Advanced Automated HVAC Fault Detection and Diagnostics Commercialization Program

California Energy Commission
Contract # 500-03-030

D4.5d – Final ARTU Performance Test Plan

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Specific Features to be Tested:

Category – Feature No.	CATEGORY, DESCRIPTION	**Test Objective**	**Test Approach/Procedure**	**Responsibility**	**Comments**
	Level 1 & 2 Features – ARTU Definition				
	HARDWARE FEATURES				
	Category 1 = ECONOMIZER				
1-11	[EITHER:] Outside air and return air dampers will have maximum leakage rates conforming to the requirements of ASHRAE 90.1-2004. [OR:] As a minimum, outdoor air and return air dampers will have blade seals.	Measure the leakage rate of the RA and OSA dampers w/ & w/o blade seals.	Test Protocol o ASHRAE Standard 90.1-2004 Test Approach o Perform a Test w/o Seals o Install Seals o Perform Test w/ Seals Test Procedure o Set rm 2 temp dB/ hum WB: 80/67 o Set rm 4 temp dB/ hum WB: at least 20°F lower than return air o Run test unit fan w/ mechanical cooling disabled o Command return damper 100% open, outdoor damper 0% open	RTTC	

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			o Measure OA & RA temps @ existing sensor locations (not a grid) o Measure Mixed Air temp with grid after air filter o Determine OA damper leakage from temperature measurements and flow mixture equation. o Compare readings to conformance rates listed in ASHRAE o Command return damper 0% open and outdoor damper 100% open o *Note air pressure at return damper must be very small to simulate true atmospheric conditions o Measure OA & RA temps @ existing sensor locations (not a grid) o Measure Mixed Air temp with grid after air filter o Determine RA damper leakage from temperature measurements and flow mixture equation o Repeat the test with seals installed Test Setup o Install grid of 9 temperature sensors in Mixed Air stream.		

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	Category 2 = FANS				
2-01	The ARTU will have supply fan power limitations as addressed in ASHRAE 90.1, when tested according to current ARI rating standards.	Verify nameplate rating of the supply fan & relief fan (if exists) vs. nominal flow rate for the 5 ton unit (2000 cfm).	Test Protocol o ASHRAE 90.1 @ ARI rating standard Test Approach ▪ (no test)	AEC/RTTC	This is not a test; only a static nameplate requirement; not a dynamic operating requirement.
CONTROL FEATURES					
	Category 1 = ECONOMIZER				
1-03	Economizer control type will be differential dry-bulb temperature control.	Verify (only) economizer control type. (Economizer sensor limits & functionality will be verified in subsequent categories)	▪ No Test o This is a physical inspection/verification. Economizer operation will be verified in subsequent tests.	AEC/RTTC	

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
1-05	Compressor operation will be locked out when the outside air temperature is lower than that at which the outside air alone can satisfy the cooling load.	Verify compressor does not run when the OAT is lower than the Thermostatic set point set by factory.	Test Protocol • ARI 210/240 Test Approach • Obtain factory lock out set point information o Generate 2nd stage call for cooling (both economizer and compressor operational) o Simulate OAT and monitor compressor operation Test Procedure o Set the lockout temp on the Carrier controller o Maintain 80/67 at coil inlet (rm2 conditions) o Set OAT (rm4 temp) to 70°F o Verify comp is running – power draw o Verify comp enable signal is sent o Verify comp running signal is sent o Lower OAT in 5F increments until 5 degrees above the set lockout temp o Lower OAT in 2F increments until lockout temp is reached o When comp shuts off at preset OAT : o Verify comp not running – no power draw	RTTC Get Lockout adjustment instructions from DL.	Interface will include display of the following Carrier unit parameters: Compressor lockout temperature, F (MCLO) Outdoor air temperature, F (OAT) Circuit A compressor, on/off (CMPA) Temp set points must be configured thru the configuration menus

