SECTION 238400

DUCTWORK

PART 1 - GENERAL

1.1 DESCRIPTION

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

B. This Section 238400 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 ductwork systems as specified herein and as shown. These systems include, but are not limited to, the following:
1. Supply air ductwork
2. Return, transfer and relief air ductwork
3. Exhaust ductwork
4. Outside air ductwork
5. Flues

1.2 INTENT

A. It is the intent of this Section of the specifications to provide a complete operable duct system as shown and specified which is reasonably airtight, free of noise, vibration and sweating, and fabricated so as to fit into the space allotted and to exhibit a minimum resistance to airflow.

1.3 DESIGN AND CONSTRUCTION

A. Ductwork shall be provided in strict accordance with the first edition - 1985 - of the SMACNA HVAC Duct Construction Standards - Metal and Flexible, NFPA No. 90A, 90B, 91 and 96, and UL 181. Horizontal snap-lock seams shall not be permitted.

B. Ductwork dimensions shown are net, clear, inside dimensions. Ductwork shall be square, rectangular, round, spiral or flat oval as noted. Conversion of duct shapes and sizes shown shall be accomplished without increasing air velocities or friction losses and is subject to prior approval by the Architect.

C. Elbows shall be either full radius type (inside radius equal to duct width), five-gore radiused flat-oval type or, in low pressure systems only, mitered with ~~double~~ single-thickness turning vanes.

D. Abrupt changes in duct sizes and shapes shall not be permitted. The total angle of diverging transitions shall be not more than 15 degrees; converging transitions shall be not more than 30 degrees unless otherwise noted or required due to structural constraints.

E. Offsets, transitions, rises and drops are not individually called out on the design drawings. They shall be provided as required to fit the ductwork into the allocated spaces.

F. Transition rectangular ductwork on bottom and sides. Maintain top of ductwork level and as high as possible.

G. All supply air ductwork between the VAV air handling units and the terminal units shall be constructed for 3" WC static pressure class at 4000 FPM velocity with Class A seals and is herein defined as "medium-pressure" ductwork. All other ductwork shall be constructed for standard 1" WC static pressure class at 2500 FPM with Class C seals and is herein defined as "low pressure ductwork."

H. Grease exhaust ductwork joints shall be continuously welded and be liquid tight.

I. Provide the following types of ductwork material for the services indicated:

TYPE OF MATERIAL		SERVICE
1.	Galvanized sheetmetal	Supply, return, exhaust and relief of comfort conditioned and outside air.
2.	Black Steel	Grease exhaust
3.	Stainless Steel or Aluminum	Dishwasher exhaust

PART 2 - PRODUCTS

2.1 GALVANIZED SHEETMETAL

A. Galvanized sheetmetal shall be lock-forming grade G90-ASTM A 525 hot dip galvanized steel sheets. Sheetmetal shall be galvanized on each side with not less than 1.25 ounces of zinc per square foot.

2.2 DOUBLE WALL DUCTWORK

A. Double wall ductwork shall be hot dip galvanized with two inches of closed cell insulation adhered to the inside surfaces.

B. The exterior duct surface shall be coated with a 1.5 mil enamel finish. All exterior joints shall be sealed weather tight.

2.3 SPIRAL DUCT

A. Spiral duct shall be utilized for all flat-oval and round ductwork in medium and high-pressure systems.

B. Spiral duct shall be the product of United McGill Corporation, R.V. Money or an approved equal.

C. Spiral ribbed duct is not acceptable.

2.4 FLUES

A. All flues shall be Type "B", double-wall, as manufactured by Metalbestos or an approved equal. Flues shall be complete with storm collars, weatherproof caps and all accessories.

2.5 DAMPERS

A. Manual Volume Dampers
1. Single blade butterfly dampers are acceptable up to 12" round or 12" x 12" square. Dampers larger than these dimensions shall be multi-blade type. Single blade dampers shall be constructed of 16 gauge or heavier galvanized

sheetmetal.

2. No multi-blade damper blade shall exceed 8" in width. All multiple blade dampers shall be constructed of 16 gauge galvanized steel or heavier. The damper frame shall be 16 gauge or heavier. The damper action shall be opposed-blade type.
3. Each blade shall pivot on a 1/2" cadmium plated, cold-rolled steel axle which pivots within self-lubricating, oilite bronze bearings.
4. The top and bottom edges of each rectangular damper blade shall be crimped for stiffness.
5. The operating rod for all dampers shall be extended outside the damper frame for attachment of an operator. Each operator shall have a position indicator and locking quadrant.
6. All dampers utilized for introduction of outside air shall have flexible, gasketed edge and end seals. The leakage rate shall be less than 4 CFM per sq. ft. of face area against a 1" W.G. differential pressure, based on a nominal 48" x 48" damper size.
7. Manual volume dampers shall be as manufactured by Louvers & Dampers, Inc. or an approved equal.

B. Control Dampers
1. Control dampers shall be of the same construction as manual volume dampers, except that no manual operator and quadrant is required. The operating rod shall be suitable for operation by an automatic pneumatic or electric operator.

