

SECTION 23 09 93

SEQUENCE OF OPERATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including general and supplementary conditions and division 1 specification sections, apply to this section.

1.2 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
- B. Related Sections Include The Following:
  - 1. Division 23 Section "HVAC Instrumentation And Controls" For Control Equipment And Devices And Submittal Requirements.

1.3 Definitions

- A. Retain acronym and abbreviation that remain after this section has been edited.
- B. ATC: Automatic Temperature Control.
- C. BMS: Building Management System.
- D. CFM: Cubic Feet Per Minute.
- E. DDC: Direct-digital controls.
- F. FAS: Fire Alarm System.
- G. HVAC: Heating, Ventilating, and Air Conditioning.
- H. MER: Mechanical Equipment Room.
- I. AHU: Air Handling Unit.
- J. VAV: Variable air volume.
- K. VFD: Variable Frequency Drive.

1.4 GENERAL

- A. Any safety shutdown shall allow for an automatic local reset and a manual remote reset and restart from the BMS system. All safety devices shall be hardwired to the starter and shall have a second contact for monitoring via the BMS.

- B. All setpoints including setpoints internal to control algorithms shall be adjustable from all BMS operator interfaces.
  - C. All alarm points shall be annunciated at the BMS audibly and visually.
  - D. All controllers shall incorporate proportional-integral-derivative control loops.
  - E. All points for a specific mechanical system shall be connected to and controlled by the same DDC controller unless otherwise specified. For example, it is not acceptable to control a supply fan with one DDC controller located at a motor control center and to control the rest of the air-handling unit points with a DDC controller located at the air-handling unit.
  - F. When there is a building wide emergency condition, including but not limited to, fire alarm, loss of power, switchover from normal power to emergency power, switchover from emergency power to normal power, etc., all BMS alarms (i.e., fan failure, pump failure, etc.) due to these conditions shall be inhibited. All alarms indicating the type of emergency condition or reason for the emergency condition shall remain active.
  - G. The BMS operating system and software shall be upgraded to the latest edition available on all operator workstations and operator interface devices.
  - H. Submit on wiring diagrams and control diagrams for all equipment listed herein regardless of whether the controls are packaged, provided by others, etc. It is the intent of this specification that this Contractor shall provide the Owner with complete and final O & M manuals that include controls for ALL equipment regardless of who provided it.
  - I. All points required by the sequence of operation including but not limited to the operator interface points listed in the sequences of operation below, as well as all of the points' associated values, shall be available to the BMS operators on all operator workstations and all operator interface devices as part of a graphical display that graphically depicts the mechanical system controlled.
  - J. The installed BMS shall have dedicated, LAN based communication buses independent of the building IT network for both primary and secondary buses.
  - K. All valves, dampers, controllers, control devices, etc. exposed to outside air conditions shall be specifically designed for outside air conditions including, but not limited to, NEMA 4 enclosures, weatherproof enclosures, and all other weather precautions recommended by the manufacturer.
  - L. The BMS contractor shall furnish, install, and wire a UPS for every primary control panel and every operator workstation.
- 1.5 AUTOMATIC RESTART SEQUENCE
- A. The BMS contractor shall submit an automatic restart sequence of operation that prioritizes the loads to be restarted, in order of importance, when a changeover in power occurs, either from normal power to emergency power or from emergency power to normal power, and when there is more than one piece of mechanical

equipment to start at the same time (e.g., at the beginning of a normally scheduled occupied cycle). The automatic restart sequence of operation shall also show the time delays between the startup of each piece of mechanical equipment.

- B. Simultaneous starting of motors shall be prevented by a sequential start program in the DDC system. This program shall also provide sequential restart after power failure of motors that were running prior to power failure.
- C. Software time delay relays shall be provided in the DDC system to allow fan motors to cool down before restarting. Motors shall have both a minimum interval time (between consecutive starts) and a minimum off time (between start and stop). The time periods shall be based on motor HP per the following table. Time periods are in minutes.

Motor Horsepower	¼-10	10-20	20-50
Minimum Interval Time	10	20	30
Minimum Off Time (adj.)	3	5	7

- D. Automatic restart of fans after a safety shutdown trip shall be software prohibited through the de-energization of the remote start/stop contact. Fan restart shall be manually initiated by the operator either locally or remotely through a computer workstation after resolving the cause for shutdown.
- E. Operator Workstation: Display the following data:
  - 1. Individual minimum interval time for each piece of mechanical equipment.
  - 2. Individual minimum off time for each piece of mechanical equipment.
  - 3. Individual motor horsepower.
  - 4. Individual restart delay for each piece of mechanical equipment.

