Air Conditioning Roof Top Units Control Sequences

Kaiser Permanente Salmon Creek Medical Building
1/2/97

System Overview

The building's space is conditioned by four 75 ton direct expansion (DX) air conditioning roof top units (ASU-1, 2, 3; 4). Heating is provided by heating coils in all VAV terminal units, two cabinet unit heaters (entry) and one unit heater (penthouse), all served from two gas boilers. Backup and unoccupied-period cooling for the telecom room C-104 is provided by a small split AC unit: low ambient condenser (AC-1) and indoor fan coil section (FCU-2). Each ASU is identical, with constant speed twin supply fans and one constant volume relief fan and exhaust damper. Cooling capacity is controlled by staging six scroll compressors and an integrated economizer. Air capacity is controlled by fan inlet vanes controlled from the static pressure at the discharge. The areas each fan serves are described roughly with the following sketch.

The ASU's have packaged controls that provide various alarms and control the duct static pressure and inlet vanes, the supply air temperature, the economizer and the building static pressure. The building automation system (BAS) ties into the ASU controller, enabling ASU operation and delivers to the ASU a supply air (SA) temperature setpoint, duct static pressure setpoint (discharge) and the building static pressure setpoint. The BAS also controls the optimum start and night low limit (unnoccupied) sequences and operation.

Sequences

[BAS] in brackets refers to sequences or parameters that are controlled by the BAS. Likewise for [Pkg] for ASU packaged controller. Adj. = adjustable parameter by operator.

Startup

1. When the unit is OFF, the inlet guide vanes are closed, supply fans, compressors, condenser fans and relief fan OFF, relief dampers closed, OSA dampers closed tight and return dampers open.
2. Excepting for optimum start and night low limit, an ASU will start at the beginning of an occupied period determined by a schedule in the BAS.
3. The unit will start with the inlet vanes closed and the ASU supply fans will run continuously.

Optimum Start

4. Optimum start schedules the warm-up mode during cooler weather.

TO BE COMPLETED WITH PARAMETERS FROM JCI

Warm-up Mode

5. After starting in the occupied mode, if the RA is less than the warm-up mode setpoint by _____F, [BAS adj] the fan system will go into warm-up mode of operation. During warm-up mode, the economizer dampers will be shut and the perimeter terminal units will have their reheat valves open _____%.

6. When the return air sensor senses that the space temperature is _____F above the warm up mode setpoint (initially _____F), the perimeter reheat valves and economizer damper return to normal operation [BAS adj].

Volume Capacity Control

7. When in occupied mode, the supply fans will run continuously. The volume of air supplied is regulated by the fan inlet guide vanes. Through the ASU controller [Pkg], these vanes modulate open (to let more air and raise the pressure) and closed (less air) to maintain the duct static pressure setpoint at the discharge plenum of the unit. The static pressure setpoint is set in the BAS and sent to the ASU controller. The appropriate setpoint was determined by the air balancer to be: ASU-1_____, ASU-2_____, ASU-3_____, ASU-4_____. At this pressure, all terminal units should be satisfied in full cooling, simultaneously. There does happen to be a duct static pressure sensor about 2/3 down the duct of each ASU that is monitored by the BAS. This sensor and value is used for reference only, and does not currently control anything.

8. The ASU controller [pkg adj] will shut down on high discharge static pressure, currently 3.4 in. w.g. in each unit.

Building Static Pressure Control

9. The building static pressure is controlled by the ASU controller, with the setpoint being set in the BAS. The constant speed relief fan will run when the economizer damper are 25% or more open [Pkg adj.] OR when the the building static pressure minus outdoor pressure (difference) is greater than the setpoint [BAS adj.], initially set at _____in. WC.

10. The relief fan damper will modulate [Pkg] to maintain the building static pressure setpoint.

11. When the relief damper is closed, the relief fan will shut OFF.

Supply Air Temperature Control

12. The ASU delivers constant temperature air (SAT) meeting the setpoint [BAS adj.], which is reset based on zone conditions. Upon ASU starting, if the SAT is above setpoint and the outside conditions are appropriate for economizing [Pkg adj], the outside air dampers open to maintain the SAT setpoint within a deadband of +/- 4F [Pkg Adj.]. Economizer is the first stage of cooling. If the economizer cannot meet the SAT setpoint, the ASU compressors start DX mechanical cooling in conjunction with the economizer. During economizing conditions, mechanical cooling will not be started until the OSA dampers are fully open. There are six compressors in two different sizes and six condenser fans (one associated with each compressor) that stage to meet the SAT setpoint. Each compressor has a 3 minute minimum ON and OFF time.

13. The compressors are automatically alternated (lead/lag staging) to equalize run time [Pkg adj.].

14. The compressors are locked out below 50F [Pkg Adj.].

Supply Air Temperature Reset

15. To minimize the mechanical cooling and terminal reheat, the SAT setpoint for each particular ASU is reset [BAS] according to the following schedule by the BAS and the setpoint sent to the ASU controller.

TO BE COMPLETED WITH PARAMETERS FROM JCI

Economizer

16. The economizer is controlled by the ASU controller. The OSA economizer is the first stage of cooling.

17. Whenever the outside air total energy content (enthalpy) is less than the setpoint (currently 25 Btu/lb [Pkg Adj.] based on OSA temperature and humidity), the OSA (economizer) dampers will begin to drive open as much as needed to try and meet the SAT setpoint. The farther the SAT is above setpoint, the faster the dampers will open.