C. Fire Dampers
1. Fire dampers shall be UL-listed and labeled for 1 1/2 hours and shall be provided with 160 degrees F. links. Dampers installed within ducts shall be Type B or Type C with the blades out of the air stream. Areas indicated shall be net, clear, open areas.

D. Smoke Dampers
1. Smoke dampers shall be UL-listed as Class 1 low-leakage smoke dampers and shall be products of Prefco.

2.6 LOW-PRESSURE DUCT BRANCHES

A. Splitter dampers shall be provided at all low-pressure ductwork branches, as required for system balancing. All low-pressure ductwork branches shall be radiused or 45 degree take-offs; straight taps are unacceptable. The length of the damper blade shall be the same as the width of the widest duct section at the split, but in no case shall blade length be less than 12". Each operator rod shall have a locking swivel joint.

2.7 FLEXIBLE DUCT

A. Flexible ductwork shall be Class 1, UL 181 air duct and meet NFPA 90A and 90B Standards.

B. The internal duct surface shall be acoustically rated, black CPE bonded to a coated steel wire helix. The external jacket shall be a fiberglass, bi-directionally reinforced, metallized vapor barrier with a standing, triple ply seam. Fiberglass insulation shall be provided between the duct surface and the jacket to achieve a maximum thermal conductance of 0.23 BTU/Hr./sq. ft./degree F. at 75 degrees F. mean.

C. Flexible ductwork shall be suitable for 10" W.G. positive pressure and 1" W.G. negative

pressure.

D. Flexible ductwork, insulation and insulation cover shall be suitable for ceiling return air plenum installation and shall comply with all applicable codes and standards regarding such ceiling plenum installations.

E. Flexible duct shall be Thermalfex M-KE or an approved equal.

F. The maximum allowable installed length of flexible ductwork shall be as follows:
1. 8'-0" on low-pressure supply air systems limited to short runouts and end of runs connected to round neck supply diffusers and registers.
2. 4'-0" on medium and high-pressure supply air systems limited to the runouts from the sheetmetal ductwork to each terminal unit.
3. 2'-0" on connections from round neck grilles to sheetmetal ductwork on return, exhaust and transfer ductwork.

G. Provide a spin-in fitting with integral scoop and volume damper at all flexible run-out connections in low-pressure supply air ductwork only.

2.8 TERMINAL UNIT RUNOUTS

A. Medium and high-pressure runouts to terminal units shall be connected to the trunk duct with factory-welded laterals, conical tees or bellmouth fittings; abrupt round to rectangular taps are strictly prohibited and shall be rejected.

2.9 FLEXIBLE CONNECTIONS

A. Provide flexible duct connections at the inlet and outlet of each belt-driven fan, indoor unit, fan coil unit, air handling unit, etc., and at all other locations indicated. Flexible connections shall be fabricated from a glass fabric coated on both sides with neoprene. Minimum weight shall be 30 oz. per sq. yard.

2.10 DUCT HARDWARE

A. Duct hardware shall be as manufactured by Young Regulator or an approved equal.

2.11 ACCESS DOORS

A. A duct access door shall be provided at each fire damper. Access doors shall be designed for 1.5 times the pressure of the duct in which they are mounted. Access doors shall be of sufficient size to provide access to the dampers for resetting the blades and replacing the links. Access doors in medium and high-pressure ductwork shall be installed downstream of fire dampers and shall be implosion type. Where access is provided through gypsum board walls or ceilings, furnish access door for installation under Division 09. Each door shall match the fire-rating of the wall or ceiling indicated.

2.12 DUCT LINER

A. Duct liner shall be one inch thick, 1 ½ lb. density (3 lb. density on medium and high pressure supply air systems) fibrous glass with one face coated with a black fire retardant compound. The permanent composite fire and smoke hazard rating of the liner shall be stenciled on the liner face and shall be:
1. Maximum flame spread 25

2. Maximum smoke developed 50

2.13 DUCT INSULATION

A. Duct insulation shall be 2" thick, minimum 3/4 lb. density fiberglass with an FSKL 0.00035" thick aluminum foil jacket, reinforced with fiberglass scrim. Thermal conductivity shall be a maximum of K = 0.24 at 75 degrees F. mean temperature.

B. Insulation adhesive shall be Benjamin Foster 85-20. Tape shall be aluminum foil and shall be SMACNA listed and labeled.

C. The composite NFPA 90A and 90B, ASTM E84, UL rating of the installed insulation shall not exceed 25/50.

2.14 GREASE EXHAUST DUCT INSULATION

A. All grease exhaust ductwork shall be wrapped with 2” fire wrap insulation to allow for zero clearance from combustible materials. Duct wrap shall be 3M Fire Barrier Duct Wrap 15A or approved equal and shall meet the requirements of UL 1978.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ductwork shall be installed in strict accordance with SMACNA, UL and NFPA standards.

B. Duct liner shall be provided for the following minimum distances or through the first elbow(s) or as otherwise indicated on the drawings, whichever is greater, downstream of each unit indicated below:

1.	Fan coil	5 feet
2.	Energy recovery unit	30 feet (OA & EX)
3.	Air handling unit	30 feet
4.	Terminal unit	5 feet (UNO)

Duct liner shall also be provided throughout all return air, transfer and plenums.

