnished with thermal overload protection.

B. Condenser coils and fans shall be protected by *louvered sheet metal coil guards* and wire mesh access protection under the condenser coils.

C. Low Sound Fans: Shall be dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into low noise, full airfoil cross section, providing vertical air discharge from extended orifices. Guards of heavy gauge, PVC (polyvinyl chloride) coated steel.

2.5 REFRIGERANT CIRCUITS

A. Refrigerant circuits shall include hot gas muffler, discharge line check valve, high side pressure relief valve, liquid line shutoff valve, removable core filter drier, and liquid line

moisture indicating sight glass, liquid line solenoid valves, and thermal expansion valves. Units shall be equipped with two independent refrigerant circuits. Substitute units, which manifold more than one compressor on a refrigerant circuit, shall provide a ground fault and circuit protection system.

B. A gauge board with manual shut-off valves to monitor discharge, suction and oil pressure shall be provided; one set per refrigerant circuit.

2.6 CONTROLS

A. Controls shall be housed in an NEMA outdoor rated, weather tight enclosure with hinged access panel.

B. Controls shall have positive acting timer to prevent short-cycling of compressor and electronic expansion valve modulation, high and low pressure cut-outs, multiple-step leaving water temperature controller, fan sequencing, anti-recycle logic, lead / lag compressor start-up and load limiting chilled water safety thermostat, field power terminal blocks, fuses and circuit breakers, motor contactors, and control relays. Unit protection and safeties shall include low chilled water flow, evaporator freezing high and low refrigerant pressure, reverse rotation, compressor over current, phase loss or imbalance, phase reversal, low oil flow.

C. Provide low ambient control and high ambient options as required to ensure unit is capable of operation from 0º F. to 125° F. (18º C to 52° C) ambient.

D. Controls shall include a differential oil pressure safety switch for each compressor.

E. Where the chiller is interfaced with a building energy management system, the chiller shall be provided with the necessary communication interface. Coordinate this requirement with the controls manufacturer and clarify communication interface in product submittal.

F. Microprocessor controller shall include a user display showing chilled water temperature and temperature setpoint. Display shall be visible without opening access panel.

2.7 ISOLATORS

A. Spring isolators shall be selected by the manufacturer and furnished for field installation under unit frame.

2.8 POWER AND ELECTRICAL REQUIREMENTS

A. Power / Control Panel:
   1. NEMA (IP65), powder painted steel cabinets with hinged, latched, and gasket sealed outer doors equipped with wind struts for safer servicing. Provide main power connection(s), compressor starters and fan motor contactors, current overloads, and factory wiring.
   2. Panel shall include control display access door.

B. Single Point Power
   1. Provide single point power connection to chiller, shall be 3 phase of scheduled voltage.

2. Circuit breaker shall be provided at point of incoming single point connection to provide disconnecting means. AND be sized to provide the motor branch circuit protection, short circuit protection and ground fault protection for the motor branch-circuit conductors, the motor control apparatus and the motors. Circuit breaker shall be equipped with lockable operating handle that shall extend through power panel door so that power may be disconnected without opening any panel doors.

C. Control Transformer: Power panel shall be supplied with a factory mounted and wired control transformer that will supply all unit control voltage from the main unit power supply. Transformer shall utilize scheduled line voltage on the primary side and provide 115V/1Ø on secondary.

D. Short Circuit Withstand Rating of the chiller electrical enclosure shall be (200V & 230V: 100,000 Amps, 380, 400 & 460V: 65,000 Amps, 575V: 42,000 Amps). Rating shall be in accordance with UL508.

E. Motor Starters: Motor starters shall be reduced inrush type (Wye-Delta or Solid State) for minimum electrical inrush. Across the line type starters will not be acceptable.

F. Power Factor
1. Provide equipment with a power factor of 95%.
2. Power factor shall be same at full load and throughout part load operation. Designs that produce a power factor that reduces during part load operation will not be acceptable.

G. Exposed compressor and fan motor power wiring shall be routed through liquid tight conduit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Chillers shall be installed as indicated and in conformance with the manufacturer's recommendations. Coordinate the actual units to be provided with all trades.

B. Each chiller shall be field checked and started up by the equipment manufacturer. Four (4) copies of the start-up report shall be forwarded to the Architect.

C. The Contractor shall be responsible for the installation of the chiller including piping, controls and all ancillary equipment in accordance with the manufacturer's written instructions.

D. Each chiller shall be interlocked with a flow switch located in the chilled water piping and with auxiliary contacts on each chilled water pump starter.

3.2 ADJUSTMENT

A. The chillers shall be tested and adjusted after installation to provide the capacities indicated.

3.3 WARRANTY

A. Manufacturer shall warrant all equipment and material of its manufacture against defects in workmanship and material for a period of eighteen (18) months from date of initial start-up or date of shipment, whichever occurs first.

END OF SECTION 236720

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SECTION 237400

TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this section is governed by the Mechanical General Section 230100.

B. This Section 237400 and the accompanying drawings cover the provisions of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the terminal units as specified herein and as shown. These units include, but are not limited to the following:
1. Variable air volume (VAV) units
2. Powered induction units (PIU)
3. Associated control systems

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted terminal units as shown and specified, which are free of excessive noise, vibration and airflow fluctuations.

1.3 BASIS OF DESIGN

A. The basis of design is Envirotec. Any proposed substitutions shall be proven equal in all aspects to the equipment specified as the basis of design.

1.4 ACCEPTABLE SUBSTITUTE MANUFACTURERS

A. Acceptable substitute manufacturers are Trane, Metalaire, Price, Carrier, Nailor and Trane.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. Variable air volume units (VAV) shall consist of primary air damper, attenuator section and noise shroud (if required to meet listed sound pressure levels), low-voltage electric primary air damper actuator, primary air controller and any other items required to perform as indicated and specified.

B. The maximum acceptable NC at the VAV unit discharge is 40 at 1.0" inlet static pressure; the maximum acceptable radiated NC is 40 at 1.0" inlet static pressure. The maximum static pressure drop through the unit shall be 0.45" W.C. The maximum inlet velocity shall be 2200 FPM. The NC levels shall be rated with an 8d B total ceiling and room effect and 5'-0" of lined ductwork downstream of the unit.

C. The unit housing shall be constructed of galvanized steel sheets, reinforced to eliminate excessive flexing. Housing shall be internally lined with acoustical fibrous glass liner conforming to NFPA requirements. Service to internal parts shall be through an access door in the bottom or side of the housing.

D. Controls shall be low-voltage electronic type with electrical actuators.

E. A pressure independent primary air volume controller shall control the supply air quantity within 5% of the air volume required to satisfy the thermostat, regardless of changes in system static pressure. Each unit shall be factory set for maximum and minimum CFM. The VAV valves shall be normally closed on a loss of control power.

F. Powered induction units (PIU's) shall be factory fabricated complete with variable air volume section, fan powered induction section, disposable filter, backdraft damper for fan section, acoustically lined plenum section, factory-mounted heating coil (installed downstream of the fan section) and all electrical contactors, P.E. switches and controls. PIU shall have variable air volume unit (VAV) for primary air with fan discharge perpendicular to the VAV unit. See Paragraphs 2.01 A through E for VAV units.

G. Intermittent operation fan powered induction section shall consist of:
1. An acoustically lined sheetmetal housing and centrifugal direct drive fan wheel.
2. Resiliently mounted, vibration-isolated, permanently lubricated, 3-speed PSC fan motor of the voltage shown on the electrical drawings.
3. Backdraft damper to prevent reverse flow through blower.

H. The plenum section shall be acoustically lined and shall receive air from either the primary VAV unit or the induction fan, and distribute the air through the low pressure duct system. Parallel (side by side) discharge is unacceptable.

I. Each PIU, when operating in the fan powered, 100% induced air mode, shall be selected to operate against a minimum external static pressure of 0.35" with a maximum NC level of 35 at the discharge. At the same operating condition, the radiated noise shall be a maximum NC level of 35. All NC ratings are based on an 8d B total ceiling and room effect and 5'-0" of lined ductwork downstream of the unit. The PIU shall produce the indicated capacity with the fan motor in low or medium speed. High-speed selection is not acceptable.

J. The PIU’s shall have intermittent fan operation except those serving toilets, lobbies and other core areas, which shall be constant volume units.