Category – Feature No.	CATEGORY, DESCRIPTION	**Test Objective**	**Test Approach/Procedure**	**Responsibility**	**Comments**
			o Verify no comp enable signal is sent o Verify no comp running signal is sent o Verify economizer goes (or stays) 100% open Test Setup o Install power transducers on compressor o Install OAT Temp sensors		
1-06	If the discharge air temperature falls below a low limit of 40 to 45°F (field adjustable), the outside air damper will modulate toward closed until the desired discharge air temperature setpoint is met.	Verify if the SA temp falls below low limit set point that the OSA damper will move toward closed until the SA temp set point is met.	Test Protocol Test approach o Simulate OAT, monitor control signals and OA damper position. Test Procedure o Set RA (rm2) to 80/67 o Set OSA (rm4) to 75°F o General call for cooling to get OSA damper to 100% and RA damper to 0% o Disable compressor so 2nd stage cooling call doesn't interfere with the test o Incrementally lower OSA temp by 10F until reach 55°F. Then lower OSA temp by 5°F	RTTC	Interface will include display of the following Carrier unit parameters: Low cool SAT setpoint, F (LCSP) Supply air temperature, F (SAT) Outdoor air temperature, F (OAT) Minimum SAT lower level, F (SATL) Economizer commanded position, % (ECCP) Economizer actual position, % (ECAP)

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			o Read SA temp o If SAT < 40-45F ▪ Record a few minutes of data during the transition to ensure damper movement ▪ Verify signal is sent to partially close OSA damper and partially open RA damper ▪ Verify SA output stays at 45F ▪ Continue to lower temp in 5 degree increments to 10 degrees below setpoint Test Setup o Install OSA Temp probes o Install SA Temp probe		
1-07	Economizer controller will utilize a deadband between economizer enable/disable operation of no greater than 2 °F in a dry-bulb temperature application.	Verify the economizer re-enables when the OSAT is 2F less than the lockout setpoint (lockout setpoint is the RA temp)	Simulate slight changes in dT and monitor control signals and economizer position. Test Protocol	RTTC	Interface will include display of the following Carrier unit parameters: OK to use economizer? Yes/no (OKEC) Economizer commanded position, % (ECCP)

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			Test Approach o Incrementally bring the OSA temp up below the RA temp and monitor movement of damper Test Procedure o Disable compressor to prevent unwanted interaction o Set RA @ 80°/67 verify no movement & no enable signal o Set OSA @ 85°F o Generate a call for cooling o At 85F verify economizer is at minimum position o Incrementally lower the OSAT by 1F o Verify economizer stays at minimum position until OSAT is 2F less than RA temp o Then verify economizer goes to 100% open when OSAT is 2F less than RA temp and not before Test Setup o Install OSA temp sensors o Install RA temp sensors o Install a rotational sensor (or a limit switch) on economizer dampers		Economizer actual position, % (ECAP) Economizer minimum position in effect, % (ECMP) Economizer cool high temperature limit, F (EHLO) Economizer cool low temperature limit, F (ELLO) Outdoor air temperature, F (OAT) Return air temperature, F (RAT)

Category – Feature No.	CATEGORY, DESCRIPTION	**Test Objective**	**Test Approach/Procedure**	**Responsibility**	**Comments**
	Category 5 = FAN CONTROL				
5-01	Continuous supply fan operation during occupied hours and intermittent operation during unoccupied hours will be the default operating modes.	Verify fan operates during scheduled hours and intermittently operates according to a call for cooling during unoccupied hours	Simulate occupied/unoccupied schedule, monitor control signals and fan operation. Spot testing (functional) Test Protocol o Get fan operating schedule for unoccupied hours Test Approach Vary the room temperature setpoint above and below room temperature and verify that fan runs continuously when space is “occupied” and cycles when space is “unoccupied.” -DD Good point. This is varying setpoint which is easier than varying room temp. Test Procedure o Set rm2 & rm4 to same conditions (economizer locked out) o Set timer of unit to appropriate occupied time o Vary room temperature setpoint above and below room temperature.	RTTC	Interface will include display of the following Carrier unit parameters: Currently occupied, yes/no (OCC) Indoor fan relay, on/off (IDF) Current occupied time, hh.mm (STRTTIME) Current unoccupied time, hh.mm (ENDTIME)