C. Duct liner shall be cut to provide overlapped and compressed longitudinal corner joints. Liner shall be installed with the coated surface facing the air stream. Duct liner shall be adhered to the ductwork with 100% coverage of the sheet metal surfaces using a fire retardant adhesive applied by spraying. Coat all exposed leading edges and all transverse joints with fire retardant adhesive. The liner shall be additionally secured using metal pins welded to the duct and speed washers. All leading edges shall be secured with sheet metal airfoils.

D. All supply air ductwork which is not lined shall be insulated. All outside air ductwork shall be insulated. Insulation shall be cut slightly longer than circumference of duct to insure full thickness at corners. All insulation shall be applied with edges tightly banded. Insulation shall be adhered to duct with fire resistant adhesive. Adhesive shall be applied so that insulation conforms to duct surfaces uniformly and firmly. In addition to the adhesive, the insulation shall be additionally secured to the bottom of all ducts 18" or wider by means of welded pins and speed clips. The protruding end of the pins shall be cut off flush after the speed clips have been applied. The vapor-barrier facing shall be thoroughly sealed with tape where the pins have pierced through. All joints shall be sealed with 2" wide

SMACNA tape. Any cuts or tears shall be sealed with SMACNA tape.

E. Flexible ducts utilized in the low-pressure ductwork systems shall be installed without kinks or bends which are less than a centerline radius equal to or greater than twice the diameter of the flexible duct being installed. Also, in the runouts from the medium or high-pressure ductwork to the terminal units, the flexible ducts shall be installed with a variance of no more than 1" per foot of installed length off a straight and level line from the centerline of the sheetmetal ductwork runout or tap to the centerline of the terminal unit inlet. The size of the flexible ductwork connected to each terminal unit shall be the equivalent size of the larger of the following:

1. The inlet size of the terminal unit.
2. The runout size indicated on the drawings.

Should the runout size indicated on the drawings differ from the inlet size of the terminal unit or where the inlet to the terminal unit is rectangular, the transition shall be made with sheetmetal and shall occur at the inlet to the terminal unit.

F. All intersections (crossing) of low-pressure and medium-pressure ductwork shall be made with offsets in the low-pressure ductwork only. The medium pressure ductwork shall be ran straight and level.

G. Contractor bid pricing shall include all required offsets, transitions, etc. for a complete and coordinated system.

H. All outside air, supply air or other conditioned air ductwork installed outdoors shall be double wall ductwork.

I. All outside exhaust ductwork shall be coated with a 1.5 mil enamel finish. Joints shall be sealed weather tight.

END OF SECTION 238400

SECTION 239000

AUTOMATIC CONTROLS AND ENERGY MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

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

B. This Section 239000 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 Automatic Controls (AC) and Energy Management System (EMS) as specified herein and as shown. This work includes, but is not limited to, the following:

1. Control panels (main and remote)
2. Thermostats
3. Temperature and pressure sensors
4. Control valves and dampers with actuators
5. Life safety shutdowns and interlock wiring
6. Relays, contactors and transformers
7. Control and power wiring (24 and 120 volt)
8. Point capacity for future interior fit-up
9. Point capacity for lighting control
10. Web accessible user workstation
11. Power meter monitoring (main and sub-meters)
12. Gas meter monitoring (main and sub-meters)
13. Water meter monitoring (main and sub-meters)
14. Emergency power system (transfer switch status)
15. Kitchen exhaust and makeup air systems

C. System shall provide all functions, monitoring, trends, etc. required by the Marriott Autograph Collection Design Standards.

1.2 SCOPE OF WORK

A. The scope of work includes, but is not limited to, provision of all equipment, hardware and software for a complete system of automatic temperature and pressure control, energy management and integrated life safety functions. The automatic controls and energy management functions shall be performed by a central processing unit (CPU) located in the engineer's office and by separate remote panels which shall be monitored by the central processing unit. CPU shall be Intel Pentium-based.

B. The control system shall be a 100% electronic DDC system. The control system shall be a fully web accessible product. The control system shall be compatible with LonTalk systems and controllers.

C. The Direct Digital Temperature Control System (DDC) shall be an integrated, fully operational temperature control system and building management system as herein specified. The Contractor shall have full responsibility for all work necessary to satisfy the requirements of this specification, including hardware and software integration.

D. The DDC System shall be a computer-based direct digital control system consisting of a central control unit (CCU) located at Owner's central maintenance office. Coordinate final location with the Owner.

