BSR/ASHRAE Standard 207P

Advisory Public Review Draft

Laboratory Method of Test of Fault Detection and Diagnostics for Airside Economizers

Advisory Public Review (August 2018)
(Draft Shows Complete Proposed New Guideline)

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FOREWORD

This standard is needed to assist users of HVAC air-side economizers with Fault Detection and Diagnostics (FDD) to verify the specification of FDD capabilities by the manufacturer of the air-side economizers or third-party providers of the FDD.

It is intended that future standards or future versions of this standard will include tests of FDD for additional faults and/or system types (particularly for air flow and refrigeration faults).

This standard, which will be used by members of the HVAC industry, is a physical laboratory test method to verify a specification that an FDD system will annunciate true faults and will not annunciate false faults for the air-side economizer system to which it is applied.

The intended users are HVAC test laboratories on behalf of the end users of HVAC equipment.

It is critical to understand that this Standard does ***not*** *prescribe what faults should be detected by an FDD system, the fault detection performance an FDD system should have, nor how an FDD system should accomplish its detections. It is the responsibility of other parties (for example, a third-party evaluating compliance with building codes, an engineer creating a design specification, an efficiency program manager, an authoring body for equipment standards, or a manufacturer) to use the language of this Standard to specify the performance of the FDD. The format and contents required for these specifications are, however, defined in this Standard, and the standard specifies a method of test for determining the actual performance of the FDD to enable comparison with and verification of the performance specification for the FDD or requirements on them.*

Note that any communication that implies successful testing per Standard 207 shall specify which particular tests were completed successfully. No communications shall imply successful testing per Standard 207 in its entirety.

1. PURPOSE

The purpose of this standard is to provide methods for laboratory testing of fault detection and diagnostic (FDD) systems to determine whether they perform as specified.

2. SCOPE

This standard applies to the FDD systems that are intended to detect or diagnose faults that affect the performance of the air-side economizers of air conditioning equipment.

This standard defines laboratory tests for four categories of economizer faults: communication, sensor, damper/actuator and outdoor air quantity.

This standard only applies to those FDD systems designed to detect or diagnose faults by evaluating instantaneous or short-term conditions and parameters.

3. DEFINITIONS

actuator: device, either electrically, pneumatically, or hydraulically operated, that acts as a motor to change the position of movable devices such as valves or dampers.

air-handling unit: assembly consisting of sections containing a fan or fans and other necessary equipment to perform one or more of the following functions: circulating, filtration, heating, cooling, heat recovery, humidifying, dehumidifying, and mixing of air. It is usually connected to an air-distribution system.

air-side economizer: duct-and-dampers arrangement with an automatic control system that together allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather.

alarm: signal, either audible or visual, or both, that alerts an operator to an off-normal condition which requires some form of corrective action.

analog sensor: a sensor with a continuously variable output used to represent another (e.g., in temperature or enthalpy measurement, an electric voltage or current output represents temperature input).

compressor: 1. device for mechanically increasing the pressure of a gas. 2. specific machine, with or without accessories, for compressing refrigerant vapor.

damper: element inserted into an air-distribution system or element of an air-distribution system permitting modification of the air resistance of the system and consequently changing the airflow rate or shutting off the airflow.

damper actuator: device that provides the necessary force to position a damper.

digital sensor: sensor where controlled and monitored analog or binary data (e.g., temperature, contact closures) are converted and sent to a controller in digital format for manipulation and calculations by the digital controller.

economizer: in this standard, the term “economizer” refers to an *air-side economizer*. See air-side economizer.

economizing not operational: system that is not making use of free cooling and all cooling is being supplied by mechanical air conditioning.

excess outdoor air: air flow that exceeds the design minimum.

false alarm: a scenario in which a fault is detected, but no significant fault is actually present.

fault: a state of the system or equipment that causes a degradation in performance.

fault detection: detection and reporting of a fault, without specification of the type or severity of the fault.

fault detection and diagnosis (FDD): the process of determining whether the monitored system deviates from normal operation and isolating the detected fault(s) from other possible faults.

fault free unit: air conditioning unit that has been verified to have no faults.

free cooling: cool outdoor air used to reduce the need for mechanical air conditioning.