K. There shall be only one electrical power connection required to each PIU assembly to provide electrical power to both the fan and the electric heater. Unit shall operate on 480-volt, 3-phase. Provide a separate fused disconnect and wiring for the fan motor. The fan motor shall draw not more than 4 amperes at high speed when connected to 277 volts, single phase. Coordinate which phase the motor is to be connected to (A, B, or C) with the electrical drawings.

2.2 ELECTRIC HEATING COILS

A. All electric heating equipment shall be UL labeled.

B. Refer to Division 26 of these specifications and to the electrical contract drawings for electrical characteristics and connections to all equipment. Coordinate all electrical heating equipment with these electrical documents.

C. Electric Heaters
1. Electric heaters shall be an integral part of the PIUs.

2. Heaters shall consist of individually mounted heating elements mounted in a sheet metal housing. Individual heating elements shall be of open coil construction.
3. Individual heating elements shall be interconnected and wired into a junction box mounted on the unit's sheet metal housing. Terminal blocks shall be used for all terminations within the junction box. Three phase electric heaters shall consist of equally rated heater elements internally connected to provide a balanced three phase load.
4. Each electric heater shall be provided with a factory installed UL listed automatic reset high temperature limit switch plus a factory installed UL listed manual reset high temperature limit switch.
5. Each electric heater shall contain a factory installed pressure type air flow switch or fan interlock relay which shall prevent heater control circuits from becoming energized until air flow across the heater coils has been established. Paddle type air switch is not acceptable.
6. Each electric heater or separately controlled section of electric heat shall be controlled by a solid state or mercury heating contactor factory mounted within the electric heater terminal box. Contactor shall be UL listed for 100,000 cycles use with resistance heating loads. Control coil contactor shall be operated by the automatic temperature control device in series with the automatic reset high temperature limit switches. Contactors shall be totally silent type.
7. Each electric heater or separately controlled section of the electric heater shall be provided with fused circuit protection as an integral part of the duct heater. Fuses shall be dual element type and shall be rated by the electric heater manufacturer based on the enclosure temperature. A fuse shall be provided in each under grounded conductor.
8. Electric heater shall be full flange type or slip-in type if the space for removal is available.
9. Electric heater dimensions shall be such that the minimum air velocity recommended by the duct heater manufacturer will be maintained based on the air quantities indicated.
10. All electric heaters shall be staged in increments not exceeding 2 KW via a solid state or mercury type silent contactor and SCR controller.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Units shall be installed as indicated and in conformance with the manufacturer's recommendations. Coordinate the actual units to be provided with all trades.

3.2 ADJUSTMENT

A. The units shall be tested and adjusted after installation to provide the capacities indicated.

END OF SECTION 237400

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SECTION 237440

ELECTRIC DUCT HEATERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this section is governed by the Mechanical General Section 230100.

B. This Section 237440 and the accompanying drawings cover the provisions of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the electric duct heaters as specified herein and as shown.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted heaters as shown and specified, which are free of excessive cycling and defects.

1.3 BASIS OF DESIGN

A. The basis of design is Reddi-Heat. Any proposed substitutions shall be proven equal in all aspects to the equipment specified as the basis of design.

1.4 ACCEPTABLE SUBSTITUTE MANUFACTURERS

A. Acceptable substitute manufacturers are Besco, Indeeco and Chromalox.

PART 2 - PRODUCTS

2.1 ELECTRIC HEATING COILS

A. All electric heating equipment shall be UL labeled.

B. Refer to Division 26 of these specifications and to the electrical contract drawings for electrical characteristics and connections to all equipment. Coordinate all electrical heating equipment with these electrical documents.

C. Electric Heaters

1. Heaters shall consist of individually mounted heating elements mounted in sheet metal housing. Individual heating elements shall be of open coil construction.

2. Individual heating elements shall be interconnected and wired into a junction box mounted on the unit's sheet metal housing. Terminal blocks shall be used for all terminations within the junction box. Three phase electric heaters shall consist of equally rated heater elements internally connected to provide a balanced three phase load.
3. Each electric heater shall be provided with a factory installed UL listed automatic reset high temperature limit switch plus a factory installed UL listed manual reset high temperature limit switch.
4. Each electric heater shall contain a factory installed pressure type air flow switch or fan interlock relay which shall prevent heater control circuits from becoming energized until air flow across the heater coils has been established. Paddle type

air switch is not acceptable.

5. Each electric heater or separately controlled section of electric heat shall be controlled by a solid state or mercury heating contactor factory mounted within the electric heater terminal box. Contactor shall be UL listed for 100,000 cycles use with resistance heating loads. Control coil contactor shall be operated by the automatic temperature control device in series with the automatic reset high temperature limit switches. Contactors shall be totally silent type.
6. Each electric heater or separately controlled section of the electric heater shall be provided with fused circuit protection as an integral part of the duct heater. Fuses shall be dual element type and shall be rated by the electric heater manufacturer based on the enclosure temperature. A fuse shall be provided in each under grounded conductor.
7. Electric heater shall be full flange type or slip-in type if the space for removal is available.
8. Electric heater dimensions shall be such that the minimum air velocity recommended by the duct heater manufacturer will be maintained based on the air quantities indicated.
9. All electric heaters shall be provided with a solid state or mercury type silent contactor and SCR controllers for modulation of heating capacity in 2 KW (max) increments.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Heaters shall be installed as indicated and in conformance with the manufacturer's recommendations. Coordinate the actual units to be provided with all trades.

B. Heater dimensions shall be based on manufacturer velocity requirements. Provide transitions in ductwork as required for inline installation. Heater dimensions may not match duct size.

C. Provide all safeties, interlocks, temperature safeties, etc. in compliance with UL.

3.2 ADJUSTMENT

A. The heaters shall be tested and adjusted after installation to provide the capacities indicated.

END OF SECTION 237440

SECTION 237600

AIR-HANDLING UNITS

PART 1 – GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 237600 and the accompanying drawings cover the provision of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the air handling units as specified herein and as shown. This work includes, but is not limited to, the following:
1. Factory-assembled air handling unit
2. Matched motor and electronic variable-speed drive

C. Air handling units shall be completely factory assembled. Only one electrical power connection shall be required for each unit.

D. Units shall be UL listed and certified in accordance with ARI 430.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted air handling units, as shown and specified, which operate efficiently and automatically, and are free of leaks, excessive noise and vibration.

1.3 BASIS OF DESIGN

A. The basis of design is McQuay Performance Climate Changer. Acceptable substitute manufacturers are Trane and Energy Labs, provided that any proposed substitutions shall be submitted in strict accordance with the requirements of Section 23 01 00.

1.4 COMMISSIONING

A. The construction process includes successful commissioning of systems to achieve Substantial Completion. Cooperation with the Commissioning Authority is required for documentation, testing and training of systems to be commissioned. Refer to Section 0191133 – General Commissioning Requirements.

PART 2 – PRODUCTS

2.1 UNIT CASINGS

A. Unit casings shall be formed, sheet steel construction with welded steel angle frame assemblies. Steel surfaces shall be either fully galvanized or phosphatized and painted with acrylic enamel for complete corrosion protection. All sections, casings, accessories and components shall match and interlock with each other.

B. The unit casings shall be provided with removable access panels or doors, which provide access to all internal parts.

C. The unit casings shall be 2” double-wall insulated internally with R-13 spray foam insulation. Insulation and facing shall meet NFPA 25/50 flame spread and smoke developed ratings. All unit components shall be insulated and thermally broken to avoid exterior surface condensation.

D. The unit casings shall be designed and constructed for minimum 4" W.G. static pressure operation.

E. Access panels in all sections shall be hinged, sealed doors.

2.2 FAN SECTION

A. Fans shall be centrifugal plenum type unless otherwise noted. Motors shall be premium efficiency. Fans shall be belt driven and shall be complete with an adjustable drive. Air handling units with fan motors and drive assemblies mounted on the exterior of the unit shall be provided with OSHA-approved belt guards.

B. Bearings shall have an ~~average~~ L10 life of 200,000 hours, shall be grease lubricated and shall be provided with fittings for lubrication. Internal bearings shall have lubrication lines extended outside the fan section and terminated with grease fittings. All grease fittings shall be located such that bearings can be greased while the unit is operating. Bearings which are too close to walls or other obstructions (within 24") shall have the grease lines extended to an unobstructed area of the casing to allow proper servicing.