E. The automatic controls and EMS shall include control points for the following as a minimum:
1. Air-Handling Units (Variable Volume)
   a. Start/Stop Control with positive status indication
   b. Supply Air Temperature
   c. Return Air Temperature
   d. Outside Air Temperature
   e. Mixed Air Temperature
   f. Dirty Filter Alarm
   g. Chilled Water Control Valve (Electronic modulating type)
   h. Hot Water Control Valve (Electronic modulating type)
   i. All Control Dampers
   j. All Wiring for above
   k. Interlock with Fire Alarm System
   l. Discharge air static pressure
   m. Adjustable point for static control
   n. Adjustable point for supply air reset
   o. Adjustable point for outside air damper (morning warm-up/pulldown and demand control ventilation)
   p. Separate start/stop point for fan powered (PIU) terminal unit control for night setback and fire alarm shutdown
   q. Variable frequency drive status and speed
   r. Return Air CO^2 level
   s. Return Air Humidity
2. Air-Handling Units (Constant volume) - Additional Points TBD
   a. Start/Stop Control with positive status indication
   b. Supply Air Temperature
   c. Return Air Temperature
   d. Outside Air Temperature
   e. Mixed Air Temperature
   f. Dirty Filter Alarm
   g. Chilled Water Control Valve (Electronic modulating type)
   h. Hot Water Control Valve (Electronic modulating type)
   i. All Control Dampers
   j. All Wiring for above
   k. Interlock with Fire Alarm System
   l. Adjustable point for supply air reset
   m. Adjustable point for outside air damper (morning warm-up)
   n. Lobby space static pressure
   o. Return air CO^2 level
   p. Return Air Humidity
3. Energy Recovery Units
   a. On / off status
   b. Dirty filter alarm
   c. Leaving air temperature
   d. Leaving air humidity
   e. Outside air duct static pressure
   f. Exhaust air duct static pressure
   g. VFD speed for each fan

h. Chilled water control valve
i. Hot water control valve

4. Fan Coil Units – (Non-Guestroom Units)
   a. Start/Stop Control with positive status indication
   b. Supply Air Temperature
   c. Outside Air Temperature
   d. Dirty Filter Alarm
   e. Chilled Water Control Valve (Electronic modulating type)
   f. Hot Water Control Valve (Electronic modulating type)
   g. All Control Dampers
   h. All Wiring for above
   i. Interlock with Fire Alarm System
   j. Electric heating coil: on / off and status
   k. Thermostat set point and space temperature
   l. Night set back control
5. Guestroom Fan Coil Units:
   a. Guestroom fan coil units shall be provided with dedicated thermostat and are not required to interface with the EMS system.
6. VAV and PIU Systems
   a. Sensors and all associated wiring
   b. Thermostat set point and space temperature
   c. User override control
   d. Airflow CFM
7. Outside Air, Toilet Exhaust and Building Pressure Exhaust Fans
   a. Stop/start
   b. Fan VFD output (if applicable)
   c. Duct static pressure
   d. Duct air temperature (outside air only)
8. Split System Air Conditioning Units
   a. Sensors and all associated wiring
   b. Thermostat set point and space temperature
9. Hydronic Water Systems (Chilled, condenser)
   a. Supply Temperature (at primary loop)
   b. Return Temperature (at primary loop))
   c. Adjust point for supply temperature
   d. Equipment start/stop
   e. All automatic control valves (position)
   f. All flow and differential pressure switches
   g. Outdoor enthalpy
   h. Outdoor air temperature
   i. Loop flows
10. Pumps
    a. Automatic lead/lag switchover
    b. Automatic start of lag or standby pump upon lead pump failure based on differential pressure switch at each pump.
    c. Start/stop to match chillers
11. Cooling tower
    a. CWS temperature
    b. CWR temperature
    c. Fan and VFD status
    d. Basin heat status
    e. All control valves

12. Heat Exchanger
    a. Control valve status
    b. Supply water temperature (hot and cold side)
    c. Return water temperature (hot and cold side)
13. Domestic Water Booster Pump System:
    a. Pump operation status
14. Domestic Hot Water System
    a. Boiler status
    b. Boiler alarm (all microprocessor monitoring points)
    c. Hot water tank temperature
    d. Circulating pump operation status
15. Direct Digital Control System:
    a. DDC Panels (main and remote)
    b. CPU and RCP
16. Carbon dioxide Monitoring:
    a. Sensors and all associated wiring
    b. Carbon dioxide setpoint and space level
    c. Outside air damper control (demand control ventilation)
17. Carbon Monoxide Monitoring
    a. Sensors and associated wiring
    b. Carbon Monoxide setpoint and space level
18. Humidity Monitoring:
    a. Sensors and all associated wiring
    b. Humidity setpoint
19. Life Safety Controls:
    a. Interlocks to the life safety controls
    b. Interlocks to the fire alarm system provided under Division 26
20. Lighting Control:
    a. Provide 35 points for interlock of lighting systems for on/off control.

1.3 AUTOMATIC SHUTDOWNS

A. All recirculating air systems (air handling units, PIU's, etc.) which supply air to paths of egress (exits, corridors, lobbies, etc.) shall be provided with smoke detectors in the supply and all return air paths for automatic shutdown of that system in the event of smoke detection.

B. All recirculating air systems (air handling units, PIUs, fan coil units, etc.) having a design airflow capacity of 2000 CFM or greater shall have smoke detectors installed to detect the presence of smoke and automatically stop the fan(s):
    1. In the supply system downstream of the filters.
    2. In the return system at each point of entry into the common return prior to any mixing with outside air.