insufficient outdoor air: air flow below the design minimum.

minimum outdoor air: the minimum amount of outdoor air required for the purpose of controlling air contaminants levels in buildings.

outdoor air: (1) air outside a building or taken from the external atmosphere and, therefore, not previously circulated through the system. (2) the air stream entering an HVAC unit through the outdoor air dampers, simulating outdoor air conditions.

packaged air conditioner: also known as self-contained unit, complete air-conditioning unit, including refrigeration compressor, cooling coils, fans, filters, automatic controls, etc., assembled into one casing.

packaged heat pump: a packaged air conditioner capable of using the refrigerating system in a reverse cycle or heat pump mode to provide heat.

performance specification: a document that defines the capabilities of an FDD system. This forms the basis for a test plan and test report.

return air: (1) air removed from a space to be recirculated or exhausted. Air extracted from a space and totally or partially returned to an air conditioner, furnace, or other heating, cooling, or ventilating system. (2) the air stream entering an HVAC unit through the return air dampers, simulating return air conditions.

sensor: device or instrument designed to detect and measure a variable.

short, or high signal: condition in which any electrical circuit is sending a high signal due to short circuit or other causes.

short cycling: excessive frequency of starting and stopping in an operating system.

specifier: for the purposes of this Standard, the specifier can be anyone who specifies the performance of an FDD system to be verified in lab tests.

supply fan: the fan that supplies air to the conditioned space for the purposes of ventilation and comfort conditioning.

test code: a unique identifier to define which specific Standard 207 test procedure is to be or was carried out.

test plan: a document that describes how FDD system testing is to be conducted. It embodies the technical requirements of this standards.

test report: a document that describes the results of testing per the requirements of this standard, and documents whether or not the FDD system met the performance specification.

4. METHODS OF TEST

4.1 Approach

The general approach is:

- Define select capabilities of an FDD system, in the form of a Performance Specification,
- identify which of the standardized tests are applicable to be performed,
- create a Test Plan that defines each applicable test and the criteria for a successful test,
- perform laboratory tests, and

- document the outcome of each test in a Test Report.

4.2 Required Tests.

Laboratory tests shall be performed to simulate a fault with a given severity. The FDD system response to that fault will be documented accordingly. The results of the tests shall be provided on a test form that conforms to the requirements in Section 5.2.

For each fault identified in the Performance Specification, the following tests shall be conducted and documented:

- Fault test: Test the system at the fault conditions, and confirm that an alarm is generated.
- No-fault test: Test the system at the no-fault conditions and confirm that no alarm is generated.

4.3 Apparatus and Measurement Accuracy

Tests shall be done in a laboratory with instrumentation that conforms to the tolerances stated in ASHRAE Standard 41.1 and 41.6 (all temperature measurements shall have an accuracy of +/- 2 degF). The FDD system shall be installed on a single zone HVAC unit with a single-speed fan (a packaged air conditioner, packaged heat pump, or air-handling unit) conforming to the manufacturer's instructions. Tests are to be performed on a fault free unit for baseline.

5. APPLICATION OF TESTING

5.1 Specification of FDD Performance

The specifier shall provide in a Performance Specification the information listed in the second column in Table 1 to indicate what faults shall be detected and the parameters of the testing. The required elements include:

- ***Specify units***: The specifier may allow results from testing of an individual model of HVAC system to represent the performance of a broader range of units. The specifier indicates their rules for allowing such representation in the Performance Specification.
- ***Test specifics recorded***: The specifier can specify what test specifics shall be recorded during testing, such as any requirements for third-party testing; time, date, and location of testing; and names of individuals conducting tests, certifying results, or witnessing the testing.
- ***Test conditions***: The specifier can define conditions required for testing. These may differ for different tests.
- ***Description of how tests were performed:*** The specifier may have their own requirements for how tests are to be performed (above and beyond the requirements of this Standard). These requirements shall be noted in the Test Plan.
- ***Measured operating conditions or parameters:*** The specifier indicates what operating conditions or parameters shall be measured.
- ***Coincident faults present during tests:*** Specifiers may have requirements for the presence of other faults during testing of the specified fault. The specific coincident faults and their required intensities shall be noted in the Performance Specification.