C. All belt-drive components shall be selected at 1.25 times the rated motor horsepower. Belts shall be anti-static type. The fan drive sheave shall be fixed; the motor drive sheave shall be adjustable.

D. The fan and drive assembly shall be dynamically balanced after final factory assembly in accordance with ARI 435-78.

2.3 COIL SECTION

A. Coil section shall be constructed from galvanized steel and insulated as specified for all unit casings.

B. Chilled water coils shall be finned-tube type, constructed of copper tubes with aluminum fins. The fins shall be aluminum, the tubes shall be copper and the tubes shall be mechanically expanded into the fins and flared into the headers. Coils shall be drainable and pitched down toward the piping connection end. Coils shall be factory tested and proven leak-proof at 300 psig air pressure under water at the factory. Coils shall have threaded connections.

C. Coils shall be rated for a minimum working pressure of 250 psig.

D. Coils shall have chilled water, drain and vent connections extended through the casing and have no exposed U-bends, headers or tubing.

E. A stainless steel drain pan shall be provided completely under the coil section. This full drain pan shall have seamless, closed cell insulation sprayed to a thickness of 1/2" on the interior surface. This insulation shall be cellular and fully adhered to the steel drain pan such that a puncture will not affect the insulation nor permit water to seep beneath the insulation. Threaded drain connections shall be provided on each side of the drain pan

with the unused connection capped.

2.4 FILTER SECTION

A. The air-handling units shall be provided with low velocity (360 FPM maximum) angled filter sections. Filter sections shall be constructed to match other unit casing sections.

B. Filter sections shall include supporting tracks and clips for the filters. Filters shall be MERV-13 as manufactured by Farr or Continental and shall be 4” thick, disposable, 80% minimum average atmospheric dust spot efficiency when tested in accordance with ASHRAE Standard 52.2. Each filter shall include a media support grid and enclosing frame. Initial resistance at 500 feet per minute shall not exceed 1.5" W.G. Access to filters shall be through hinged access door(s) with gasketing and sealing latches.

2.5 VIBRATION ISOLATION

A. Air handling units shall be complete with vibration isolation provided by the unit manufacturer. Air handling units may be provided with internal isolation of the fan/motor assembly. The entire air-handling unit shall then be mounted on neoprene acoustical friction pads.

B. Should internal vibration not be provided, then adjustable, freestanding, open-spring type isolators with combination leveling and equipment fastening bolt shall be provided by the unit manufacturer. The spring shall be welded to the spring mounted baseplate and compression plate for stability. The isolator shall be designed for a minimum horizontal-to-vertical spring rate of 1.0. An elastomeric pad having a minimum thickness of 1/4" shall be bonded to the baseplate. Nut, adjusting bolts and washers shall be galvanized to prevent corrosion. Provide bolt holes for isolators. Isolators shall have a minimum 1.5" operating deflection.

2.6 VARIABLE AIR VOLUME CONTROL

A. Air handling units shall be provided with electronic variable speed drives (frequency inverters) and matching high-efficiency motors. Electronic drives shall be as manufactured by Eaton, Danfoss, ABB or York/JCI. Motors shall be Reliance XE or U.S. Motors High-Efficiency model. Electronic drive control signal shall be carefully coordinated with the automatic controls and energy management system.

B. Electronic drives shall be complete with isolation transformers or diode bridge to eliminate feedback on the power line. The drives shall be protected from overcurrent, short circuit, undervoltage, overvoltage, phase failure and overtemperature. The front panel face shall include on-off control switch with pilot light, manual speed adjustment, and a hand-off-automatic switch. Manual bypass is not required. Provide one (1) spare drive of each size.

2.7 DISCHARGE PLENUMS

A. Units shall be provided with double wall-lined discharge plenums sized for the unit and duct connections shown.

PART 3 – EXECUTION

3.1 INSTALLATION

A. The air handling units and associated controls shall be installed in strict accordance with the manufacturer's recommendations.

B. Automatic shutdown controls shall be provided to meet local codes (or NFPA 90A as a minimum) and shall consist of firestats and/or duct-mounted smoke detectors interlocked to the unit for shutdown on the detection of fire or smoke. Units having airflows of over 15,000 CFM shall be provided with smoke dampers on the entering side of the filter section to close on unit shutdown.

C. The associated control system shall be completely wired under this Division 23. Wiring shall be in accordance with the N.E.C. and shall meet all requirements for this installation.

D. The coil vent shall be provided with a manual, valved vent and the coil drain shall be provided with a blow-down valve with male hose threads.

E. The condensate drain piping shall be complete with a drain trap constructed with sufficient head (vertical distance between inlet and outlet of trap) to drain throughout the units' operating range.

F. All service access requirements shall be maintained as shown on the plans and required by the manufacturer. Special attention is called to the unit orientation and requirement for no rear access.

G. Unit shall be fully integrated in to the building EMS system. See 239000 for control requirements.

3.2 STARTUP

A. Provide the services of a factory trained and qualified service technician who shall inspect the installation including external interlock and power connections; supervise leak testing, initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.

3.3 COMMISSIONING TESTS

A. Testing of systems/equipment specified in this Section shall be coordinated, scheduled, and documented in accordance with the requirements of Section 019113 – General Commissioning Requirements.

3.4 COMMISSIONING DEMONSTRATION

A. Demonstration of operation and training of Owner’s personnel in operation and maintenance of systems/equipment specified in this Section is required. Coordination of the demonstration/training by qualified, factory authorized representatives is required with the Commissioning Authority. Instruction shall include a minimum number of hours as specified herein and approval of the formal training program is required by the Commissioning Authority. Refer to Section 019113 – General Commissioning Requirements.

END OF SECTION 237600

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SECTION 237650

FAN COIL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 237600 and the accompanying drawings cover the provision of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the air handling units as specified herein and as shown. This work includes, but is not limited to, the following:
1. Factory-assembled Fan Coil Unit.
2. Control System.

C. Fan coil units shall be completely factory assembled. Only one electrical power connection shall be required for each unit.

D. Units shall be UL listed and certified in accordance with ARI 210.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted air handling units, as shown and specified, which operate efficiently and automatically, and are free of leaks, excessive noise and vibration.

1.3 BASIS OF DESIGN

A. The basis of design is International Environmental. Acceptable substitute manufacturers are Trane, Carrier, American Thermal or Envirotech provided that any proposed substitutions shall be submitted in strict accordance with the requirements of Section 230100.

PART 2 - PRODUCTS

2.1 UNIT CASINGS

A. Unit casings shall be formed, 18-gauge sheet steel construction with welded steel angle frame assemblies. Steel surfaces shall be either fully galvanized or phosphatized and painted with acrylic enamel for complete corrosion protection. All sections, casings, accessories and components shall match and interlock with each other.

B. The unit casing shall be insulated with closed cell insulation.

2.2 FAN SECTION

A. Fans shall be double width, double inlet, forward curved centrifugal type unless otherwise noted. Fan blades and wheel shall be of aluminum construction.

B. All belt-drive components shall be selected at 1.25 times the rated motor horsepower. Belts shall be anti-static type. The fan drive sheave shall be fixed; the motor drive sheave

shall be adjustable.

C. The fan and drive assembly shall be dynamically balanced after final factory assembly in accordance with ARI 435-78.

2.3 COIL SECTION (Cooling)

A. Coil section shall be constructed from galvanized steel and insulated as specified for all unit casings.

B. Chilled water coils shall be finned-tube type, constructed of copper tubes with aluminum fins. The fins shall be aluminum, the tubes shall be copper and the tubes shall be mechanically expanded into the fins and flared into the headers. Coils shall be drainable and pitched down toward the piping connection end. Coils shall be factory tested and proven leak-proof at 450 psig air pressure under water at the factory. Coils shall have threaded connections.

C. Coils shall be rated for a minimum working pressure of 300 psig and shall be 6-row coils at a minimum.

D. Coils shall have chilled water drain and vent connections extended through the casing and have no exposed U-bends, headers or tubing.

E. A drain pan shall be provided completely under the coil section. This full drain pan shall have seamless, closed cell insulation sprayed to a thickness of 1/2" on the interior surface. This insulation shall be cellular and fully adhered to the steel drain pan such that a puncture will not affect the insulation nor permit water to seep beneath the insulation. Threaded drain connections shall be provided on each side of the drain pan with the unused connection capped.