C. Smoke detectors shall be furnished by Division 26 for installation under this Division 23 in accordance with NFPA 72E. All smoke detectors shall be connected to the Life Safety System in accordance with the requirements of the NFPA Signaling System Standards (NFPA 72) such that actuation of any smoke detector will sound the fire alarm. No system shall restart until the fire alarm controls are reset. Coordinate interlocks (quantity, location, etc.) with Division 26.

D. Activation of any smoke detector shall sound an audible alarm in a normally occupied area of the building.

E. Detector trouble condition shall be indicated visually or audibly in a normally occupied area of the building and shall be identified as air duct detector trouble.

F. Smoke dampers shall be installed in systems over 15,000 CFM capacity serving multiple floors to isolate the air handling equipment (including filters) from the remainder of the system so as to restrict circulation of smoke, and arranged to close automatically when the system is not in operation.

G. All system shut downs shall comply with NFPA and Fire Marshal requirements.

H. An accessible test station shall be provided in compliance with the Marriott Autograph Collection Design Standards.

1.4 INTENT

A. It is the intent of this Section of the specifications to provide a complete, operable, adjusted Automatic Control and Energy Management System as shown and specified which is free of hunting and excessive cycling.

1.5 OWNER STANDARDS

A. The controls contractor shall obtain a copy of the Marriott Autograph Collection Design Standards. All systems shall be provided and installed per this standard.

1.6 ACCEPTABLE MANUFACTURERS

A. Basis of design is Alerton.

B. Acceptable substitute manufacturers for the automatic controls and EMS are Automated Logic, Honeywell, Trane, and Siemens.

C. All automatic controls and EMS shall be installed by technicians who are either directly employed by the manufacturer or are properly trained technicians in the direct employ of an authorized dealer and installer for the manufacturer.

PART 2 - PRODUCTS

2.1 CENTRAL CONTROL PANEL (CCP)

A. The function of the Center Control Panel (CCP) shall be to provide global commands and data for the Remote Control Panels (RCP) and to allow for remote communication with a personal computer based workstation (see 1.2 above). This workstation is to be located as requested by the Owner and shall be web access capable. Provide all required data communication devices for communication between CCP and the personal computer workstation.

B. The CCP shall contain the complete building operating system so that continuous connection to the personal computer workstation is not required for normal operation.

C. The CCP shall contain the system clock to provide time based control functions. This clock shall be battery backed by a self-charging battery system. This system shall be capable of maintaining the system clock for up to seven days minimum.

D. The CCP shall continuously scan all RCPs and zone control panels (ZPC) storing field data and alarms to allow for quick retrieval by the personal computer workstation. Communication between the CCP and RCP shall be LON based.

E. CCP memory shall be battery backed RAM. The self-charging battery system shall be capable of maintaining the memory for a minimum of seven days. The control contractor shall reprogram CCPs should a memory failure occur during the first five years of system operation. This reprogramming shall be at no cost to the owner.

F. All communication ports for the CCP shall be provided with lightning protection devices. These devices shall include gas discharge diodes and metal oxide varisters and shall be capable of suppressing spikes up to 1000 V in less than 100 nano seconds.

G. Interface to the CCPs via the personal computer workstation shall be through a menu driven program that supports dynamic color graphics. Menus shall be self-prompting with documentation provided on the screen to reduce the need for referencing the owner's manual. On line help shall be provided via a hot key to pull up additional documentation as needed to aid the operator.

H. High resolution color graphics shall be provided as described in this specification and on the Input/Output Summary Table. These graphics shall be dynamic displaying the most current data on the screen. Setpoints referenced in the Input/Output Summary shall be changeable through these color graphic screens. Provide a manual control menu to allow the operator to manually turn on or off points, start and stop equipment, manually adjust outputs, restart control calculations, or release points to automatic control.

I. The CCP shall be able to inform the operator of communication failures between CCP's, CCP's and RCP's and CCP and ZCP's. Statistics on these communications shall be maintained and stored in the CCP to aid in the identification of problems in the communication wiring.

J. Provide a personal computer workstation. This workstation shall be connected to the network for local control access.

2.2 REMOTE CONTROL PANELS (RCP)

A. Standalone Remote Control Panels (RCP) shall be provided on each Air-Handling Unit, in the pump room and as otherwise required for full control.

B. RCP's shall be standalone controllers responsible for all input/output and local control loop algorithms. Control programs for local control shall be contained in the RCP so that control is maintained should communication with the CCP be lost. Control programs shall be stored in non-volatile yet changeable EEPROM type memory. Setpoints for all control loops shall be changeable in the field by the owner. Provide all interface devices and software so that these changes can be made. DDC controllers requiring their programs to be downloaded from the CCP are not acceptable. The control contractor shall reprogram RCPs should a memory failure occur during the first five years of system operation. This reprogramming shall be at no cost to the owner.

C. Provide a means for operator interface to provide local display and adjustment of all inputs, outputs and setpoints.

2.3 ZONE CONTROL PANELS (ZPC)

A. Zone control panels shall be provided for each terminal unit to provide standalone control of that unit. These controllers shall have point capacity as required to accomplish the specified sequence of operation and point list.

