Addendum e to
ASHRAE Guideline 36-2024

Public Review Draft

Proposed Addendum e to Guideline 36-2024, High-Performance Sequences of Operation for HVAC Systems

First Public Review (July 2026)
(Draft shows Proposed Changes to Current Guideline)

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FOREWORD

Note: In this addendum, changes to the current guideline are indicated in the text by underlining (for additions) and strikethrough (for deletions) unless the instructions specifically mention some other means of indicating the changes. Only these changes are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed substantive changes.

This addendum fixes errors in the equations used for FC #4 and #5 as well as removes redundant text and updates formatting for consistency with the AHU AFDD sections. Also adds clarifications on which fault conditions apply based on FCU configuration.

Addendum e to Guideline 36-2021

(IP and SI Units)

Revise Section 5.22.6 as follows:

5.22.6. Automatic Fault Detection and Diagnostics

Automatic fault detection and diagnostics (AFDD) is a sophisticated system for detecting and diagnosing air-handler faults.

To function correctly, AFDD requires specific sensors and data be available, as detailed in the sequences below. If this information is not available, AFDD tests that do not apply should be deleted.

The AFDD routines for FCUs continually assess FCU performance by comparing the values of BAS inputs and outputs to a subset of potential fault conditions. The subset of potential fault conditions that is assessed at any point depends on the operating state (OS) of the ~~AHU~~FCU, as determined by the position of the cooling and heating valves. Time delays are applied to the evaluation and reporting of fault conditions to suppress false alarms. Fault conditions that pass these filters are reported to the building operator along with a series of possible causes.

These equations assume that the FCU is equipped with hydronic heating and cooling coils. If any of these components are not present, the associated tests and variables should be omitted from the programming.

5.22.6.1. AFDD conditions are evaluated continuously and separately for each operating FCU.

5.22.6.2. The OS of each FCU shall be defined by the commanded positions of the heating-coil control valve and cooling-coil control valve in accordance with Table 5.22.6.2 and Figure 5.22.6.2.

Table 5.22.6.2 FCU Operating States

Operating State	Heating Valve Position	Cooling Valve Position
#1: Heating	> 0	= 0
#2 No Heating or Cooling	= 0	= 0
#3: Cooling	= 0	> 0
#4 Unknown	No other OS applies	

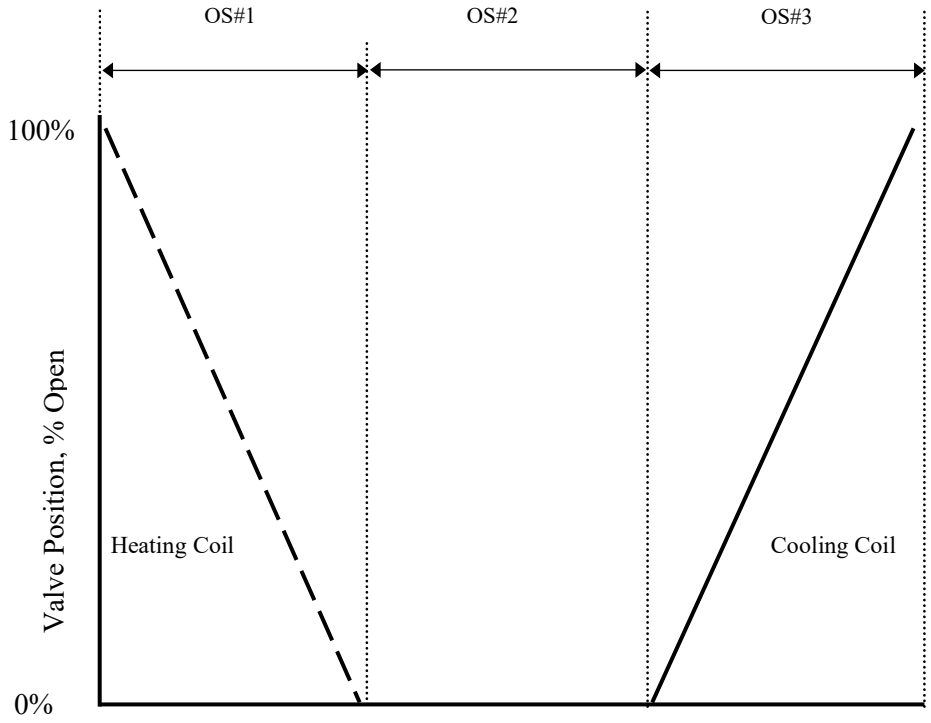

Figure 5.22.6.2~~2~~ FCU operating states.