2.4 FILTER SECTION

A. Units shall have minimum 1 inch thick, low velocity, glass fiber throwaway filters. Filter size shall be an approved Emory standard size.

2.5 VIBRATION ISOLATION

A. Units shall be complete with vibration isolation provided by the unit manufacturer. Units may be provided with internal isolation of the fan/motor assembly.

B. Should internal vibration not be provided, then adjustable, free-standing, open-spring type isolators with combination leveling and equipment fastening bolt shall be provided by the unit manufacturer. The spring shall be welded to the spring mounted baseplate and compression plate for stability. The isolator shall be designed for a minimum horizontal-to-vertical spring rate of 1.0. An elastomeric pad having a minimum thickness of 1/4" shall be bonded to the baseplate. Nut, adjusting bolts and washers shall be galvanized to prevent corrosion. Provide bolt holes for isolators. Isolators shall have a minimum 1.5" operating deflection.

PART 3 – EXECUTION

3.1 INSTALLATION

A. The air handling units and associated controls shall be installed in strict accordance with the manufacturer's recommendations.

B. Automatic shutdown controls shall be provided to meet local codes (or NFPA 90A as a minimum) and shall consist of firestats and/or duct-mounted smoke detectors interlocked to the unit for shutdown on the detection of fire or smoke.

C. The associated control system shall be completely wired under this Division 23. Wiring shall be in accordance with the N.E.C. and shall meet all requirements for this installation.

D. The coil vent shall be provided with a manual, valved vent and the coil drain shall be provided with a blow-down valve with male hose threads.

E. The condensate drain piping shall be complete with a drain trap constructed with sufficient head (vertical distance between inlet and outlet of trap) to drain throughout the units' operating range. Drain piping shall be 1" minimum.

F. Each unit shall be provided with a 316 stainless steel drain pan installed as detailed.

G. All units shall be located to allow for all required service. Filters shall be replaceable without bending.

3.2 STARTUP

A. Provide the services of a factory trained and qualified service technician who shall inspect the installation including external interlock and power connections; supervise leak testing, initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.

END OF SECTION 237650

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SECTION 237660

MODULAR HIGH-RISE FAN COIL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 237660 and the accompanying drawings cover the provision of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the air handling units as specified herein and as shown. This work includes, but is not limited to, the following:
1. Pre Piped Modular Factory-assembled Fan Coil Unit.
2. Control System and accessories.

C. Fan coil units shall be completely factory assembled. Only one electrical power connection shall be required for each unit.

D. Units shall be ETL listed and certified in accordance with AHRI 440. Units shall be UL listed for one-hour fire rating in 'back-to-back' systems.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted air handling units, as shown and specified, which operate efficiently and automatically, and are free of leaks, excessive noise and vibration.

1.3 BASIS OF DESIGN

A. The basis of design is International Environmental. Acceptable substitute manufacturers are Temspec, Whalen, or Zehnder Rittling provided that any proposed substitutions shall be submitted in strict accordance with the requirements of Section 230100.

PART 2 - PRODUCTS

2.1 UNIT CASINGS

A. Unit casings shall be formed, 18-gauge sheet steel construction with welded steel angle frame assemblies. Steel surfaces shall be either fully galvanized for complete corrosion protection in a concealed installation or provided with an oven baked paint finish. Color selection for painted units shall be by the architect. All sections, casings, accessories and components shall match and interlock with each other.

B. The unit casing shall be insulated with ½" thick fiberglass insulation. Insulation in the coil section shall be foil faced or closed cell.

C. Units shall be provided with supply air discharge openings for field installation of a supply register. The supply register shall be as specified on the drawings.

D. Single units shall be for concealed installation and provided with a full piping riser chase enclosure. Units shall be designed to have sheet rock wall board applied directly to the unit surface. All openings shall have standard ½" drywall flanges such that no framing around the opening is required.

E. Back to back pre-piped units shall be similar to single units except the housing will contain two complete units in one cabinet. The two units shall share a common set of chilled/hot water and condensate supply and return risers. Each unit will have independent thermostats, control valves, power connection, etc. The common riser chase shall be filled with insulation where piping crosses and gypsum board shall be provided to internally isolate the two unit sections. Barrier between back to back units shall be UL Listed for a one hour rating and shall be listed in the UL Fire Resistance Directory, 27WL.

F. Back-to-back field piped units shall be similar to the back-to-back pre piped units except they are not factory piped as one pair. The master unit is provided with a piping riser without enclosure and the slave unit is provided with piping stubs for field connection to the master unit risers.

2.2 FAN SECTION

A. Fans shall be double width, double inlet, forward curved centrifugal type unless otherwise noted. Fan blades and wheel shall be of aluminum construction. Blower housing shall be of galvanized steel with rolled lock or spot welded seam.

B. The fan motor shall be direct drive with the motor mounted to the blower housing, in the supply air path. Direct drive assemblies shall be provided with three speed PSC type motors with UL Listed thermal overload device to protect against over current draw and over heating.

C. The fan and drive assembly shall be dynamically balanced after final factory assembly.

D. Fan and motor shall be accessible for removal through the front unit access panel and shall.

E. Provide standard motor or high static option to achieve scheduled design airflow and static pressure.

2.3 COIL SECTION (Heating and Cooling)

A. Coil section shall be constructed from galvanized steel and insulated as specified for all unit casings.

B. Coils shall be finned-tube type, constructed of copper tubes with aluminum fins. The fins shall be aluminum, the tubes shall be copper and the tubes shall be mechanically expanded into the fins and flared into the headers. Coils shall be factory tested and proven leak-proof at 300 psig air pressure under water at the factory.

C. Coils shall be rated for a minimum working pressure of 250 psig at 200 degrees F. Coils shall be 3/1, 3/2, or 4/1 row-split as required for the scheduled performance.

D. Coils shall have chilled water drain and air vents.

2.4 VALVES AND ACCESSORIES (HOT AND CHILLED WATER)

A. Each unit shall be provided with 4 ball valves for isolation (supply and return).

B. Balancing valve shall be a Bell & Gossett circuit setter, Flow Design YR, or a Hayes Model #2517 flow control valve located on the return piping line.

C. Provide a two-position, 150 psig rated, motorized control valve (three way with bypass at the top unit only).

D. Provide a test plug at the supply and return for pressure and temperature measuring or gauges.

2.5 FILTER SECTION

A. Units shall have minimum 1-inch thick, low velocity, MERV-8 filters.

B. The filter shall be removable through the return air access panel.

2.6 UNIT DRAIN PAN

A. A stainless steel drain pan shall be provided completely under the entire unit/coil section. This full drain pan shall have seamless, fire retardant, closed cell insulation sprayed to a thickness of 1/8" on the interior surface. This insulation shall be cellular and fully adhered to the steel drain pan such that a puncture will not affect the insulation nor permit water to seep beneath the insulation.

B. Drain connection shall be provided on the side of the drain pan and shall be factory piped to the drain riser with a removable P-trap.

2.7 RETURN AIR GRILLE ACCESS PANEL

A. Return panels shall be fabricated of 18 gauge steel available for flush mounting with an accessory recessed frame for a smooth, finished appearance. Panels shall be secured with tamper proof quarter turn fasteners for access to all internal components.

B. Return panels shall be provided with an oven baked paint finish. The finish color shall be suitable for field painting. Paint color shall match wall color or trim color as selected by the architect.

2.8 CONTROLS

A. Units shall be provided with an accessory thermostat for remote installation in the location shown.

B. Thermostat shall be heating/cooling type with automatic changeover. Thermostat shall operate to cycle the chilled water control valve and hot water control valve to maintain space temperature. InnComm E528 Enviro Smart Digital Series.

C. Fan operation shall be manually selected to medium or low speed only via a silent relay from the thermostat.

D. Provide a condensate overflow shutoff switch to protect the building in the event of blocked primary condensate.

2.9 PIPING RISERS

A. Factory provided piping risers shall be Type L hard drawn copper tubing meeting ASTM B88 or ASTM B280.

B. The top of the risers will be provided with a swaged type opening to receive the riser piping from the unit above without a mechanical coupling. The joint shall be connected per manufacturer requirements. Provide a riser extension for field installation if the factory installed riser does not extend to the unit above.