#### 1.6 SEQUENCE OF OPERATION

##### A. Air Handling Units- ( AHU 65,66,67 and 69)

- 1. General
  - a. The BMS contractor shall furnish, mount and wire power to all control panels from the electrical contractor provided circuit board. The BMS contractor shall wire with power all fire/smoke dampers and smoke dampers. The BMS contractor is also responsible for all fan interlocks. The fire/smoke and smoke dampers shall be provided and installed by the mechanical contractor.

2. Safeties

- a. The supply smoke detector shall stop all supply fans upon the presence of smoke through the DDC system and the supply and return smoke dampers shall close. The associated return fan shall operate with the relief damper in the fully open position and the outdoor air damper shall be fully closed.
- b. Upon activation of the return duct smoke detector, the outdoor and relief air dampers will fully open and the return damper will close. Supply and return fans will continue to operate. The fire overcall start/stop point will bypass the freezestat and supply duct smoke detector and open the cooling coil valve.
- c. High discharge air pressure switches one located downstream of the supply fan and upstream of the closest damper and one located downstream of the return fan and upstream of the closest dampers shall stop the supply and associated return air fans when duct pressure exceeds design. The supply and return fans shall remain off until the air pressure switch is manually reset.
- d. Low discharge air pressure switches one located upstream of the supply fan and downstream of the closest damper and one located upstream of the return fan and downstream of the closest damper shall stop the supply fan and associated return air fan when pressure exceeds design. The supply and return fans shall remain off until the air pressure switch is manually set.
- e. A freezestat installed downstream of the preheat coil and upstream of the cooling coil shall de-energize the supply and associated return fans upon sensing a temperature below 40°F (adj.). The preheat coil 2-way valve shall allow 100% flow through the coil.
- f. A differential pressure sensor shall monitor the pressure across each filter bank. A high pressure alarm shall annunciate at the BMS when the high filter differential pressure setpoint is surpassed.
- g. A high humidity limit sensor with auto-reset capability shall modulate the humidifier to limit the supply air humidity to 90% RH (adj).

3. Enabled Mode

- a. The air-handling units are intended to run 24/7 and shall be started from the BMS.
- b. Upon a command to start, all associated two position dampers (i.e.; smoke dampers, fire/smoke dampers, etc.) shall open and be proven by end switch. The BMS contractor shall install a time delay relay which shall delay the supply and return fan starter 30secs (adj.) before energizing. The supply fans and return fans shall start in parallel at minimum speed. After a 30 second delay the supply fans shall ramp up in parallel to maintain static pressure setpoint in the supply air duct.

The supply fan speed will be reduced if required to prevent the fan discharge static pressure from exceeding the high limit setpoint.

- c. A normally closed two position automatic damper shall be installed in a cross tie on the supply and return ducts as shown on the floor plans between AHU 65 and AHU-67. The purpose of the cross tie is an emergency back-up should a unit fail. The cross tie dampers shall be manually enabled from the controls computer and shall be monitored via an end switch.
- d. The speed of the return fan VFD for RF-65, 66, and 69 shall be controlled to track the supply fans via airflow stations in the supply and return fan inlets to maintain a fixed CFM differential as indicated on the airflow tracking schedule. The speed of the return fan VFD for RF 67A and 67B, shall modulate to maintain a return static pressure setpoint. The return fan speed for all return fans will be reduced if required to prevent the fan suction static pressure from exceeding the high limit setpoint.
- E. The return air and exhaust air dampers shall modulate, the return air damper closing and the exhaust air damper opening, so as to maintain the minimum outdoor air quantity through the minimum outdoor air damper airflow station.

#### Air Tracking Schedule

AHU	S. A. CFM	R.A. CFM	Min O.A. CFM
AHU-65	26,000	19,500	6,500
AHU-66	20,150	18,000	4,030
AHU-67	40,000	33,725	8,000
AHU-69	19,350	8,900	10,650

- 4. Discharge Air Temperature Control:
  - a. AHU's 65, 66 and 69 shall have a discharge air setpoint of 55 degrees (adj).
  - b. AHU-67 shall have an initial discharge air temperature setpoint of 60 degrees F. Cooling requests from the space VAV box controllers shall reduce this initial discharge air setpoint downward to 55 degrees F, if additional cooling is required in the spaces. Discharge air setpoint shall reduce downward as required to maintain 50% R.H. as sensed by any O.R. room humidistat. The D.A.T. shall have a minimum setpoint of 50 degrees F and a maximum setpoint of 65 degrees F, based on the VAV box controller's demands.