Note that some of the contents of Table 1 may be provided in codes or regulations to which the FDD system must comply, rather than from manufacturer specifications. Informative Annex A provides an example format for recording this information, but any format that provides this same information is allowed.

5.2 Development of a Test Plan

A Test Plan document shall be developed to describe how FDD system testing is to be conducted. It is based on the items listed in the Performance Specification and embodies the detailed test procedures provided in Section 6 below.

5.3 Documentation of Results of Performance Testing

For each test performed, the results shall be documented by recording in a Test Report all the information listed in the third column in Table 1 below. The required elements include:

- ***Specify units***: The make, model, size, and serial number of the actual unit tested, along with any features.
- ***Test specifics recorded***: Actual test specifics, as noted in the Performance Specification, such as third-party testing; time, date, and location of testing; and names of individuals conducting tests, certifying results, or witnessing the testing.
- ***Test conditions***: The actual conditions under which the unit was tested.
- ***Description of how tests were performed:*** A description of how the tests were actually performed.
- ***Measured operating conditions or parameters:*** Measurements taken and parameters set during the testing.
- ***Coincident faults present during tests:*** Any coincident faults and their measured or observed intensities.
- ***Confirmation that an alarm was generated during Fault Test:*** Note whether or not an alarm was generated, and state which alarm it was.
- ***Confirmation that NO alarm was generated during No Fault Test:*** Note whether or not an alarm was generated.

Informative Annex B provides an example format for recording this information, but any format that provides this same information is allowed.

Note that any communication that implies successful testing per Standard 207 shall specify which of the particular tests were completed successfully (Test Code). No communications shall imply successful testing per Standard 207 in its entirety.

6. DETAILED TEST PROCEDURES

Methods for testing of particular faults are described in this Section. Each subsection identifies an area of the economizer system or an operating mode that is to be tested. Each of these subsections consists of a number of individual tests, each with a unique "test code." This code shall be used consistently in the Performance Specification, Test Plan, and Test Report. It shall also be used in specifying the particular tests that the FDD system has passed.

Each test procedure below describes both "fault" and "no-fault" conditions. In order to pass a specific test, then, an FDD system must be witnessed to generate an alarm when at the fault conditions, and to generate NO alarm when at the no-fault conditions.

Table 1: Information that shall be included in specification of FDD Performance and recorded in Test Result Report

FACTOR	INCLUDE IN SPECIFICATION	INCLUDE IN RESULTS
Test code	Test Code	Test Code
Specify units	Rules for allowing a single model to represent a range of units.	Actual unit tested (make, model, size, serial number)
Test specifics recorded	List of test specifics to be recorded (such as requirements for third-party testing, time, date, location, and names of tester, certifier, witnesses)	Record of test specifics (such as third-party testing, time, date, location, and names of tester, certifier, witnesses)
Test conditions	Test conditions required for testing	Measured test conditions
Description of how tests are performed	Description of factors to be included in Test Plan	Notes on how test was actually performed
Measured operating conditions or parameters	List of operating conditions or parameters to be measured	Measurements of operating conditions or parameters
Coincident faults present during tests	List of coincident faults to be included in Test Plan (fault and fault intensity)	Notes on actual coincident faults present during test, with measurements (fault and fault intensity)
Confirmation: Alarm generated during Fault Test	N/A	Confirm that an alarm was generated during Fault Test, state which alarm
Confirmation: No alarm generated during No Fault Test	N/A	Confirm that no alarm was generated during No Fault Test

6.1 Baseline Setting Procedures

Before testing, verify the alarms to be tested are included in the current firmware version of the FDD system you are testing. Ensure that the controller and the unit are properly commissioned and installed per the manufacturer's literature. Confirm there are no alarms indicated by the economizer and that all sensor readings are within their specified tolerances. At the start of each test the unit must be in the fault free condition and when the test is complete the unit must be returned to the fault free condition prior to performing next test.

6.2 No Sensor Communication Test Procedures

Make a list of all sensors in the system and determine from the list below select the test for the sensor type.

<u>No Sensor Communication Test: Digital Communicating Sensors</u>

Test Code: ECON-SENSCOM-DG
Fault Conditions: Disconnect communication wire(s) between sensor and controller.
No-Fault Conditions: Reconnect communication wire(s) between sensor and controller.

