

Economizer Fault Detection and Diagnostics (FDD) for Built-Up Air Handlers – Draft Report

Draft Code Language

Last Updated: March 2017

1. INTRODUCTION

The California Statewide Utility Codes and Standards Team actively supports the California Energy Commission in developing revisions to the 2019 California Building Energy Efficiency Standards (Title 24, Part 6). Our joint intent is to achieve significant energy savings through the development of reasonable, responsible, and cost-effective code change proposals for the 2019 Title 24 code change cycle.

The Statewide Utility Team is proposing code change for Economizer Fault Detection and Diagnostics (FDD) for Built-Up Air Handlers.

Economizer fault detection and diagnostics (FDD) enables automatic detection and diagnosis of economizer faults, such as a sensor failure, that can improve economizer operation. The proposed code change would introduce FDD requirements for built-up air handlers greater than 54,000 kBtu/h in capacity. FDD systems can be standalone, such as those on-board many packaged systems, or they can be integrated into a building direct digital control (DDC) system.

This measure seeks to add the above requirements to Title 24, Part 6. Additional language meant to take advantage of California's relatively dry-summer climate and increase the number of waterside economizer hours is also included. A maximum system approach which allows the system to run in full economizer mode at 49°F wet-bulb, compared to the previous requirement of 45°F wet-bulb is proposed.

The Statewide Utility Team is requesting feedback on the draft code language presented in this document. Input we receive will inform the code change proposal that the Statewide Utility Team will be proposing to the California Energy Commission in April 2017.

To provide feedback, please email us at info@title24stakeholders.com or contact the measure lead at:

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For more information about the California Statewide Utility Codes and Standards Team's 2019 Title 24, Part 6 advocacy efforts, and the latest information on this code change proposal please visit: www.title24stakeholders.com.

2. DRAFT CODE LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2016 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

2.1 Standards

SECTION 100.0 – SCOPE

TABLE 100.0-A APPLICATION OF STANDARDS

Occupancies	Application	Mandatory	Prescriptive	Performance	Additions/Alterations
[...]					
Covered Processes	Envelope, Ventilation, <u>Space Conditioning,</u> and Process Loads	110.2, <u>120.2(i),</u> 120.6	140.9	140.1	120.6, 140.9

SECTION 120.2 – REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS

Nonresidential, high-rise residential, and hotel/motel buildings shall comply with the applicable requirements of Sections 120.2(a) through 120.2(k).

- (i) **Economizer Fault Detection and Diagnostics (FDD).** All newly installed ~~air-cooled packaged direct expansion units with an~~ air handlers with a mechanical cooling capacity greater than 54,000 Btu/hr ~~with and~~ an installed air economizer shall include a stand alone or integrated Fault Detection and Diagnostics (FDD) system in accordance with Subsections 120.2(i)1 through 120.2(i)8.
1. The following temperature sensors shall be permanently installed to monitor system operation: outside air, supply air, and when required for differential economizer operation, a return air sensor; and
 2. Temperature sensors shall have an accuracy of $\pm 2^{\circ}\text{F}$ over the range of 40°F to 80°F ; and
 3. The controller shall have the capability of displaying the value of each sensor; and
 4. The controller shall provide system status by indicating the following conditions:
 - A. Free cooling available;
 - B. Economizer enabled
 - C. ~~Compressor-Mechanical cooling~~ enabled;
 - D. Heating enabled, if the system is capable of heating; and
 - E. Mixed air low limit cycle active.
 5. The unit controller shall allow manually initiate initiation of each operating mode so that the operation of ~~compressors-cooling systems,~~ economizers, fans, and heating systems can be independently tested and verified; and

6. Faults shall be reported in one of the following ways:
 - A. Reported to an Energy Management Control System regularly monitored by facility personnel.
 - B. Annunciated locally on one or more zone thermostats, or a device within five (5) feet of zone thermostat(s), clearly visible, at eye level, and meeting the following requirements:
 - i. On the thermostat, device, or an adjacent written sign, display instructions to contact
 - ii. In buildings with multiple tenants, the annunciation shall either be within property management offices or in a common space accessible by the property or building manager.
 - C. Reported to a fault management application which automatically provides notification of the fault to remote HVAC service provider.
7. The FDD system shall detect the following faults:
 - A. Air temperature sensor failure/fault;
 - B. Not economizing when it should;
 - C. Economizing when it should not;
 - D. Damper not modulating; and
 - E. Excess outdoor air.
8. The FDD System shall be certified by the Energy Commission as meeting requirements of Sections 120.2(i)1 through 120.2(i)7 in accordance with Section 110.0 and JA6.3.

2.2 Reference Appendices

JA6.3 Economizer Fault Detection and Diagnostics Certification Submittal Requirements.