B. ZCP software shall be non-volatile yet changeable EEPROM type memory. Systems using non-changeable ROM or battery backed RAM are not acceptable due to servicing problems.

C. All control devices mounted in the return air plenum including the ZCP shall be UL rated for use in return air plenums. Provide evidence of the UL rating during the submittal process.

D. Provide a laptop computer or tablet with sufficient capability for interfacing with the ZCP's. This laptop shall allow the operator to plug into the zone temperature sensor and read inputs and outputs, adjust setpoints and manually operate the associated terminal unit.

E. Controls for the terminal units shall be mounted, wired, and tested by the terminal unit manufacturer. Provide the terminal unit manufacturer with control devices, point-to-point wiring diagrams, and a checkout simulator board to aid in the control installation.

2.4 SENSORS

A. Sensors shall be high-accuracy, (plus or minus 0.1%), resistance temperature type.
1. Space temperature sensors shall be equipped with blank covers suitable for wall mounting. Color shall be selected by the Architect.
2. Mixed air sensors shall be of the averaging type with a 22-foot minimum element strung evenly across the entering side of the coil bank and securely attached.
3. Discharge air sensors shall be insertion type sensor mounted in a location that will permit measurement of an average discharge temperature as tested by the AHU manufacturer, or shall be an averaging sensor with 20 foot element strung and evenly spaced across the discharge duct.
4. Outside air sensor shall be a mounted in a shaded location in a weatherproof housing.
5. Mixed air low limit thermostat shall be the manual reset type with a minimum 20-foot multi-point sensing element, securely and evenly spaced across the entering side of the coil bank. Provide multiple low limits when coil face area exceeds 16 square feet and factory wire in series.
6. Carbon monoxide sensors shall be wall mounted devices and shall be interlocked with the EMS system to alarm upon detection of CO.
7. Carbon dioxide sensors shall be wall mounted devices and shall be interlocked with the EMS system. Carbon dioxide sensors shall measure CO^2 in PPM in a range of 0-2000 PPM. Accuracy shall be +/- 3% of reading with stability within 5% over 5 years.

2.5 ACTUATORS

A. Damper and valve actuators shall be low-voltage electronic, positive positioning, spring return; factory selected, mounted and tested for proper operation based on unit size, type, and torque requirements.

B. Actuators shall be selected for the response time required for proper system operation.

2.6 PRESSURE INDEPENDENT TEMPERATURE CONTROL VALVES

A. Basis of specification is the Danfoss AB-QM. All valves and actuators supplied under this specification must be from a single manufacturer. Installation procedures, commissioning, functionality, and flow performance must remain identical throughout all sizes supplied and installed.

B. Warranty: Valve and actuator shall be warranted by the manufacturer for 5 years from the date of purchase.

C. The Temperature Control Valve
1. The valve will be pressure independent, and control pressure across the control valve orifice. Valve shall require no more than 3 PSID to operate pressure independent.
2. The control valve must have the ability to limit flow to the maximum design flow specific for each coil. Flow shall not vary more than +/-5% through the entire operating pressure range of 3 to 60 psi.
3. Provide **user adjustable** maximum flow within valve control range; Adjustment method shall indicate percentage of valve flow range and utilize spring locked method of adjustment.
4. Controlling the regulation of pressure shall be mechanical only (no metering) utilizing an integrated EPDM diaphragm design, stainless steel spring, and pressure control disc and shall require no internal maintenance or replaceable cartridges.
5. Regulate internal control valve differential pressure to provide 100% control valve authority at all positions of the valve, and maintain proportional / linear flow coil characteristics and maintain a linear flow characteristic throughout the operating range of 3 to 60 psi.
6. Be available in union tailpiece kits for sizes ranging from ½" to 2"; and flanges for sizes ranging from 2-1/2" to 10'; if ISO gaskets are required the manufacturer will supply an adequate quantity for the project.
7. Provide back seated globe design of **brass or ductile iron construction**. No plastics of any kind shall be permitted within the valve body. Valve shall provide Class 4 shut-off on all sizes.
8. The manufacturer shall provide 3rd party operation and flow documentation to certify the characteristics of the valve.
9. The valves maximum coil flow setting shall be the **responsibility of the mechanical contractor** and must be completed prior to the installation of the actuator by the temperature control contractor.

D. The Temperature Control Valve Actuator
1. Electronic Actuator shall be self-learning, and have the ability to self-commission to match the set point flows of the valves.
2. Be an actuator from the same manufacturer as the valve.
3. The actuator shall provide full stroke at each flow setting of the valve.
4. Actuator mounting shall be integral with the valve body on sizes thru 1¼".
5. Actuator must be provided with wiring harness and plug assembly.
6. Have the ability to supply on/off, floating, proportional, safety spring and/or feedback options.
7. Be available in a thermostatic, thermal or electronic version.

8. Provide a visible position indication.
9. Operate the valve through its full range and have a minimum close off pressure of 90psi.
10. Have an option of selectable system characteristic (Log or Lin) for motorized actuators.
11. The actuator shall be selected, supplied, installed and commissioned by the temperature control contractor.