C. The risers, including any extension shall be factory insulated with ¾" closed cell foam insulation. The insulation shall cover the entire riser including the swaged joint. Insulation shall have flame spread and smoke development rating of 25/50.

2.10 VIBRATION ISOLATION

A. Units shall be complete with vibration isolation provided by the unit manufacturer. Units may be provided with internal isolation of the fan/motor assembly.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The fan coil units and associated controls shall be installed in strict accordance with the manufacturer's recommendations.

B. Automatic shutdown controls shall be provided to meet local codes (or NFPA 90A as a minimum).

C. The associated control system shall be completely wired under this Division 23. Wiring shall be in accordance with the N.E.C. and shall meet all requirements for this installation.

D. The coil vent shall be provided with a manual, valved vent and the coil drain shall be provided with a blow-down valve with male hose threads (at the bottom of each riser).

E. The condensate drain piping shall be complete with a drain trap constructed with sufficient head (vertical distance between inlet and outlet of trap) to drain throughout the units' operating range. Drain piping to drain riser shall be 3/4" minimum.

F. All units shall be located to allow for all required service. Filters shall be replaceable without bending.

G. Back-to-back units with two supply openings shall be provided with a visual and sound baffle between the openings.

H. Supply registers shall be provided of the type specified on the drawings and shall match the unit opening size. Provide a double deflection aluminum register in the event no device is shown or otherwise specified.

I. Riser piping for stacking units shall be field connected to the unit above/below per manufacturer's recommendations. The factory applied insulation ends shall be sealed as required in specification section 23 18 10.

J. Pressure testing of the piping systems shall be performed after completion of installation as required in specification section 23 01 00 for testing of a complete system.

K. Unit supply grill and return / access panel shall be factory painted in a color selected by the architect.

3.2 STARTUP

A. Provide the services of a factory trained and qualified service technician who shall inspect the installation including external interlock and power connections; supervise leak testing, initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.

END OF SECTION 237660

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SECTION 237730

SPLIT SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 237730 and the accompanying drawings cover the provision of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the split systems as specified herein and as shown. This work includes, but is not limited to, the following:
1. Split system fan coil, heating section and condensing units
2. Control system (interlocked to all split system components)

C. Split system units shall be self-contained, automatic, packaged units. These units shall be completely factory assembled as unitary packages complete with operating controls, internal wiring and piping and fully charged with R-22 refrigerant. Only one electrical power connection shall be required for each unit.

D. Units shall be UL listed and cooling capacities shall be certified in accordance with ARI 210.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted split systems, as shown and specified, which operate efficiently and automatically, and are free of excessive noise and vibration.

1.3 BASIS OF DESIGN

A. The basis of design is Trane. Any proposed substitutions shall be submitted in accordance with the prior approval requirements. Acceptable substitute manufacturers are McQuay and Carrier provided they meet the requirements of 230100.

PART 2 - PRODUCTS

2.1 UNIT CASINGS

A. Unit casings shall be formed, galvanized steel construction with welded assembly. Galvanized steel surfaces shall be bonderized and painted with baked acrylic enamel for complete weather protection. Accessories and components shall match and interlock with all other split system components. Fan coil unit casings shall be fully internally insulated with liner which meets NFPA 25/50 flame spread/smoke developed ratings.

2.2 CONDENSING UNITS

A. Condensing unit refrigeration systems shall be factory charged and ready for operation. All units with capacities greater than five (5) tons shall be provided with minimum 2-stage

(50% and 100%) cooling. Compressor(s) shall be direct drive, 3600 RPM, hermetic reciprocating type with centrifugal oil pump, crankcase heater and internal pressure relief valve. Compressor(s) shall have internal spring isolation and sound muffling and exhibit minimum vibration transmission and noise. Anti-recycle timers shall be provided to prevent excessive cycling of compressors thru utilization of a minimum five (5) minute time shutdown of unit on interruption of power or controlled shutdown.

B. Condensing unit condenser fans shall be direct-driven, propeller blade type. Condensing unit heat rejection shall be vertically upward. Provide controls for low ambient operation to 10º F.

2.3 COILS

A. Evaporator and condenser coils shall be copper tubing mechanically bonded to heavy duty aluminum fins. Aluminum tubes shall not be acceptable.

B. Coils shall be coated for corrosion protection.

2.4 ELECTRIC HEATING SECTIONS

A. Electric heating sections shall be UL listed with nickel-chromium open coil resistance heating elements. Each heater shall be protected by an automatic reset high-limit thermostat and manual reset high-limit thermostat for the primary and secondary overcurrent/thermal protection. A proof of airflow/fan interlock shall also be provided. Controls shall provide for multiple stage start-up and operation. Contactors shall be solid state or mercury (totally silent) type.

2.5 CONTROLS AND ACCESSORIES

A. All operating and safety controls which are internal to each unit shall be factory installed and shall include, as a minimum, solid state compressor overload protection, magnetic contactors, thermostatic expansion valve(s), refrigerant line drier(s), outdoor fan and compressor cycling thermostats, high and low limit protection against excessive temperatures or pressures.

B. A 24 volt transformer shall be provided to accommodate an accessory 24 volt indoor thermostat complete with an electronic programmable night setback, separate automatic heat/cool settings, auto/manual fan control and seasonal selector. Thermostat shall provide staging of the cooling and heating to match the stages of each component.

C. Controls on electric heat section shall meet NEMA specifications and requirements.

D. Automatic shutdown controls shall be provided to meet local codes (or NFPA 90A as a minimum) and shall consist of firestats and duct-mounted smoke detectors interlocked to the fan coil unit for shutdown on the detection of fire or smoke.

2.6 FILTERS

A. Units shall have minimum 1 inch thick, low velocity, glass fiber throwaway filters in commercially available sizes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The split systems and associated controls shall be installed in strict accordance with the manufacturer's recommendations.

B. The control system shall be completely wired under this Division 23. Wiring shall be in accordance with the N.E.C. and shall meet all requirements for this installation. Integrate in to EMS system. See 23 90 00 for requirements.

C. See the details and plan layouts for unit arrangement.

3.2 STARTUP

A. Provide the services of a factory trained and qualified service technician employed by the unit manufacturer who shall inspect the installation including external interlock and power connections; supervise leak testing, initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.

B. This service technician shall forward a report in four (4) copies to the Owner when the unit is in safe and proper operating condition. This report shall include all pressure and control settings, meg readings, voltage readings per phase during start and run, and shall list minor discrepancies to be corrected that affect safe and reliable operation. One additional copy of the report shall be left in the unit control panel. One copy of bound installation, operation, maintenance service and parts brochures, including applicable serial numbers, full unit description and parts ordering sources, shall be placed in the unit control panel at the time of startup; four (4) additional copies shall be forwarded to the Owner.

END OF SECTION 237730

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SECTION 237790

ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this Section is governed by the Mechanical General Section 230100.

B. This Section 237790 and the accompanying drawings cover the provisions of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the heat recovery units as specified herein and as shown. This work includes, but is not limited to, the following:
1. Heat recovery units including curbs and accessories
2. Control system (interlocked to the units)

C. Units shall be self-contained, rooftop curb-mounted, single package type. The heat recovery units shall be completely factory assembled as a unitary package complete with operating controls and shall be completely piped, internally wired. Only one electrical power connection shall be required.

D. Capacity and energy efficiency shall not be less than scheduled. Unit shall be provided with factory installed options listed below.

E. Unit shall be design certified to conform to appropriate UL/ANSI Standards by ETL or other nationally recognized testing laboratory.

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted heat recovery units, as shown and specified which are free of excessive noise and vibration.

1.3 BASIS OF DESIGN

A. The basis of design is Annexair. Any proposed substitutions or equals by other manufacturers shall be proven equal in all respects to the equipment specified as the basis of design. Particular attention is called to the requirements of Section 23 01 00.

PART 2 – PRODUCTS

2.1 CABINET

A. Wall and roof panels shall consist of 2" thick dual wall 18 gauge galvanized solid exterior skins and 22-gauge galvanized steel solid interior skins enclosing 2" thick 1.8 PCF insulation.

B. Outdoor air intake and exhaust air discharge openings shall have galvanized steel sheet metal hoods with openings covered with bird screen.