Title 24, Part 6, Section 120.2(i) requires that economizer FDD functions be installed on ~~all air-cooled unitary air conditioning systems with an~~ air handlers with a mechanical cooling capacity over 54,000 Btu/hr cooling capacity and an economizer, with the ability to detect the faults specified in Section 120.2(i). Each air conditioning system manufacturer, controls supplier, or FDD supplier wishing to certify that their FDD analytics conform to the FDD requirements of Title 24, Part 6, may do so in a written declaration. This requires that a letter be sent to the California Energy Commission declaring that the FDD conforms to Title 24, Part 6, Section 120.2(i). The declaration at the end of this section shall be used to submit to the California Energy Commission.

NA7.5.12 Automatic Fault Detection and Diagnostics (AFDD) for Air Handling Units and Zone Terminal Units.

NA7.5.12.1 Functional Testing for Air Handling Units

Testing of each AHU with FDD controls shall include the following tests.

- (a) Bypass alarm delays
Step 1: If applicable, bypass alarm delays to ensure that faults generate alarms immediately
- (b) Sensor ~~drift~~/failure:
 - Step 1: Disconnect ~~outside air~~ local supply air temperature sensor from unit controller.
 - Step 2: Verify that the FDD system reports a fault.
 - Step 3: Connect ~~SOAT~~ sensor to the unit controller.
 - Step 4: Verify that FDD indicates normal system operation and clear all faults and alarms.
- (c) ~~Damper/actuator fault~~ Inappropriate economizing:

Step 1: Override the operating state to occupied heating mode.

~~Step 42: From the control system workstation, command override the mixing box economizer dampers to full open (100% outdoor air mode).~~

~~Step 23: Disconnect power to the actuator and Verify that a fault is reported at the control workstation.~~

~~Step 34: Reconnect power to the actuator and command the mixing box dampers to full open Remove all overrides.~~

~~Step 45: Verify that the control system indicates normal system operation and clear all faults and alarms does not report a fault.~~

Step 6: Override the operating state to economizer-only cooling mode.

~~Step 57: From the control system workstation, command override the mixing box economizer dampers to a full closed position (0% outdoor air mode).~~

~~Step 68: Disconnect power to the actuator and Verify that a fault is reported at the control workstation.~~

~~Step 79: Reconnect power to the actuator and command the dampers closed Remove all overrides.~~

~~Step 810: Verify that the control system indicates normal system operation and clear all faults and alarms does not report a fault during normal operation.~~

~~(d) Valve/actuator fault:~~

~~Step 1: From the control system workstation, command the heating and cooling coil valves to full open or closed, then disconnect power to the actuator and verify that a fault is reported at the control workstation.~~

Note that the Statewide CASE Team recommends item (d) Valve/actuator fault be removed from this test and onto a new test. Furthermore, the Statewide CASE recommends that this step be modified in the same way as Step 2 above. Because Step 3 is not directly related to economizers, it is out of the scope of this proposal.

Note that the Statewide CASE Team also recommends that item (e) Steps 1 and 2 also be eliminated due to redundancy with item (d), if item (d) is revised in the same way as item (c). Because item (d), (e)1, and (e)2 are about valves, they are out of the scope of this proposal.

~~(e) Inappropriate simultaneous heating, mechanical cooling, and/or economizing:~~

~~Step 1: From the control system workstation, override the heating coil valve and verify that a fault is reported at the control workstation.~~

~~Step 2: From the control system workstation, override the cooling coil valve and verify that a fault is reported at the control workstation.~~

~~Step 3: From the control system workstation, override the mixing box dampers and verify that a fault is reported at the control workstation.~~

~~(e) Reinstate alarm delay~~

~~Step 1: Reinstate alarm delays to ensure that faults generate alarms as before Step 1, if applicable~~

NA7.5.12.2 Functional Testing for Zone Terminal Units

Note that the Statewide CASE Team recommends NA7.5.12.2 (functional test for zone terminal units) be removed from this test and onto a new acceptance test. Because NA7.5.12.2 is not directly related to economizers, it is out of the scope of this proposal.

2.3 ACM Reference Manual

The Statewide CASE Team proposes that compliance software outputs always show, on the NRCC-MCH-01-E form, that the air handling unit functional test of the NRCA-MCH-13-A form must be used for acceptance testing in built-up systems with air handlers larger than 54 kBtu/h in size with an economizer.

The valve/actuator portion of the air handling unit functional test, and the zone terminal unit functional test, should remain optional compliance credits in NRCA-MCH-13-B. The compliance credits for these portions of the test must be recalculated.