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			o Monitor fan power to verify continuous operation o Verify controller maintained scheduled fan operation o Set timer of unit to appropriate unoccupied time and no call for heating or cooling. Fan should stay OFF o Monitor fan operation – verify there is no power o Generate call for cooling. Fan should command ON o Monitor fan operation – verify fan does turn on o Verify controller sent fan on signal (yes/no) Test Setup o Install power monitoring equipment on supply fan motor		
5-02	During unoccupied hours, the supply fan will operate for a short period after compressor turns off. Note: Do we all agree on 2 mins. for the time the fan stays on after comp turns off ?	Verify fan operates for prescribed period of time (2 mins) after compressor turns off during unoccupied hours.	Note: 5-02 Test Continues from 5-01 Test Test Protocol Test Approach o Simulate occupied/unoccupied schedule, monitor control signals and fan operation. Spot testing (functional) Test Procedure	RTTC	Interface will include display of the following Carrier unit parameters: Fan-off delay, mech cooling, s (FODC) Refer to 5-01 for additional display parameters

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			o Continue from previous test with economizer locked out, system in unoccupied mode, and call for cooling. Fan should be ON o Remove call for cooling o Record time when compressor turns off o Record time when supply fan turns off o Calculate delay time period of comp off to supply fan off & compare to published values Test Setup o Install power monitoring on comp o Install power monitoring on supply fan motor		
	Category 7 = THERMOSTATS				
7-03	Thermostat or controller will be capable of interfacing with an occupancy sensor, switching the unit to intermediate temperature settings when no occupants are present during normally occupied hours.	Verify the temperature setpoints in the controller reset to an intermediate setpoint when triggered by the occupancy sensor (i.e. the zone is unoccupied)	Test Protocol Test Approach o Set occupied, unoccupied and intermediate heating & cooling thermostat setpoints. o Simulate occ. / unocc. condition with a manual switch	RTTC	FDSI will provide this control functionality. The FDSI user interface will have a screen to provide occupied, intermediate, and unoccupied setpoints for cooling and heating. A revised setpoint will be sent to the Carrier unit control when the occupancy sensor switch indicates that the zone is unoccupied during a scheduled occupied period.

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	Note: Package unit does not even need to run for this test as we are testing the controller output.	during normally occupied hours.	o Verify new intermediate setpoint is established when switch is activated during normally occupied hours Test Procedure o Set rm2 conditions to 80/67 o Set rm4 to 95F o Set occupancy switch to 'occupied' & verify normal operation o Toggle occupancy switch to 'unoccupied' & confirm new intermediate thermostatic setpoint is achieved. Test Setup o Install SA temp sensors o Install occ/unocc test switch		The current mode will be indicated and the parameters identified below will be displayed. The following Carrier unit parameters will be used as inputs to the FDSI controller: Remote occupancy switch configuration, x (RMSW) Remote occupancy switch, on/off (RMOC) Current occupied time, hh.mm (STRTTIME) Current unoccupied time, hh.mm (ENDTIME) The following Carrier unit parameters will be used as outputs from the FDSI controller and sent to the Carrier unit control: Unoccupied cool setpoint, F (UCSP) Unoccupied heat setpoint, F (UHSP)

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	Category 8 = SENSORS				
8-01	Sensors that are used to detect outdoor air and return air conditions shall have the following accuracy. Temperature sensors shall have an accuracy of ± 1°F.	 Verify the accuracy of Carrier installed sensors	No physical tests – Verify the certification of Carrier's sensors N/A	AEC/RTTC	Interface will include display of the following Carrier unit parameters: Outdoor air temperature, F (OAT) Return air temperature, F (RAT)
	Category 10 = ADVANCED MONITORING				
10-01	(A) – The following sensors should be permanently installed to monitor system operation and, **(B) – The controller should have the capability of displaying the value of each parameter:**		This is not a test but an installation task. These are FDS specific sensors that will be collaboratively installed by FDS & RTTC teams for the operation of the FDS controller. RTTC will also install its own sensors in the same FDS locations	FDS/RTTC	Interface will include display of the following Carrier unit parameters: Outdoor air temperature, F (OAT) Return air temperature, F (RAT) Supply air temperature, F (SAT) Space temperature, F (SPT) Sat. suction temperature, F (SSTA)