The OS is distinct from, and should not be confused with, the zone status (cooling, heating, deadband).

OS#1 through OS#3 (see Table 5.22.6.2) represent normal operation during which a fault may nevertheless occur if so determined by the fault condition tests in Section 5.22.6.5~~5.18.13.5~~. By contrast, OS#4 may represent an abnormal or incorrect condition (such as simultaneous heating and cooling) arising from a controller failure or programming error.

~~5.22.6.3. The following points must be available to the AFDD routines for each FCU:~~

~~*For the AFDD routines to be effective, an averaging sensor is recommended for the supply air temperature but it is noted that in most cases a single point sensor will be provided with the FCU.*~~

~~a. SAT = supply air temperature~~

~~b. RAT = return air temperature (if present)~~

~~c. SATsp = supply air temperature setpoint~~

~~d. HC = heating coil valve position command; 0% ≤ HC ≤ 100%~~

~~e. CC = cooling coil valve position command; 0% ≤ CC ≤ 100%~~

~~f. FS = fan speed command; 0% ≤ FS ≤ 100%~~

~~5.22.6.4. The following values must be continuously calculated by the AFDD routines for each FCU:~~

~~a. Five minute rolling averages with 1 minute sampling of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently.~~

~~1. SAT_{avg} = rolling average of supply air temperature~~

~~2. RAT_{avg} = rolling average of return air temperature (if fitted)~~

~~3. ΔOS = number of changes in OS during the previous 60 minutes (moving window)~~

5.22.6.3. For each FCU, the following values must be continuously monitored or determined by the AFDD routines and mapped to the indicated variables, which are used in the fault detection equations that follow.

a. Continuously measure the following points:

1. SATsp = supply air temperature setpoint

2. HC = heating-coil valve position command; 0% ≤ HC ≤ 100%

3. CC = cooling-coil valve position command; 0% ≤ CC ≤ 100%

4. FS = fan-speed command; 0% ≤ FS ≤ 100%

b. Calculate five-minute rolling averages with one-minute sampling time of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently.

1. SAT_{avg} = rolling average of supply air temperature

2. RAT_{avg} = rolling average of return air temperature

c. ΔOS = number of changes in OS during the previous 60 minutes (moving window)

5.22.6.4. The internal variables shown in Table ~~5.22.6.5~~5.22.6.4 shall be defined for each FCU. All parameters are adjustable by the operator, with initial values as given below.

Default values are derived from NISTIR 7365 and have been validated in field trials. They are expected to be appropriate for most circumstances, but individual installations may benefit from tuning to improve sensitivity and reduce false alarms.

The default values have been intentionally biased toward minimizing false alarms, if necessary at the expense of missing real alarms. This avoids excessive false alarms that will erode user confidence and responsiveness. However, if the goal is to achieve the best possible energy performance and system operation, these values should be adjusted based on field measurement and operational experience.

Values for physical factors such as fan heat, duct heat gain, and sensor error can be measured in the field or derived from trend logs. Likewise, the occupancy delay and switch delays can be refined by observing in trend data the time required to achieve quasi steady state operation.

Other factors can be tuned by observing false positives and false negatives (i.e., unreported faults). If transient conditions or noise cause false errors, increase the alarm delay. Likewise, failure to report real faults can be addressed by adjusting the heating coil, cooling coil, temperature, or flow thresholds.

Table 5.22.6.4~~5.22.6.5~~ FCU Internal Variables

Variable Name	Description	Default Value
ΔT_{SF}	Temperature rise across supply fan	0.5°C (1°F)
ε_{SAT}	Temperature error threshold for SAT sensor	1°C (2°F)
ε_{RAT}	Temperature error threshold for RAT sensor	1°C (2°F)

ΔOSmax	Maximum number of changes in Operating State during the previous 60 minutes (moving window)	7
ModeDelay	Time in minutes to suspend Fault Condition evaluation after a change in mode	30
AlarmDelay	Time in minutes that a Fault Condition must persist before triggering an alarm	30
TestModeDelay	Time in minutes that Test Mode is enabled	120

The purpose of TestModeDelay is to ensure that normal fault reporting occurs after the testing and commissioning process is completed as described in Section 5.22.6.10~~5.18.13.11~~.