2.4 Compliance Manuals

Chapter 4, Section 4.5.1.8, of the Nonresidential Compliance Manual will need to be revised according to the changes to the standard. Example 4-38 and Table 4-23 will also need to be revised accordingly. In addition to changes reflecting the Standards, the Statewide CASE Team proposes adding the following language at the end of Section 4.5.1.8:

For air handlers controlled by DDC, sequences of operations (SOO) must be developed to adhere with the requirements of 120.2(i)1 through 7.

ASHRAE Guideline 36-2017 is one good reference for developing SOO specifically for the faults listed in 120.2(7). To properly adhere to Guideline 36, all SOO design elements in sections 5.N.14 and/or sections 5.P.11 must be implemented, including defining operating states, the use an alarm delay, and the installation of an averaging mixed air temperature (MAT) sensor. If a designer wishes to use Guideline 36 to detect the required economizer faults in Title 24 section 120.2(i)7, SOO should include Guideline 36 Fault Conditions #2, 3, and 5 through 13 at a minimum. Other Title 24 FDD requirements in Section 120.2(i) and acceptance tests are not met by including these fault conditions into SOO.

Due to the proposed changes to the Automatic Fault Detection and Diagnostics (AFDD) for Air Handling Units and Zone Terminal Units acceptance test, Chapter 13 Acceptance Tests will also need to be revised according to proposals in Section 2.5 below.

2.5 Compliance Forms

The existing acceptance form for NRCA-MCH-13-A, Automatic Fault Detection and Diagnostics (AFDD) for Air Handling Units and Zone Terminal Units, are revised according to proposed changes in 2.2. Several parts of this test are recommended to be moved to NRCA-MCH-13-B.

B. Functional Testing for Air Handling Units	Results
Testing of each AHU with FDD controls shall include the following tests:	
Step 1: Bypass alarm delays	
a. <u>If applicable, bypass alarm delays to ensure that faults generate alarms immediately</u>	Yes/No
Step 12: Sensor drift/failure	
a. Disconnect <u>outside air local supply air</u> temperature sensor from unit controller.	Yes/No
b. Verify that the FDD system reports a fault.	Yes/No
c. Connect <u>SOAT</u> sensor to the unit controller.	Yes/No
d. Verify that FDD indicates normal system operation <u>and clear all faults and alarms.</u>	Yes/No

Step 23: Damper/actuator fault-Inappropriate economizing	
a. Override the operating state to occupied heating mode.	<u>Yes/No</u>
ab. From the control system workstation, command override the mixing-box-economizer dampers to full-open (100% outdoor air mode).	Yes/No
bc. Disconnect power to the actuator and Verify that a fault is reported at the control workstation.	Yes/No
ed. Reconnect power to the actuator and command the mixing-box dampers to full open Remove all overrides.	Yes/No
de. Verify that the control system indicates normal system operation and clear all faults and alarms does not report a fault.	Yes/No
f. Override the operating state to economizer-only cooling mode.	<u>Yes/No</u>
eg. From the control system workstation, command override the mixing-box-economizer dampers to a full-closed position (0% outdoor air mode).	Yes/No
fh. Disconnect power to the actuator and Verify that a fault is reported at the control workstation.	Yes/No
gi. Reconnect power to the actuator and command the dampers closed Remove all overrides.	Yes/No
hj. Verify that the control system indicates normal system operation and clear all faults and alarms does not report a fault during normal operation.	Yes/No

Step 3: Valve/actuator fault	
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Note that the Statewide CASE Team recommends Step 3 (valve/actuator faults) be removed from this test and onto a new NRCA-MCH-13-B compliance form. Furthermore, the Statewide CASE recommends that this step be modified in the same way as Step 2 above. Because Step 3 is not directly related to economizers, it is out of the scope of this proposal.

Step 4: Inappropriate simultaneous heating, mechanical cooling, and/or economizing	
a. From the control system workstation, override the heating coil valve and verify that a fault is reported at the control workstation.	Yes/No
b. From the control system workstation, override the cooling coil valve and verify that a fault is reported at the control workstation.	Yes/No
c. From the control system workstation, override the mixing-box dampers and verify that a fault is reported at the control workstation.	Yes/No

Note that the Statewide CASE Team recommends that Steps 4a and 4b. also be eliminated due to redundancy with Step 3, if Step 3 is revised in the same way as Step 2. Because Steps 3, 4a, and 4b are about valves, they are out of the scope of this proposal.

Step 4: Reinstate alarm delay	
a. Reinstate alarm delays to ensure that faults generate alarms as before Step 1, if applicable	<u>Yes/No</u>

C. Functional Testing for Zone Terminal Units	
Testing of each AHU with FDD controls shall include the following tests:	Results

Note that the Statewide CASE Team recommends Part C (functional test for zone terminal units) be removed from this test and onto a new NRCA-MCH-13-B compliance form. Because Part C is not directly related to economizers, it is out of the