CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Second Stakeholder Meeting for Nonresidential HVAC

Economizer Fault Detection & Diagnostics (FDD) for Built-Up Air Handlers

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Farhad Farahmand
TRC Energy Services
Ffarahmand@trcsolutions.com

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Compliance and Enforcement Barriers – CEC Certification

- Joint Appendix JA6.3 requires submittal of evidence for CEC Certification
  - "Manufacturer instructions"
  - Sensor specifications
  - Test procedure and alarm responses
- Market actors that could submit for CEC Certification
  - ~~Mechanical designer SOO~~
  - Controls contractor SOO
    - L&H AirCo certified an Alerton product
  - DDC manufacturer pre-configured FDD modules
    - Many have expressed interest and capability to develop
    - Flexible to allow integration with a variety of systems
    - But not too flexible to avoid improper setup
  - 3rd party FDD vendors perhaps using in-field setup

Compliance and Enforcement Barriers – Acceptance Test

- NRCA-MCH-13-A: Automatic Fault Detection and Diagnostics for Air Handling Units and Zone Terminal Units
  - Currently a compliance credit
  - Includes functional test for economizer FDD, coil valves, and zone terminal unit FDD
- Functional test for economizer FDD on NRCA-MCH-13-A would become mandatory (with revisions)
  - Anticipated about 1 hour per AHU
- Other functional tests would remain compliance credit under new form NRCA-MCH-13-B

Cost Details

The Statewide CASE Team collected costs for adding RAT and MAT sensors to the air handler primarily from two sources: mechanical designers and controls contractors. Mechanical designers provided a rule-of-thumb meant to represent the cost of an additional control point, summarized below in Table 15. Designers also noted that MATs and RATs are more often installed in built-up air handlers, if not for control then for monitoring and trending. Nonetheless, the CASE Team conservatively assumed that RATs and MATs represented entirely additional control points.

Table 15: Mechanical Designer Costs Per Additional Control Point

Designer	Minimum of Range	Maximum of Range	Average
#1	$1,000	$2,000	$1,500
#2	$500	$2,000	$1,250
#3	$1,000	$1,500	$1,250
Average Cost			$1,333

Based on Table 15, the average cost for adding two control points (the RAT and MAT) would be $2,666 per air handler, or $34,658 for the thirteen air handlers in the large office prototype. The Statewide CASE Team also spoke with two controls contractors to attain itemized costs for adding the two control points, summarized in Table 16. Costs include all markups.

Table 16: Current Incremental Construction Cost for Economizer FDD in Built-Up Systems

		Control Contractor #1			Control Contractor #2		
Row	Cost Component	Number of Units Per Air Handler	Cost Per Unit	Cost Per Air Handler	Number of Units Per Air Handler	Cost Per Unit	Cost Per Air Handler
A	Averaging MAT Sensor	4	$238	$952	4	$170	$680
B	RAT Sensor	1	$78	$78	1	$50	$50
C	Upsized Controller	1	$700	$700	1	$350	$350
D	Control and Electrical Contractor Installation and Wiring (Hours and Materials)	5	$105	$525	-	-	$1,150
E	Control Contractor Implementation, Startup, and Testing (Hours)	1	$75	$75	4	$125	$500
F	**Total Cost Per Air Handler (A+B+C+D+E)**			$2,355			$2,730
G	**Total Cost for 13 Air Handlers (F x 13)**			**$30,610**			**$35,490**
H	**Average Cost for RAT, MAT, and FDD SOO**			**$33,050**			

Based on Table 16, the average cost for adding the RAT and MAT and programming the FDD SOO would be $33,050. The overall average of the mechanical design estimate and the control contractor cost estimates for implementing the necessary sensors and controls to complete economizer FDD is $33,854, or $2,604 per air handler.

Proposed Code Change Language - Standards

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 ±2°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 manual~~ly 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

Proposed Code Change Language – Acceptance Test

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. If applicable, bypass alarm delays to ensure that faults generate alarms immediately	Yes/No
Step ~~1~~2: Sensor ~~drift/~~failure	
a. Disconnect ~~outside air~~ local supply air temperature sensor from unit controller.	Yes/No
b. Verify that the FDD system reports a fault.	Yes/No
c. Connect S~~O~~AT sensor to the unit controller.	Yes/No
d. Verify that FDD indicates normal system operation and clear all faults and alarms.	Yes/No
Step ~~2~~3: ~~Damper/actuator fault~~ Inappropriate economizing	
a. Override the operating state to occupied heating mode.	Yes/No
~~a~~b. From the control system workstation, ~~command~~ override the ~~mixing box~~ economizer dampers to ~~full open (~~100% outdoor air mode~~)~~.	Yes/No
~~b~~c. ~~Disconnect power to the actuator and~~ Verify that a fault is reported at the control workstation.	Yes/No
~~c~~d. ~~Reconnect power to the actuator and command the mixing box dampers to full open~~ Remove all overrides.	Yes/No
~~d~~e. 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.	Yes/No
~~e~~g. From the control system workstation, ~~command~~ override the ~~mixing box~~ economizer dampers to ~~a full closed position (~~0% outdoor air mode~~)~~.	Yes/No
~~f~~h. ~~Disconnect power to the actuator and~~ Verify that a fault is reported at the control workstation.	Yes/No
~~g~~i. ~~Reconnect power to the actuator and command the dampers closed~~ Remove all overrides.	Yes/No
~~h~~j. 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

Proposed Code Change Language

~~Step 3: Valve/actuator fault~~	

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	Yes/No

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

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 scope of this proposal.