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	• Refrigerant suction pressure • Refrigerant suction temperature • Liquid line pressure • Liquid line temperature • Outside air temperature • Outside air relative humidity • Return air temperature • Return air relative humidity • Supply air temperature • Supply air relative humidity.				Sat. condensing temperature, F (SCTA) Suction Pressure A, psig (SSPA) Interface will include display of the following FDSI parameters: Outdoor air temperature, F (OAT) Return air temperature, F (RAT) Supply air temperature, F (SAT) Single-point mixed air temperature, F (MAT) Evaporating temperature, F (ET) Outdoor air humidity, % (OAH) Return air humidity, % (RAH) Supply air humidity, % (SAH) Single-point mixed air humidity, % (MAH) Average mixed air temperature, F (AMT) Airflow status, on/off (SAF) Supply or space differential pressure,

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
					in wc (SDP) Suction pressure, psig (SP) Liquid pressure, psig (LP) Suction temperature, F (ST) Liquid temperature, F (LT) Discharge temperature, F (DT) Filter temperature, F (FT) Air-off-condenser temperature, F (AOC) Condensing temperature, F (CT)
10-02	The controller will provide system status by indicating the following conditions:	FDS controller & sensors are properly wired & commissioned to display the necessary status indicators	Test Protocol o ARI 210/240 Test Approach • Receive low limit temp value (x) from Carrier • Perform Spot check of alarms & signals for the key parameters listed below Test Procedure • Establish steady state conditions at 80/67 & 95F • Verify the alarms and signals of the following key parameters as listed	FDSI	

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			• Compressor running • Compressor enabled • Economizer enabled • Free cooling available • Mixed air low limit cycle active • Heating enabled Test Setup • Install lab meters/sensors as necessary to Spot check alarms and signals of key parameters		
	• Compressor Running • Compressor enabled		Monitor for Alarm Monitor for Signal		The intent is to display the status when the compressor is on, not an alarm when it is not. Interface will include display of the following Carrier unit parameters: OK to use compressors? Yes/No (OKMC) Circuit A compressor, on/off (CMPA) Compressor A1 feedback, on/off (CSA1)

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	• Economizer enabled		Monitor for Signal		Interface will include display of the following Carrier unit parameters: Economizer commanded position, % (ECCP) Economizer actual position, % (ECAP) Power exhaust 1 relay, on/off (PE1)
	• Free cooling available		Monitor for Signal		Free cooling is Economizer cooling Interface will include display of the following Carrier unit parameters: OK to use economizer? yes/no (OKEC)
	• Mixed air low limit cycle active		Visually Monitor damper movement Monitor OSA temp & compare to low limit temp (x) Monitor for Indication Signal		Interface will include display of the following Carrier unit parameters: Low cool SAT setpoint, F (LCSP) High cool SAT setpoint, F (HCSP) Supply air temperature, F (SAT) Outdoor air temperature, F (OAT) Minimum SAT lower level, F (SATL)