C. Access shall be provided through large hinged, tightly sealed doors or removable access panels. Access doors shall be constructed of the same materials as the unit casing. Each

door shall be provided with two cam type handles and two heavy duty hinges to achieve maximum sealing. All doors shall open against the air pressure.

2.2 PAINT FINISH

A. Constructed of hot dipped galvanized G90 steel that is chemically treated with zinc phosphate, coated with 0.3 MIL polyurethane primer, then finished with 0.8 MIL polyester top coat. Finish shall meet or exceeds 500 hour Salt Spray Test per ASTM B117 97.

2.3 ASSEMBLY AND TEST

A. The unit shall be completely factory assembled, pre-wired and thoroughly leak and safety control tested.

2.4 ROOF CURB

A. Unit shall sit on structural steel.

2.5 ELECTRICAL

A. Unit shall require a 480 volt, 3-phase, 60 cycle power connection at the main electrical panel. The electrical panel shall be NEMA 12 rated and mounted on the unit exterior or integral to the unit housing. The electric panel shall consist of a non-fused disconnect, fused IEC full voltage starters for each fan and constant speed wheel, control power transformer, and HOA switch for the unit. Electrical panels shall bear an UL/CSA label. Unit shall require only one (1) electrical connection.

2.6 SUPPLY AND EXHAUST FANS

A. Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise beyond the peak efficiency to ensure quiet and stable operation. Fans shall have a non-overloading design with self-limiting horsepower characteristics and shall reach a peak in the normal selection area. All fans shall be capable of operating over the minimum pressure class limits as specified in AMCA's standard 2408-69.

B. Fans shall be tested in accordance with AMCA 211 and AMCA 311 test codes for air moving devices and shall be guaranteed by the manufacturer to deliver rated published performance levels. Fans shall be licensed to bear the AMCA certified ratings seal for both sound and air.

C. Inlet plates shall be of heavy-gauge reinforced steel construction. The inlet plate incorporates a removable spun inlet cone designed for smooth airflow into the accompanying inlet retaining ring of the fan wheel.

D. Drives and belts shall be located external to the fan casing and rated for 150% of the required motor HP.

E. The entire fan assembly, excluding the shaft, shall be thoroughly degreased and de-burred before application of a rust-preventative primer. After the fan is completely assembled, a finish coat of paint shall be applied to the entire assembly. The fan shaft shall be coated with a petroleum-based rust protectant. Aluminum components shall be unpainted.

F. Fan motors shall be standard NEMA frame, inverter duty, premium efficiency, with 1.15 service factor and open drip-proof TEFC enclosures. Protective guards shall enclose rotating fan and drive parts.

G. Fans assemblies shall have adjustable motor bases, motors and V-belt drives mounted with the assembly mounted on deflection spring isolators with flexible connections between fan and fan wall.

H. Variable speed control of both supply and exhaust fans shall be accomplished by the use of frequency inverter. (See specification Section 23 17 20. The inverter shall include all digital programming with a manual speed adjustment on the front of the inverter. Control of the inverter shall be as described in the sequence of operation.

2.7 ENERGY RECOVERY WHEEL

A. Enthalpy Recovery Wheel - The rotor media shall be made of aluminum which is coated to prohibit corrosion. All media surfaces shall be coated with a non-migrating solid adsorbent layer prior to being formed into the honeycomb media structure to insure that all surfaces are coated and that adequate latent capacity is provided. The media shall have a flame spread of less than 25 and a smoke developed of less than 50 when rated in accordance with ASTM E87. In addition to the desiccant coating that is applied to the surfaces of the aluminum substrate, the two faces of the total energy recovery wheel shall be covered and sealed with a two-part polymer heavy duty coating specifically chosen for chemical resistance.

B. The desiccant shall be inorganic and specifically developed for the selective adsorption of water vapor. The desiccant shall utilize a 3A molecular sieve certified by the manufacturer to have an internal pore diameter distribution which limits adsorption to materials not larger than the critical diameter of a water molecule (2.8 angstroms).

C. Submit certification by a qualified independent organization documenting equal sensible and latent recovery efficiencies conducted in accordance with ASHRAE 84-78P and the results presented in accordance with ARI 1060 standards.

D. An independent wheel test from a credible test laboratory shall document that the desiccant material utilized does not transfer pollutants typically encountered in the indoor air environment. The cross-contamination and performance certification reports shall be provided upon written request for engineering review.

E. The unit shall be provided with a factory set, field adjustable purge sector designed to limit cross contamination to less than .04 percent of that of the exhaust air stream concentration when operated under appropriate conditions.

F. The rotor shall be supplied with labyrinth seals only, which at no time shall make contact with any rotating surface of the exchanger rotor face. These multi-pass seals shall utilize four labyrinth stages for optimum performance.

G. The rotor media shall be provided in segmented fashion to allow for field erection or replacement of one section at a time without requiring side access. The media shall be rigidly held in place by a structural spoke system made of extruded aluminum.

H. The rotor housing shall be a structural framework which limits the deflection of the rotor due to air pressure loss to less than 1/32". The housing is made of galvanized steel to prevent corrosion. The rotor is supported by two pillow block bearings which can be

maintained or replaced without the removal of the rotor from its casing or the media from its spoke system.

2.8 DAMPERS

A. Outdoor Air Damper shall have modulating electric actuators with an integral limit switch. The limit switch shall be wired through the supply fan coil.

B. Frame shall be roll formed, galvanized steel hat-shaped channel, reinforced at corners, structurally equivalent to 13-gauge (2.3 mm) U-channel.

C. Blades –shall be single skin with 3 longitudinal grooves with opposed Action. Blades shall be made of a minimum 16-gauge (1.6 mm) equivalent thickness, galvanized steel with a nominal 6-inch width.

D. Bearings shall have molded synthetic sleeve, turning in extruded hole in frame.

E. Blades shall have Inflatable PVC coated fiberglass material and galvanized steel mechanically attached to blade edge. Jam seals shall be flexible metal compression type.

F. Linkage shall be concealed in frame.

G. Finish shall be mill galvanized.

H. Damper shall be able to withstand -40 to 200 degrees F (-40 to 93 degrees C). Capacity of damper is to withstand maximum backpressure of 5 inches w.g @ a 12 inch blade length. in the closed position and maximum air velocity of 2,000 fpm in the open position. Leakage shall be a maximum of 3.7 cfm per sq ft at a 1-inch w.g. Blade operation shall be 0.01 in w.g. from start to open, and 0.05-inch w.g. fully open. Pressure drop shall be a maximum of 0.07-inch w.g. at 1,500 fpm across a 24 inch x 24 inch damper.

I. Exhaust air damper shall be gravity operated backdraft type.

2.9 FILTER SECTION

A. Outdoor air and exhaust air filters shall be Farr type 30/30 or approved equal. Air filters shall be 2" thick, pleated, disposable type. Each filter shall consist of non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter media shall have an average efficiency of 25-30% on ASHRAE Test Standard. The filter shall be listed by Underwriters' Laboratories as Class 2. A bank of galvanized universal holding frames shall be arranged for upstream access. Provisions shall be made on the downstream side of the frames to prevent filter blowout from moisture or overloading.

2.10 CONTROLS AND ACCESSORIES

Energy recovery units shall be controlled as follows:

A. Control Hardware - Each unit contains a microprocessor controller. Temperature and humidity sensors shall be located in appropriate locations throughout the unit for proper unit control. Pressure transducers shall be provided to measure filter loading. and fan airflow. Current transformers shall be provided for fan status. Rotation detectors are included for wheel status. Supply duct static pressure is included for supply fan inverter control.

B. Communications – Each Controller shall be provided with an Open Protocol Port configurable for EAI-232 or EIA-485 (2- or 4- wire). Network protocol shall be selectable for BACnet MS/TP, BACnet PTP, Modbus, or N2.

C. Wheel Speed Control- Variable speed control of the Enthalpy wheel shall be accomplished by the use of an A/C inverter. The inverter shall include all digital programming with a manual speed adjustment on the front of the inverter. The drive system shall allow for a turndown ratio of 80:1 (20 rpm to 1/4 rpm). Control of the inverter shall be as described in the sequence of operation.

