Title 24-2013 Language and Explanation of the Mandatory HVAC FDD Requirement

The initial PIER FDD project goal was to develop and submit an FDD prescriptive measure to Title 24. At the same time, a parallel project with a similar goal was initiated by the utilities Codes and Standards Enhancement (CASE) program. The PIER and CASE research teams joined forces to fully collaborate all the way through the Title 24 measure development process. Based on final negotiations carried out through a working group of the Western HVAC Performance Alliance (WHPA) Subcommittee on In-field/Onboard FDD consisting of PIER project personnel, HVAC manufacturer representatives, California engineering consultants, an FDD tool developer, and utility representatives, mandatory measure was submitted and subsequently approved by the CEC in May 2012. Field compliance acceptance test requirements are in development along with workforce education and training materials, and an HVAC manufacturer option to pre-certify with the CEC to meet compliance objectives, entire equipment lines with the required FDD capabilities.

From California 2013 BUILDING ENERGY EFFICIENCY STANDARDS Title 24, Part 6

SECTION 122120.2 – REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS

(i) **Economizer Fault Detection and Diagnostics (FDD).** All newly installed air-cooled unitary direct-expansion units, equipped with an economizer and with mechanical cooling capacity at AHRI conditions of greater than or equal to 54,000 Btu/hr, and equipped with an economizer, shall include a Fault Detection and Diagnostics (FDD) system in accordance with subsections 120.2(i)21 through 120.2(i)9. Air-cooled unitary direct expansion units include packaged, split-systems, heat pumps, and variable refrigerant flow (VRF), where the VRF capacity is defined by that of the condensing unit.

1. The following temperature sensors shall be permanently installed to monitor system operation: outside air, supply air, and return air; and
2. Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F; and
3. Refrigerant pressure sensors, if used, shall have an accuracy of ±3 percent of full scale; and
4. The controller shall have the capability of displaying the value of each sensor; and
5. The controller shall provide system status by indicating the following conditions:
    A. Free cooling available
    B. Economizer enabled
    C. Compressor enabled
    D. Heating enabled
    E. Mixed air low limit cycle active
6. The unit controller shall manually initiate each operating mode so that the operation of compressors, economizers, fans, and heating system can be independently tested and verified; and
7. Faults shall be reported to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats; and

8. 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
E. Excess outdoor air

9. The FDD System shall be certified by the Energy Commission as meeting requirements 120.2(i)1 through 120.2(i)8 in accordance with Section 100(h). Certification Requirements for Manufactured Equipment, Products, and Devices: that is, the FDD system shall be certified by the manufacturer in a declaration, executed under penalty of perjury under the laws of the State of California, that all the information provided pursuant to the certification is true, complete, accurate and in compliance with all applicable provisions of Part 6.

Fault Descriptions and Explanation

The fault conditions listed above are described in more detail:

A. *Air temperature sensor failure/fault.* This failure mode is a malfunctioning air temperature sensor, such as the outside air, discharge air, or return air temperature sensor. This could include mis-calibration, complete failure either through damage to the sensor or its wiring, or failure due to disconnected wiring. Reporting of sensors faults is found in many RTUs today.
B. *Not economizing when it should.* In this case, the economizer should be enabled, but for some reason it is not providing free cooling. This leads to an unnecessary increase in mechanical cooling energy. Two examples are the economizer high limit setpoint is too low, say 55degF, or the economizer is stuck closed.
C. *Economizing when it should not*. This is opposite to the previous case of not economizing when it should. In this case, conditions are such that the economizer should be at minimum ventilation position but for some reason it is open beyond the correct position. This leads to an unnecessary increase in heating and cooling energy. Two examples are the economizer high limit setpoint is too high, say 80degF, or the economizer is stuck open.
D. *Damper not modulating.* This issue represents a stuck, disconnected, or otherwise inoperable damper that does not modulate open and closed. It is a combination of the previous two faults: not economizing when it should and economizing when it should not.
E. *Excess outdoor air.* This failure mode is the economizer provides an excessive level of ventilation, usually much higher than is needed for design minimum ventilation. It causes an energy penalty during periods when the economizer should not be enabled, that is, during cooling mode when outdoor conditions are higher than the economizer high limit setpoint. During heating mode, excess outdoor air will increase heating energy.

A key component of the Title 24 measure is that the notice of a given fault at the RTU be delivered remotely from the RTU to operating or service personnel or to specific zone

thermostat in the building that is tied to the RTU. Performance degradation faults are more prevalent than catastrophic faults that can shut down a unit entirely. It is therefore important to provide notice as soon as possible so they are not unnoticed until scheduled maintenance. The method of signaling the fault directly from the rooftop unit is not prescribed in the measure. HVAC manufacturers are free to choose an appropriate option.

2013 Nonresidential Reference Appendices

NA7.5.11 Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units

NA7.5.11.1 Construction Inspection

Prior to Functional Testing, verify and document the following:

- Verify fault detection and diagnostics (FDD) hardware is installed on HVAC unit.
- Verify the FDD system matches the make and model reported on the design drawings.
- Verify the following air temperature sensors are permanently installed:
    - outside air
    - supply air
    - return air
- Verify the controller has the capability of displaying the value of the following parameters:
    - Air temperatures: outside air, supply air, return air.
    - Refrigerant pressure and temperature sensors (if present, their output shall be made available)
- Verify the controller provides system status by indicating the following conditions:
    - Free cooling available
    - Economizer enabled
    - Compressor enabled
    - Heating enabled
    - Mixed air low limit cycle active

NA7.5.11.2 Functional Testing

For each HVAC unit to be tested, complete the following:

NA7.5.11.2.1 Functional Testing for Air Temperature Sensor Failure/Fault

Step 1: Verify the FDD system indicates normal operation.

Step 2: Disconnect outside air temperature sensor from unit controller. Verify and document the following:

- FDD system reports a fault.

Step 3: Connect outside air temperature sensor to unit controller. Verify and document the following:

- FDD system indicates normal operation.

NA7.5.11.2.2 Functional Testing for Excess Outside Air

Step 1: Coordinate this test with NA7.5.1 Outdoor Air

- If NA7.5.1 Outdoor Air passes, verify FDD system indicates normal operation.

NA7.5.11.2.3 Functional Testing for Economizer Operation

Step 1: Interfere with normal unit operation so test NA7.5.4 Air Economizer Controls fails by immobilizing the outdoor air economizer damper according to manufacturer's instructions

- After NA7.5.4 Air Economizer Controls fails, verify FDD system reports a fault.

A. Free cooling available
B. Economizer enabled
C. Compressor enabled
D. Heating enabled
E. Mixed air low limit cycle active

NA7.5.11.2.4 Functional Testing for Refrigerant Diagnostic Sensors

Step 1: During normal cooling operation, record refrigerant temperatures and pressures, and saturated discharge temperature and saturated suction temperature, if displayed by the unit controller.

Step 2: During same operating conditions as Step 1, install calibrated refrigerant gauge with an accuracy of plus or minus 3% shall be used to determine and record saturated discharge temperature and saturated suction temperatures. If either temperature determined is more than 5 F different than recorded in Step 1, test has failed. Otherwise, test passes.

- Refrigeration gauges shall be calibrated according to the manufacturer's calibration procedure to conform to the accuracy requirement specified. All testers performing diagnostic tests shall obtain evidence from the manufacturer that the equipment meets the accuracy specifications. The evidence shall include equipment model, serial number, the name and signature of the person of the test laboratory verifying the accuracy, and the instrument accuracy. All diagnostic testing equipment is subject to re-calibration when the period of the manufacturer's guaranteed accuracy expires.