- c. On a call for cooling, if the outdoor air enthalpy is less than the return air enthalpy, the return air and relief air dampers shall modulate accordingly, subject to a 45 degree F mixed air low limit, so as to maintain discharge air setpoint.
  - d. If economizer cooling is not available or cannot meet the cooling requirements, the chilled water valve shall modulate open to maintain D.A.T. If outdoor air temperature is 50 degrees or lower the chilled water valve shall remain closed:
  - e. When the discharge air temperature drops below setpoint, the preheat coil control valve shall first modulate open to maintain setpoint. The control system shall prevent the preheat coil and chilled water coil valves from simultaneous operation.
5. Humidification:
- a. For AHU's 65, 66 and 69 the steam humidifier shall be modulated to maintain the return air relative humidity (30% R.H. adj.) For AHU-67, the steam humidifier shall modulate to maintain the minimum space relative humidity of 30% RH at any OR space humidistat. As the humidity of the air increases the humidifier shall modulate down. The reverse shall occur when the humidity of the air decreases. A high limit humidistat shall limit the signal to the humidifier if the humidity of the supply air exceeds 90% R.H. (adj.). The humidifier shall remain off whenever the chilled water valve is opened. Upon a loss in airflow, a panel mounted static pressure switch shall de-energize the humidifier.
6. De-energized/Unoccupied Mode:
- a. In the de-energized mode, the fans shall stop, the outdoor air and exhaust air dampers shall close.
  - b. During the unoccupied mode AHU-67 shall reduce its minimum outdoor air from 8,000 CFM, to 4,000 CFM.
- B. General Exhaust Fans: (EF-193)
1. General exhaust fans shall be provided with an automatic damper at the exhaust louver which shall be interlocked with the fan to "open/closed" when the fan is "on/off."
  2. The general exhaust fan is intended to run 24/7.

## 1.7 POINTS LIST

- A. Note: For point software association, see sequence of operation. All points shall be able to integrate to all trends, totalizers, etc., as applicable. Additional points not specifically called for herein, but required to perform the sequence as specified, shall be provided at no additional cost to the owner.

1. A. The ATC contactor shall carry an allowance for installing, wiring and software programming for 10 additional monitoring and control points of each type (AI, AO, DI, DO) for owners use (i.e. 40 points). These 40 points are over and above points required that are not specifically listed below or required per sequence of operations.

System Point	Point				Alarms			Comments
	AI	AO	D I	DO	Hi	Low	Off Normal	
Air Handling Units								
Start/Stop Supply Fan				X				
Start/ Stop Return Fan				X				
Supply Fan Status	X				X	X		Via Amp Sensor and Delta P Sensor
Supply Air Flow Volume	X							Via Fan AFMS's
Return Fan Status	X				X	X		Via Amp Sensor and Delta Sensor
Supply smoke Dampers			X	X				Open/Close With End Switch
Return Smoke Dampers			X	X				Open/Close With End Switch
Minimum Outside Air Damper		X						
Economizer Outdoor Air Damper		X						Provide Position Feedback
Relief Air Damper		X						Provide Position Feedback
Return Air Damper		X						Provide Position Feedback
Minimum Outdoor Air Flow Volume	X							Via Air Flow Station At Min Outdoor Air Intake
Return Air Flow Volume	X							Via Fan AFMS's
Return Smoke Detectors			X				X	
Supply Smoke Detector			X				X	
Return Air Temperature	X							
Return Air Humidity	X							Provide Enthalpy Calculations
Mixed Air Temperature	X							
Outdoor Air Temperature (Global PT)	X							
Outdoor Air Humidity (Global PT)	X							Provide Enthalpy Calculations

Heating Coil Leaving Air Temperature	X							
Cooling Coil Freezestat			X				X	
Discharge Air Temperature	X				X	X		
Discharge Air Humidity	X				X			
Humidifier Air Flow Switch			X				X	
Humidifier Start/Stop				X				
Supply Fan VFD Modulation		X					X	Provide VFD Trouble Alarm And All VFD Points Specified
Return Fan VFD Modulation		X					X	Provide VFD Trouble Alarm And All VFD Points Specified
Supply And Return Fans High And Low Static Safety			X		X	X		Via Delta P Switch
Prefilter Dirty Alarm			X		X			Via Filter Delta P
Discharge Filter Dirty Alarm			X		X			Via Filter Delta P
Preheat Valve		X						Provide Position Feedback
Cooling Valve		X						Provide Feedback
Humidifier Valve		X						Provide position feedback
Supply Duct Static Pressure	X	X			X			
Return Duct Static Pressure	X	X			X			
Supply cross tie damper			X	X				2 supply dampers between AHU-67 and 65
Return Cross tie damper			X	X				1 damper between AHU-67 and 65

System Points	Points				Alarm			Comments
	AI	AO	DI	DO	Hi	Low	Off Normal	
Exhaust Fans								
Start/Stop and Status	X		X	X			X	Via Amperage Sensor And DP Sensor
High Static Safety			X			X		Via Delta P Switch
Fan Isolation Dampers				X				

PART 2 - PRODUCTS

(NOT APPLICABLE)

PART 3 - EXECUTION

(NOT APPLICABLE)

END OF SECTION