<u>No Sensor Communication Test: Wireless Sensors</u>

Test Code: ECON-SENSCOM-WL
Fault Conditions: Remove power from sensor.

No-Fault Conditions: Replace power from sensor.

No Sensor Communication Test: Analog Sensors

Test Code: ECON-SENSCOM-AN
Fault Conditions: Disconnect wire(s) between sensor and controller.
No-Fault Conditions: Reconnect wire(s) between sensor and controller.

No Sensor Communication Test: Open or No Signal

Test Code: ECON-SENSCOM-OPNSG
Fault Conditions: Disconnect control signal wire between sensor and controller.
No-Fault Conditions: Reconnect control signal wire between sensor and controller.

No Sensor Communication Test: Short or High Signal

Test Code: ECON-SENSCOM-SHORT
Fault Conditions: Disconnect control signal wire between sensor and controller. Connect a precision current or voltage source to the signal wire entering the controller. Apply a current or voltage greater than the highest normal signal specified by sensor manufacturer.
No-Fault Conditions: Disconnect the precision current or voltage source to the signal wire entering the controller. Reconnect the control signal wire between sensor.

6.3 No Actuator Communication Test Procedures

Make a list of all actuators in the system and determine from the list below select the test for the sensor type.

No Actuator Communication Test: Digital Communicating

Test Code: ECON-ACTUCOM-DG
Fault Conditions: Disconnect communication wire(s) between actuator and controller.
No-Fault Conditions: Reconnect communication wire(s) between actuator and controller.

No Actuator Communication Test: Wireless Actuators

Test Code: ECON-ACTUCOM-WL
Fault Conditions: Remove power from actuator.
No-Fault Conditions: Replace power from actuator.

No Actuator Communication Test: Analog

Test Code: ECON-ACTUCOM-AN
Fault Conditions: Disconnect wire(s) between actuator and controller.
No-Fault Conditions: Reconnect wire(s) between actuator and controller.

No Actuator Communication Test: Open or No Signal

Test Code: ECON-ACTUCOM-OPNSG
Fault Conditions: Disconnect control signal wire between actuator and controller.
No-Fault Conditions: Reconnect control signal wire between actuator and controller.

No Actuator Communication Test: Short or High Signal

Test Code:	ECON-ACTUCOM-SHORT
Fault Conditions:	Disconnect control signal wire between actuator and controller. Connect a precision current or voltage source to the signal wire entering the controller. Apply a current or voltage greater than the highest normal signal specified by actuator manufacturer.
No-Fault Conditions:	Disconnect the precision current or voltage source to the signal wire entering the controller. Reconnect the control signal wire between actuator and controller.

6.4 Unresponsive Damper / Actuator Test Procedures

Make a list of all dampers in the system and determine from the list below select the test for the sensor type.

Unresponsive Damper/Actuator Test: Actuator Unresponsive

Test Code:	ECON-UNRESP-ACTU
Fault Conditions:	Set to 0%. Disconnect actuator wire from controller or disconnect power from actuator. Configure economizer system to send control signal to the actuator to 50% of full control signal range.
No-Fault Conditions:	Reconnect actuator wire to controller or reconnect power to actuator. Clear all active alarms on FDD system. Apply control signal to the actuator to 50% of full control signal range.

Unresponsive Damper/Actuator Test: Damper Unresponsive, Actuator Responsive

Test Code:	ECON-UNRESP-DMPR
Fault Conditions:	Disconnect actuator from damper assembly. Command actuator to position specified by the test condition.
No-Fault Conditions:	Reconnect the actuator to the damper assembly. Command actuator to position specified by the test condition. Damper should move in response to actuator movement.

6.5 Inappropriate Damper Position Test Procedures

For each of the tests in this section, disable Demand Ventilation. Adjust outdoor air temperature to a point in the specified range. Adjust outdoor air relative humidity between 40 and 60% RH. Manually position the outdoor air economizer damper to a point in the range specified for the Fault or No-Fault tests (percent outdoor air, by volume. Either initiate a call for cooling or ensure that there is NO call for cooling, as specified. Adjust return air temperature to at least 10 °F above outdoor air temperature. Confirm whether or not an alarm was generated.