2.7 CONTROL DAMPERS

A. Control dampers shall be opposed blade type for modulation and air mixing service and parallel blade for two-position (OPEN-CLOSED) service.

B. All damper frames shall be constructed of minimum 16 gauge galvanized sheet metal and shall have flanges for duct mounting.

C. Damper blades shall not exceed 8" in width. All blades shall be of roll-form break design and shall be constructed of minimum 16 ga. galvanized sheet steel. All blades shall be provided with edge and end seals.

D. All damper blade bushings shall be made of oilite bronze.

E. All dampers shall be low leakage type.

2.8 SMOKE DAMPERS

A. Smoke dampers shall be UL listed and labeled as Class I low-leakage smoke dampers.

B. Smoke dampers shall be as manufactured by Prefco or Ruskin.

C. Smoke dampers shall be interlocked with the fire alarm system. Coordinate quantity and location with Division 26.

2.9 ROOM SENSORS AND THERMOSTATS

A. Provide wall sensors with digital setpoint display and user adjustment capability in all locations shown.

B. Guestroom sensors shall be Inncom e4 Smart Digital Thermostat Model e528. Control functions shall include integral lighting control, bedside control and central network control with entry door switch and wireless RF switch at the sliding door.

2.10 PRESSURE SENSORS

A. Duct static pressure sensors shall be located within the ductwork in a representative location and shall have an installed accuracy of $\pm$ 5% over the normal operating range of the sensed medium. These sensors shall be capable of withstanding 200% of the maximum pressure of the system.

2.11 HUMIDITY SENSORS

A. Electronic humidity sensors shall be provided as required to provide installed accuracies of $\pm$

3% from 10 to 90% relative humidity. Humidity sensors shall be capable of recovering from complete saturation without changing calibration point.

2.12 HVAC SYSTEM FIRE COMMAND PANEL

A. A fire command panel shall be located in the fire command room of the adjacent office building. This panel will be provided by Division 26. Provide all necessary relays for each piece of HVAC equipment. See Specification 28 72 10, 2.1 P. Coordinate carefully with Division 26. Complete panel layout and control functions shall be prepared for submittal to the Architect and Fire Marshall for approval. All functions and control required by the Marriott Autograph Collection Standards shall be included.

2.13 REFRIGERANT MONITOR

A. A multi-port refrigerant monitor shall be provided per the requirements of ASHRAE 15. The monitor shall be selected for the refrigerant used in the refrigeration machine room (central plant) and shall activate alarm upon detection of toxicity in excess of the corresponding TLV-TWA.

B. The refrigerant monitor shall be capable of manual reset from within the machine room.

C. The alarm sensor outlet tubing shall be routed to a location above the floor adjacent to each chiller.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The 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. All necessary interface controllers, components, software, etc. shall be provided for full communication with all equipment. Coordinate requirements with equipment vendor for each respective component.

D. All contactors shall be solid state or mercury totally silent type.

3.2 SOFTWARE CAPABILITIES - Additional software functions TBD

A. General Operation
   1. The central control panel (CCP) shall have the following control routines:
      a. Time-of-day scheduling
      b. Remote scheduling override
      c. Temperature control
      d. Night setback
      e. Optimum start and optimum stop
      f. Demand limiting
      g. Temperature compensated duty cycling
      h. Analog monitoring

2. The program shall be based upon a Julian calendar and it shall provide automatic leap year compensation. It shall automatically set forward for daylight savings time and setback for standard time.

B. Anti-recycle Equipment Protection Timers
1. Protection of each HVAC unit shall be provided through individually programmable "minimum on", and "minimum off" timers. These shall have the highest priority over the software functions. All timers shall be individually programmable from 0 to 120 minutes.

C. User Access
1. User access shall be through the use of a prompted, menu driven, English language communications routine. Entries will be made on the unit-mounted keypad with liquid crystal display (LCD) or through a local or remote terminal.
2. The control program shall have individual security passwords for a minimum of eight users. It shall be partitioned into multiple levels of user access with data entry restrictions being assignable by password. User log on/log off attempts shall be recorded.
3. The system shall be web accessible with full control capability. Access shall be password protected for security.

D. Time-of-Day Scheduling
1. The scheduling program shall be based upon an eight-day (seven work days + holiday) timeclock. It shall have four day-types per load. The program shall have the capability to execute up to six timed events within each day-type. The events shall include equipment start and stop and optimum start and stop. The program shall allow the operator to add, delete, or change the schedules at any time.
2. There shall be a minimum of 12 holidays, each with an assignable length of one to seven days.

E. Optimum Start/Stop
1. The optimum start/stop program shall determine start/stop timing by comparing inside/outside temperatures and building historical data. Optimum start/stop shall be done for each zone independently.

F. Duty Cycling
1. The control program shall allow the cycling of equipment to reduce equipment run times and correspondingly lower equipment operating costs. There shall be four different cycling day types per load, each containing four user designable cycle pattern start times. The program will have a minimum of eight cycle patterns containing user defined pattern lengths and off times.
2. The control program shall be capable of altering duty cycle patterns to compensate for changes in space conditions. Control is to be automatic, suspending cycle control if sensed temperature is outside of comfort deadband. Simple pattern switching, based upon temperature setpoint shall not be considered equal.