5.22.6.5. Table ~~5.20.6.6~~ 5.22.6.5 shows potential fault conditions that can be evaluated by the AFDD routines.

a. If the equation statement is TRUE, then the specified fault condition exists. ~~The fault conditions to be evaluated at any given time will depend on the OS of the AHU.~~

b. Only those fault condition equations that apply to the current OS of the AHU shall be evaluated.

The equations in Table ~~5.20.6.6~~5.22.6.5 assume that the SAT sensor is located downstream of the supply fan and the RAT sensor is located upstream of the supply fan. If actual sensor locations differ from these assumptions, it may be necessary to add or delete fan heat correction factors.

Table 5.22.6.5~~5.22.6.6~~ FCU Fault Conditions

FC #1	**Equation**	$\Delta OS > \Delta OS_{MAX}$	**Applies to OS #1 – #4**
	Description	Too many changes in Operating State	
	Possible Diagnosis	Unstable control due to poorly tuned loop or mechanical problem	
FC #2	**Equation**	$SAT_{AVG} < SATSP - \varepsilon_{SAT}$ and $HC \geq 99\%$	**Applies to OS #1 (if heating coil)**
	Description	SAT too low in full heating	
	Possible Diagnosis	SAT sensor error Cooling coil valve leaking or stuck open Heating coil valve stuck closed or actuator failure Fouled or undersized heating coil HW temperature too low, HW DP too low or HW unavailable Gas or electric heat is unavailable DX cooling is stuck on	

FC #3	**Equation**	$SAT_{AVG} > SAT_{SP} + \varepsilon_{SAT}$ and $CC \geq 99\%$	**Applies to OS #3 (if cooling coil)**
	Description	SAT too high in full cooling	
	Possible Diagnosis	SAT sensor error Cooling coil valve stuck closed or actuator failure Fouled or undersized cooling coil CHW temperature too high, CHW DP too low or CHW unavailable DX cooling unavailable Gas or electric heat stuck on Heating coil valve leaking or stuck open	
FC#4	**Equation**	$RAT_{AVG} - SAT_{AVG} \geq \sqrt{\varepsilon_{RAT}^2 + \varepsilon_{SAT}^2} + \Delta T_{SF}$	**Applies to OS #2 (cooling only FCU with RAT)(if cooling coil with RAT)**
	Description	Temperature drop across inactive cooling coil	
	Possible Diagnosis	RAT sensor error SAT sensor error Cooling coil valve stuck open or leaking DX cooling stuck on	
FC#5	**Equation**	$SAT_{AVG} - RAT_{AVG} \leq \sqrt{\varepsilon_{RAT}^2 + \varepsilon_{SAT}^2} + \Delta T_{SF}$	**Applies to OS #2 (heating only FCU with RAT)(if heating coil with RAT)**
	Description	Temperature rise across inactive heating coil	
	Possible Diagnosis	RAT sensor error SAT sensor error Heating coil valve stuck open or leaking Gas or electric heat stuck on	

~~5.22.6.6. A subset of all potential fault conditions is evaluated by the AFDD routines. The set of applicable fault conditions depends on the OS of the FCU.~~

~~a. In OS#1 (Heating), the following fault conditions shall be evaluated:~~

~~1. FC#1: Too many changes in OS~~

~~2. FC#2: SAT too low in full heating~~

~~b. In OS#2 (Deadband), the following fault conditions shall be evaluated:~~

~~1. FC#5: Temperature drop across inactive heating coil (heating only FCU~~

~~2. FC#4: Temperature drop across inactive cooling coil (cooling only FCU~~

~~c. In OS#3 (Cooling), the following fault conditions shall be evaluated:~~

~~1. FC#1: Too many changes in OS~~

~~2. FC#3: SAT too high in full cooling~~

~~d. In OS#4 (other), the following fault conditions shall be evaluated:~~

~~1. FC#1: Too many changes in OS~~

5.22.6.6. For each FCU, the operator shall be able to suppress the alarm for any fault condition.

5.22.6.7. Evaluation of fault conditions shall be suspended under the following conditions:

a. When FCU is not operating

b. For a period of ModeDelay minutes following a change in mode (e.g., from Warmup Mode or Cooldown Mode to Occupied Mode) of any Zone Group served by the FCU.

5.22.6.8. Fault conditions that are not applicable to the current OS shall not be evaluated.

5.22.6.9. A fault condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.

5.22.6.10. Test mode shall temporarily set ModeDelay and AlarmDelay to 0 minutes for a period of TestModeDelay minutes to allow instant testing of the AFDD system and ensure normal fault detection occurs after testing is complete.

5.22.6.11. When a fault condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from Table 5.22.6.5.