High Temperature Test: Excess Outdoor Air

Test Code:	ECON-HIGH-EXSOA	
	Outdoor Air Temperature:	85-100 °F
	Initiate Call for Cooling.	
Fault Conditions:	Economizer Damper Position:	>50% OA
No-Fault Conditions:	Economizer Damper Position:	<20% OA

High Temperature Test: Insufficient Outdoor Air

Test Code:	ECON-HIGH-LOWOA	
	Outdoor Air Temperature:	85-100° F
	Initiate Call for Cooling.	
Fault Conditions:	Economizer Damper Position:	<5% OA
No-Fault Conditions:	Economizer Damper Position:	>50% OA

Moderate Temperature Test: Economizing Not Operational

Test Code:	ECON-MOD-NOECON	
	Outdoor Air Temperature:	60-70 °F
	Initiate Call for Cooling.	
Fault Conditions:	Economizer Damper Position:	<40% OA
No-Fault Conditions:	Economizer Damper Position:	>70% OA

Moderate Temperature Test: Insufficient Outdoor Air

Test Code:	ECON-MOD-LOWOA	
	Outdoor Air Temperature:	60-70 °F
	Initiate Call for Cooling.	
Fault Conditions:	Economizer Damper Position:	<5% OA
No-Fault Conditions:	Economizer Damper Position:	>50% OA

Low Temperature Test: Economizing Not Operational

Test Code:	ECON-LOW-NOECON	
	Outdoor Air Temperature:	40-55 °F
	Initiate Call for Cooling.	
Fault Conditions:	Economizer Damper Position:	<40% OA
No-Fault Conditions:	Economizer Damper Position:	>70% OA

Low Temperature Test: Insufficient Outdoor Air

Test Code:	ECON-LOW-LOWOA	
	Outdoor Air Temperature:	40-55 °F
	Initiate Call for Cooling.	
Fault Conditions:	Economizer Damper Position:	<5% OA
No-Fault Conditions:	Economizer Damper Position:	>50% OA

Low Temperature Test: Excess Outdoor Air

Test Code:	ECON-LOW-EXSOA	
	Outdoor Air Temperature:	40-55 °F
	Ensure NO Call for Cooling.	
Fault Conditions:	Economizer Damper Position:	>50% OA

No-Fault Conditions: Economizer Damper Position: <20% OA

6.6 Short Cycling Test Procedures

Short Cycling Test: Supply Fan

Test Code:	ECON-SCYC-SFAN
Fault Conditions:	Moderate Temperature (60-72 degF), RH 40-60%. Adjust Economizer to Minimum Outdoor Air (20% by volume for test scenario). Cycle Supply Fan ON, then OFF, five times (a total of ten changes in status) in 20 minutes or less. Check after each transition—a fault can come up before the full 5 rounds.
No-Fault Conditions:	Fan cycling once in 20 minutes no fault.

Short Cycling Test: Compressor(s)

Test Code:	ECON-SCYC-COMP1
Fault Conditions:	Activate call for each-stage cooling, verify that Compressor for that stage is running. Make sure the economizer is not modulating the dampers. Cycle Compressor OFF, then ON, 5 times (or until fault is called) within 20 minutes.
No-Fault Conditions:	Compressor cycling once in 20 minutes is no fault.

7. REFERENCES

ASHRAE Standard 41

Standard 41.1-2013 -- Standard Method for Temperature Measurement

Standard 41.2-1987 (RA 92) -- Standard Methods for Laboratory Airflow Measurement

Standard 41.3-2014 -- Standard Methods for Pressure Measurement (ANSI Approved)

Standard 41.6-2014 -- Standard Method for Humidity Measurement (ANSI Approved)

Standard 41.7-1984 (RA 2006) -- Method of Test for Measurement of Flow of Gas (ANSI approved)

California Title 24 2016

ICC IECC-2015. 2015 International Energy Conservation Code

INFORMATIVE ANNEX A – SAMPLE FDD PERFORMANCE SPECIFICATION

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INFORMATIVE ANNEX B – SAMPLE TEST REPORT

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