G. Electrical Demand Control
1. The central control panel shall have the capability to control building peak kilowatt demand by selectively turning off loads. The control program shall be based upon a predictive sliding window technique and will contain a self-adjusting demand limiting routine. The user shall be able to designate the estimated kw value, maximum off time, and priority level for each load.

2. When demand control is required, the program will shed the predicted kw requirements by starting with the lowest level of priority. When all available loads within a priority level have been shed, the program will then proceed to the next priority level. Equipment assigned to the same priority level will be shed on a rotating basis. The number of available priority levels shall be equal to the number of loads. Zone comfort will be protected by equipment "maximum off" entries and demand limiting temperature deadbands. Anti-recycling timers will protect the controlled equipment as specified above.
3. The system shall be able to monitor building power consumption by signals generated by a current transformer mounted in the electrical switchgear.
4. The current transformer will be provided by this Division.

H. Analog Monitoring and Control
1. The central control panel shall be able to monitor any analog sensor whose control format is based upon a variable resistance, current or voltage signal. Each analog input shall have a day and night, and high and low alarm limits.

2. The control program shall have the functions of day and night temperature control and optimum start and stop. In all cases, it shall be able to initiate contact closure and/or adjust equipment operation based upon occupied (day) and unoccupied (night) heating and cooling setpoints. The program shall include user selectable deadbands for automatic adjustment of demand, night setback and duty cycling strategies based upon deviation from zone temperature.

I. Remote Override with Switch Closure
1. The user shall have the ability to override the scheduled status of a zone by use of remote, two-position switches located on each space temperature sensor. Closure of the switch will turn each designated load either on or off for a pre-assigned minimum time of one minute to 720 minutes (adjustable). The control system shall record the selected zone and the total duration of override.

J. Trend Prints
1. The system shall be able to monitor and independently generate trend prints for up to eight parameters. A sampling period from one minute to 24-hours shall be assignable to each load.

K. Boolean Processing
1. The system shall be able to change building control strategies by comparing binary input information based on logic statements. A minimum of four binary inputs can be used for this comparison.

L. Power Monitoring
1. EMS shall monitor and trend power consumption from all equipment VFD’s and meters in the building in accordance with the building’s measurement and verification plan.

3.3 SEQUENCES OF OPERATION (outline level – further sequences pending design completion)

A. Chiller System
B. Cooling Tower Sequencing and Control
C. Cooling Tower Fan Control
D. Chilled Water Pump Pressure Setpoint Optimization

E. Waterside Economizer
F. Air-Handling Units (variable air volume)
G. Air-Handling Units (constant volume)
H. Fan Coil Units (Non-Guestroom Units)
I. Outside Air Units
J. Zone Overrides
K. Powered Induction Units (PIU)
L. Split Systems
M. Electric Heaters
N. Fans
O. Hotel Guestroom Fan Coil Units
P. Miscellaneous
Q. Energy Recovery Unit

3.4 STARTUP

A. Provide the services of a factory trained and qualified service technician employed by the AC and EMS manufacturer who shall inspect the installation including external interlock and power connections; supervise testing, initial operation and calibration of these operating and safety controls.

B. This service technician shall forward a report in four (4) copies to the Owner when the ATC and EMS is in safe and proper operating condition. This report shall include all pressure and control settings, 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 central control panel. One copy of bound installation, operation, maintenance service and parts brochures, including applicable serial numbers and parts ordering sources, shall be placed in the central control panel at the time of startup; four (4) additional copies shall be forwarded to the Owner.

3.5 GRAPHICS

A. Graphics shall be provided for each mechanical system including the pumps, all fans, outside air riser, toilet exhaust riser, pressure relief riser, each air-handling unit and each terminal unit. Graphics shall show each point that is monitored. Graphics for each terminal unit shall be indexed by the tenant's name. Additional graphics shall show each floor with zone temperatures. If one graphic is not sufficiently large to capture an entire system or floor then it shall be logically separated into two graphics.

B. A graphic for each air-handling unit shall indicate fan status, duct SP setpoint, measured duct SP, leaving air temperature setpoint and leaving air temperature. Alarm status diagnostic alarm messages.

C. A graphic for each non-guestroom fan coil unit shall indicate fan status, leaving air temperature and compressor ON-OFF alarm status for diagnostic alarm messages.

D. An individual graphic for each terminal unit shall provide actual room temperature, occupied and unoccupied room cooling and heating setpoint, fan status, stages of active heat, CFM and alarm messages.

E. Floor plan graphics shall show the ductwork, interior walls, equipment locations, and thermostat locations. Floor plans served by VAV systems shall identify the current critical

zone and the current self-contained unit SP setpoint.

F. Provide sketches of proposed graphics for review by the owner to coordinate the design of these graphics.

3.6 OWNER TRAINING

A. Provide the service of a qualified EMS system technician for three (3), 8 hour days for owner training. The three (3) days shall be non-consecutive and shall be coordinated and scheduled with the owner.

END OF SECTION 239000