1. The drive shall provide low motor noise and high starting torque. The inverter shall be rated for constant torque applications, with current overload rating of 150% for 60 seconds.
2. Display and Program Features - The digital operator shall provide 4-digit LED status display with a built-in analog speed potentiometer, as well as digital programming of up to 200 parameters. The drive shall also have an analog input, a multi-function output, two multi-function open collector outputs, and an analog output as standard.
3. Integral Software –The drive shall have on-board software that enables upload, download, and monitoring of parameters. Software on board shall also add functionality to the drive by reconfiguring drive defaults, establishing presets and eliminating peripheral controls and PLCs.
4. Communications - A RS-485 Modbus communication port shall be integral and standard, allowing 32 nodes on a single network. Plug-in interface option boards enable the drive to communicate with all the major networks, such as DeviceNet, Profibus-DP, and others. The option board installs directly on the drive control board via simple snap-in connectors.
5. Enclosure - The inverter is provided in a NEMA 1 enclosure from 1/8 to 10 HP at 230 VAC and 1/2 to 10 HP at 460 VAC. Provisions must be made by unit manufacturer to maintain acceptable environment conditions for the operation of the drive.

2.11 COILS

A. Hot and chilled water coils (and common components) shall meet requirements of specification 237600.

PART 3 – EXECUTION

3.1 INSTALLATION

A. The heat recovery units and associated controls shall be installed in strict accordance with the manufacturer's recommendations.

B. The control system shall be completely wired under this Division 23. Wiring shall be in accordance with the N.E.C. and shall meet all requirements for this installation.

C. Heat recovery units shall be labeled with a red bakelite sign with one inch engraved white letters.

3.2 STARTUP

A. Provide the services of a factory trained and qualified service technician employed by the unit manufacturer who shall inspect the installation including external control interlock and

electrical power connections; supervise leak testing, initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.

B. This service technician shall forward a report in four (4) copies to the Owner when the unit is in safe and proper operating condition. This report shall include all pressure and control settings, voltage readings per phase during start and run, and shall list minor discrepancies to be corrected that affect safe and reliable operation. One additional copy of the report shall be left in the unit control panel. One copy of bound installation, operation, maintenance service and parts brochures, including applicable serial numbers, full unit description and parts ordering sources, shall be placed in the unit control panel at the time of startup; four (4) additional copies shall be forwarded to the Owner.

3.3 WARRANTY

A. The unit manufacturer shall warrant to the Buyer that for a period of eighteen months from the date of shipment the goods to be delivered to the Buyer shall in all material respects be free from defects in material and workmanship when used in a proper and normal manner. Should any failure to conform to the above appear within eighteen months after the date of shipment, the unit manufacturer shall upon prompt notification thereof during the Warranty Period and confirmation to the unit manufacturer's satisfaction that the goods have been stored, installed, operated and maintained properly and in accordance with standard industry practice, correct the non-conformity at the unit manufacturer's option either by repairing any defective part or parts or by making available at the unit manufacturer's plant a repaired or replacement part.

END OF SECTION 237790

SECTION 238000

AIR DISTRIBUTION DEVICES

PART 1 – GENERAL

1.1 DESCRIPTION

A. This Section 238000 and the accompanying drawings cover the provisions of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of air distribution devices as specified herein and as shown. These units include, but are not limited to the following:
   1. Ceiling Diffusers (CD)
   2. Return Air Grilles (RAG)
   3. Exhaust Registers (ER)
   4. Linear Slot Diffusers (LSD)
   5. Linear Return Slots (LRS)
   6. Linear Exhaust Slots (LES)
   7. Ceiling Registers (CR)
   8. Return Air Registers (RAR)
   9. Supply Registers (SR)

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted air distribution devices as shown and specified which are free of excessive noise, vibration and airflow fluctuations.

1.3 SELECTION CRITERIA

A. All air distribution devices shall be selected in accordance with the following minimum criteria unless otherwise noted below or on the drawings:
   1. Method of mounting shall be compatible with the ceiling, wall or duct surface which it mounts on or in; i.e. lay-in, surface mounting, plaster frame, duct collar, etc. The architectural drawings shall be referenced to determine the mounting method for each device. All flanges on surface mounted devices shall be provided with a gasket.
   2. All diffusers, registers, and grilles for use in the Guest rooms and all other Public Areas must be factory primed for custom finish painting by others. Coordinate all finishes with Architect.

1.4 BASIS OF DESIGN

A. The basis of design is Titus. Any proposed substitutions shall be proven equal in all respects to the equipment specified as the basis of design. Any modifications to ductwork, controls, ceilings, building structure, etc., that result from any substitution shall be coordinated with all trades. This coordination shall occur before delivery of equipment and any modifications shall be performed without incurring additions to the Contract.

1.5 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are Price, Carnes, and Metal Aire, provided that their units, performance, appearance and physical characteristics are equal in all respects for this

specific project.

PART 2 – PRODUCTS

2.1 DESCRIPTION

A. Ceiling Diffuser (CD)

1. CD ceiling diffusers in kitchens shall be high performance louvered face diffuser Titus TMS, or approved equal. The diffusers shall have three cones, which give a uniform face size and appearance when different neck sizes are used in the same area. All cones shall be one piece precision die-stamped; the black cone shall also include an integrally drawn inlet (welded-in inlets and corner joints are not acceptable). The two inner cones shall be constructed as a single, removable inner cone assembly for easy installation and cleaning. The inner cone assembly must have a hole with removable plug in the center to allow quick adjustment of an optional inlet damper without removing the inner cone assembly. Diffusers shall be constructed of 24-gauge steel. Provide with foil-backed insulating blanket. Diffuser performance data shall be in accordance with ADC equipment test code 162R4. The maximum NC level at design airflow shall not exceed 30.
2. CD ceiling diffusers in all other areas shall be architectural ceiling diffuser Titus OMNI, or approved equal. The diffuser shall have a 22-gauge steel face panel that captures a secondary 22-gauge panel. The face panel is removable by means of four hanger brackets. The exposed surface of the panel shall be smooth, flat, and free of visible fasteners. The face panel shall project ¼" below the outside border of the diffuser backpan. Panels projecting more than ¼" below the outside border are not acceptable. The back of the face panel shall have an aerodynamically shaped, rolled edge to ensure a tight horizontal discharge pattern. A single metal thickness on the edges of the face panel will not be acceptable. Ceiling diffusers with a 24x24 inch full face shall have no less than an 18x18 inch face panel size. The backpan shall be one piece precision die-stameped and shall include an integrally drawn inlet (welded-in inlets and corner joints are not acceptable). The diffuser backpan shall be constructed of 22-gauge steel. Provide with foil-backed insulating blanket. The diffuser neck shall have a minimum of 1-1/4" depth available for duct connection. The pencil hardness shall be HB to H. The manufacturer shall provide published performance data for the square panel diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Diffuser performance data shall be in accordance with ADC equipment test code 162R4. The maximum NC level at design airflow shall not exceed 30.

B. Return Air Grilles (RAG)

1. Return air grilles shall be hollow core, egg crate, lay-in type Titus 50F, or approved equal. Performance data shall be in accordance with ADC 1062R4. Grilles shall provide free area of at least 90%. Outer borders shall be constructed of heaver extruded aluminum with a thickness of 0.040-0.050 inches and shall have countersunk screw holes for a neat appearance. Border width shall be 1-1/4" on all sides and shall be interlocked at the four corners and mechanically staked to form a rigid frame. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

C. Exhaust Registers (ER)

1. Exhaust registers shall be Titus 355RL. The fixed deflection blades shall be parallel to the long dimension of the grille. Construction shall be of steer with a 1-

1/4" wide border on all sides. Screw holes shall be countersunk for a neat appearance. Corners shall be welded with full penetration resistance welds. Deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test performance data. Blades shall be held firmly in place by mullions from behind the grille and fixed to the grille by welding in place. Blade deflection angle shall be 35°. Opposed-blade volume damper shall be constructed of heavy gauge steel. Damper must be operable from the face of the grille. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Diffuser performance data shall be in accordance with ADC equipment test code 162R4. The maximum NC level at design airflow shall not exceed 30.