18. If the outdoor enthalpy is greater than the setpoint, the OSA dampers will remain at their minimum setting.

19. The OSA dampers are linked to the RA dampers and modulate opposite of each other (OSA dampers at min. = RA dampers 100% open).

20. The economizer is integrated and will function at the same time as mechnanical cooling.

Fresh Air Control

21. To keep the quantity of OSA entering the building less variable (cfm, not % OSA), regardless of the total volume of air being circulated, the ASU uses an OSA compensation routine. As the inlet vanes close and let less total volume through the system, the compensation routine causes the OSA dampers to open proportionately more, according to the following parameters [Pkg Adj.]:

Inlet Guide Vane Position	Min. Economizer Position
0% open	_____%
100% open	_____%

The objective is to maintain a minimum of _____cfm of outside air entering the building from each ASU during occupied periods. This represents about _____cfm per occupant.

For reference, under typical conditons the inlet vanes are roughly linear: (60% open = 60% flow, however at 0% open, leakage allows about 25% flow). The OSA dampers are nonlinear: (20% open = 30% flow, 60% open = 80% flow, 90% open = 97% flow).

22. During morning warm-up and night low limit, the outside air dampers are shut.

Unnoccupied Mode / Night *Low* Limit

23. During unnoccupied periods [BAS schedule], the _____ zone temperatures will be monitored. When one or more of these zones is _____F below the unnoccupied heating setpoint (currently _____F [BAS adj] for _____minutes [BAS adj], the associated ASU and a lead boiler will start.

24. The ASU's, boilers and heating coil valves will function as normal to bring all ASU zones to the unnoccupied setpoint, except:

25. The economizer dampers will remain shut and the exhaust fans will remain OFF.

26. Once the poled zones have all met setpoint for _____minutes, the ASU and boilers will shut OFF.

TO BE VERIFIED AND COMPLETED WITH JCI PARAMETERS

Unnoccupied Mode / Night *High* Limit

27. During unnoccupied periods [BAS schedule], the _____ zone temperatures will be monitored. When one or more of these zones is _____F above the unnoccupied cooling setpoint (currently _____F [BAS adj] for _____minutes [BAS adj], the associated ASU will start.

28. The ASU will function as normal to bring all ASU zones to the unnoccupied setpoint, except:

29. The exhaust fans will remain OFF.

30. Once the poled zones have all met setpoint for _____minutes, the ASU will shut OFF.

TO BE COMPLETED WITH JCI PARAMETERS

Exhaust Fan Interlocks

31. Exhaust fan EF-1a and EF-1b shall run when ASU-1 is in the occupied mode of operation.

32. Exhaust fan EF-2 shall run when ASU-2 is in the occupied mode of operation.

33. Exhaust fan EF-3 shall run when ASU-3 is in the occupied mode of operation.

34. Exhaust fans are locked out during warmup and unnoccupied modes.

ASU Shutdowns and Alarms

35. The ASU will shut down from a number of internal faults per the O&M manuals. In addition, there is a dirty filter alarm from the BAS.

    a) Filter. When the differential pressure across the filter bank exceeds _____in. WC, an alarm will be generated in the BAS.

    b) Compressor failure. When there is a failure with a compressor, the BAS will generate an alarm.

36. An individual ASU will also shut down any of the following Emergency Shutdowns from external alarms, each requiring a manual reset at the ASU control panel:
    a. High duct static pressure (Note: The ASU has its own high duct static setpoint as well.)
    b. Supply duct smoke detector
    c. Return duct smoke detector
    d. Emergency shutdown switch (on the BAS ASU controller in the penthouse)

37. Any general fire alarm (space smoke detector, pull station, sprinkler flow) will cause all ASU's to shut down, but on such an alarm the ASU will automatically reset upon the fire alarm panel being reset. (See the Fire Alarm Response Matrix for additional details.)

Interlock With Telecom Room C-104

38. During unnoccupied periods, if the terminal unit 1-43 (TU) thermostat reads the room temperature to be above the unnoccupied TU setpoint (currently 80F [BAS adj], ASU-___ will turn ON and run in Night High Limit Mode until the telecom unnoccupied TU setpoint is met for _____minutes and then the ASU will shut OFF. (Refer to the FCU-2 and ACU-1 sequences for more details.)

39.

Points Monitored by the BAS	Points Adjustable From the BAS
SAT (near the duct smoke detector)	Discharge duct static pressure setpoint
RAT (near the duct smoke detector)	Building static pressure setpoint
Duct static pressure (~2/3 down duct)	SAT setpoint
Building static pressure	
Filter status	
Zone temperature surrogate (located in the return duct)	
Supply fan failure alarm	
Compressor failure alarm	
Inlet vane position command	

40. Terminal Boxes Designated as "Perimeter"[1]

First Floor		Second Floor	
1-1	1-34	2-1	2-35
1-3	1-37	2-2	2-36
1-12	1-38	2-3	2-37
1-20	1-39	2-4	2-44
1-21	1-40	2-10	2-45
1-26	1-41	2-18	2-48
1-27	1-44	2-19	2-50
1-29		2-27	
1-30		2-32	

[1]per earlier addendum from Manfull-Curtis

Further Information

Refer to the following Trane publications for further sequencing and feature details. *Trane Engineering Bulletin*, RT-EB-110, the *Programming Trouble Shooting Guide* and the *Installation Operation Maintenance Manual* in the O&M Manuals.