D. Linear Slots
   1. Supply (LSD)
      a. Linear slot shall be Titus Flowbar High Throw diffuser. Linear slots in the high ceiling shall be Jet Throw. Diffuser shall be aluminum construction with one (1) or more parallel slot(s). Diffuser shall be equipped with an individually adjustable pattern controller. Each ALS shall be provided with a lined stem plenum with tappings for round duct connections as indicated. Maximum NC shall not exceed ~~30~~ 20 at design airflow. Linear shall conform to NFPA 90A 25/50 requirements. Border option shall be mud-in type with no visible flange. Provide lined return air plenums over all return air sections.
   2. Return (LRS)
      a. Linear return slots shall equal specified LSD with the following exceptions:
         1) Plenums shall have maximum available inlet size.
         2) Pattern controls are not required.
   3. Exhaust (LES)
      a. Linear exhaust slots shall equal LSDs except for exhaust applications. Plenums shall have maximum available inlet size. Coordinate with flex duct connection size.

E. Return Air Registers (RAR)
   1. Return air registers shall be surface mounted, aluminum registers with curved hemmed edge blades with an opposed blade damper. Damper blades shall be gang operated by means of a key which can be removed after balancing. RAR's shall be Titus 355RL, sized as indicated.

F. Supply Registers (SR)
   1. Supply registers shall be surface mounted, aluminum, adjustable double-deflection type complete with opposed blade dampers for balancing purposes. The outermost set of deflection blades shall be parallel to the long dimension of the SR and the innermost set of deflection blades shall be parallel to the short dimension of the SR. The registers shall be tested in accordance with ADC standards and shall be selected to provide design airflow at a maximum NC of 30. SR's shall be Titus 300FL Series, sized as indicated.

G. Ceiling Registers (CR)
   Ceiling registers shall be surface mounted, steel devices sized as indicated. CR's shall be provided complete with opposed blade dampers for balancing purposes. Face patterns shall be selected for two, three or four-way blow patterns as indicated or noted. Curved blades shall also be adjustable to achieve airflow ranging from horizontal to full vertical down blow. Registers shall be tested in accordance with ADC standards and shall be

capable of delivering design airflows indicated at a maximum NC level of 35. CR's shall be Titus 250AA.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Air distribution devices shall be installed as indicated and in conformance with the manufacturer's recommendations. The color, frame and border types shall be coordinated with architectural requirements and shall be selected to install in the finished surface indicated.

3.2 ADJUSTMENT

A. Grilles, registers, and diffusers shall be tested and adjusted to provide the scheduled airflow capacities.

B. All adjustable air distribution devices located within three feet of any wall shall be set to blow directly away from, or parallel to, the wall.

C. In all slot diffuser applications, the inactive sections of the slot shall be finished with perforated steel, painted flat black. These sections shall be open to the plenum as a return air path.

END OF SECTION 238000

SECTION 238200

FANS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All work specified in this section is governed by the Mechanical General Section 230100.

B. This Section 238200 and the accompanying drawings cover the provision of all labor, equipment, appliances and materials, and performing all operations in connection with the construction and installation of the fans as specified herein and as shown. These fans include, but are not limited to the following:
1. Roof-mounted centrifugal exhaust fans
2. Ceiling/cabinet fans
3. Sidewall propeller exhaust
4. Direct drive vane axial fans
5. Roof-mounted kitchen upblast exhaust fans
6. Inline kitchen exhaust fan

1.2 INTENT

A. It is the intent of this Section of the specifications to provide complete, operable, adjusted fans as shown and specified which are free of excessive noise, vibration and airflow fluctuations.

1.3 BASIS OF DESIGN

A. The basis of design is Greenheck. Any proposed substitutions shall be proven equal in all aspects to the equipment specified as the basis of design. Particular attention is called to the requirements of Section 230100.

1.4 ACCEPTABLE SUBSTITUTE MANUFACTURERS

A. Acceptable substitute manufacturers are Cook, Acme, and Penn.

PART 2- PRODUCTS

2.1 GENERAL REQUIREMENTS

A. All non-filtered fans shall be factory tested, rated and certified in accordance with the requirements of AMCA Standard No. 210 and shall be labeled accordingly. Filtered fans may be non-labeled but must be rated in an AMCA approved laboratory in accordance with 210.

B. All roof-mounted fans shall be constructed such that water cannot enter the building through the fan regardless of whether or not the fan is operating.

C. All roof-mounted fans shall be provided complete with roof curbs. Roof curbs shall be of aluminum construction, insulated, canted and complete with wood nailer strips. Insulation

shall meet NFPA 25/50 flame spread/smoke developed ratings.

D. All exhaust fans (except those utilized for grease exhaust service) shall be provided complete with gravity-type backdraft dampers.

E. All belt-drive assemblies shall be mounted on vibration isolators.

F. All motors on belt-drive assemblies shall be mounted on slide bases to provide adjustment of belt tension.

G. All belt-drives shall be rated for not less than 150% of the connected motor horsepower.

H. All belt-drives driven by a 5 HP or larger motor shall be multiple belt arrangements.

I. All belt-drives shall be adjustable to a minimum speed variation of plus or minus 20% of the design RPM.

J. All centrifugal fan wheels shall be statically and dynamically balance.

K. All electric motors and equipment shall be UL labeled.

L. Refer to Division 26 of these specifications and to the electrical contract drawings for electrical characteristics and connections to all equipment. Coordinate all electric motors and other equipment with these electrical documents.

M. Fans used for smoke exhaust / control shall be UL rated for smoke control.

N. All exhaust fans shall be located 20 feet (minimum) from outside air intake. Any systems not in compliance with this requirement shall be brought to the attention of the Architect prior to installation.

O. All kitchen exhaust fans shall be listed by UL 762 and cUL) – Standard Power Roof Ventilators for Restaurant Exhaust Appliances.

P. All kitchen exhaust fans shall be in accordance with NFPA 96 – Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations and all applicable local codes.

Q. Roof curbs for kitchen exhaust fans shall meet NFPA requirements.

R. All motors associated with kitchen exhaust fans shall be located outside of the airstream.

2.2 ROOF-MOUNTED CENTRIFUGAL EXHAUST FANS

A. Roof-mounted centrifugal exhaust fans shall be Greenheck Model G for direct drive fans and Greenheck Model GB for belt-drive fans, or an approved equal.

2.3 CEILING/CABINET EXHAUST FANS

A. Ceiling/cabinet exhaust fans shall be Greenheck CSP or an approved equal.

2.4 SIDEWALL PROPELLER EXHAUST FANS

A. Fans shall be wall propeller type with wall mounting panel, wire fan guard, and motor guard screen. Fans used for exhaust shall have a gravity backdraft damper.

B. Wall panel shall be steel, reinforced with steel channel for motor and fan mounting frame. Exposed surfaces shall have backed enamel or epoxy finish. Panel shall have a spun venturi formed into the panel. For exhaust service, venturi shall point out; for supply service, venturi shall point in.

C. Fan wheel shall be axial blade type constructed of steel or aluminum. Blades shall be welded to fan hub. Fan shall have 6 blades (minimum). Fan shall have same finish as wall panel. On belt driven units, shaft bearings shall be self-aligning, pillow block type. Bearings not permanently sealed and lubricated shall have grease fittings.

D. Fan shall be Greenheck Model SBE or approved equal.

2.5 DIRECT DRIVE VAN AXIAL FANS

A. Direct drive vane axial fans shall be Greenheck Model VADS or approved equal.

2.6 ROOF-MOUNTED KITCHEN UPBLAST EXHAUST FANS

A. Roof-mounted kitchen exhaust fans shall be Greenheck Model USGF for heavy grease exhaust applications or an approved equal.

2.7 INLINE KITCHEN EXHAUST FANS

A. Inline mounted kitchen exhaust fans shall be Greenheck Model TCB or an approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fans shall be installed as indicated and in conformance with the manufacturer's recommendations. Coordinate the actual units to be provided with all trades.

B. All exhaust fans shall be provided with a backdraft damper for system isolation.

C. All supply fans shall be provided with a motor operated damper interlocked with the fan to open when energized. Provide with an end switch so the fan does not energize until the fan is fully energized.

D. Kitchen exhaust fans shall be provided with hinged access, grease collector, flexible power connection and other accessories required by code.

E. Fans types not specified herein shall comply with scheduled requirements and general requirements in this specification.

F. Centrifugal utility fans shall be installed on equipment rails on vibration isolators.

Equipment rails shall be flashed in to the roof same as a roof curb.

G. The pool equipment exhaust fan shall be explosion proof and construction suitable for the chemical environment.

3.2 ADJUSTMENT

A. The fans shall be tested and adjusted after installation to provide the capacities indicated.

END OF SECTION 238200