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	• Heating enabled.		Monitor for Enable Signal		Economizer commanded position, % (ECCP) Economizer actual position, % (ECAP) Interface will include display of the following Carrier unit parameters: Heat stage 1 relay, on/off (HT1)
	Category 11 = ADVANCED DIAGNOSTICS				
11-02	Controller will be able to detect faulty and failed sensors (short or open circuit). Upon detecting a faulty sensor, the controller will send a fault signal to the thermostat and/or energy management system. The thermostat and/or energy management system will be capable of receiving and displaying the signal. Per conf call w/ FDS & Todd	Test that failure of built in sensors is detected and displayed properly on FDS controller	Disconnect sensor from controller. Apply dummy signal and observe reaction. Open or short sensors to test thermistors. Test Protocol Test Approach Test Procedure • Repeat steps below for each sensor in the list of	RTTC	Refer to sensor list under 10-01. FDSI sensor faults (open or short) will be indicated. Interface will include display of the following Carrier unit parameters: Current alarms (CURR) T064 Circuit A Saturated Condensing Temp Thermistor Failure T073 Outdoor Air Temperature Thermistor Failure

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	Rossi: all sensors need to be tested		sensors to be tested. • Locate the appropriate sensor on the test unit • Disconnect the sensor from its corresponding circuit • Verify fault on EMS • Re-connect sensor into its corresponding circuit • Next sensor. Test Setup		T074 Space Temperature Thermistor Failure T075 Supply Air Temperature Thermistor Failure T092 Circuit A Suction Pressure Transducer Failure T102 Compressor A1 Current Sensor Failure
11-03	Sense a non-operating (does not operate at all) or improperly operating (w/ a block of wood can prevent full closure) economizer damper and send a fault signal upon detection.	Determine if signal is properly registering non-operation or malfunction of the economizer.	Compare control signal to digital feedback position of economizer. Test Protocol Test Approach • Determine the correct economizer functionality o For non operating economizer: ▪ Actuator failure o For improperly operating economizer: ▪ Damper movement failure	RTTC	Interface will include display of the following Carrier unit parameters: Current alarms (CURR) T179 Loss of communication with the Economizer Control Board T180 Loss of communication with the Economizer Actuator T414 Economizer fault RTTC will only address the economizer faults of motor failure & improper blade movement (not the communications fault).

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			Test Procedure for Actuator failure ▪ Set RA (rm2) to 80/67 ▪ Set OSA (rm4) to 75F ▪ Inhibit movement of the economizer by removing power ▪ Generate call for cooling ▪ Monitor for a fault on the FDD display Test Procedure for Damper movement failure o Set RA (rm2) to 80/67 o Set OSA (rm4) to 75F o Place a block of wood into the economizer damper to prevent movement o Generate a call for cooling o Monitor for a fault on the FDD display Test Setup o Install OSA temp sensors o Install RA temp sensors		

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
11-04	The unit will have the diagnostic capability to detect when the air temperature differential across the evaporator coil is less or greater than a predetermined value (i.e. target temperature drop as determined by Carrier Slide Rule or equivalent calculator).	Detect when there is an air flow issue (high dT) or a capacity issue (low dT) This feature will be used in further generation of diagnostics in category 11-06.	Take this out since we are already addressing this in 11-06	RTTC	Indoor temperature difference diagnostic will be displayed on FDSI interface. A fault condition will be identified when appropriate (in 11-06)
11-05	The unit will have the diagnostic capability to self-monitor refrigerant charge level, and detect when the refrigerant charge is +/-20% outside of factory preset charge	Verify a change in charge level is detected by the existing FDD system	Test Protocol ▪ ARI 210/240 Test Approach o Run unit with factory set charge o Incrementally add 5%, 10%, 15% & 20% charge & let unit stabilize for 20 mins. o Add charge and verify incorrect level is detected on FDD. o Run unit with factory set charge o Incrementally remove 5%, 10%, 15% & 20% charge & let unit stabilize for 20 mins.	RTTC	Refrigerant charge diagnostic will be displayed on FDSI interface. A fault condition will be identified when appropriate. Interface will include display of the following Carrier unit parameters: Current alarms (CURR) T110 Circuit A Loss of Charge

Category – Feature No.	CATEGORY, DESCRIPTION	**Test Objective**	**Test Approach/Procedure**	**Responsibility**	**Comments**
			o Remove charge and verify incorrect level is detected on FDD. Test Procedure ▪ Set rm conditions ▪ Run & stabilize unit ▪ Log data for 10 min after 20 mins of equalization ▪ Vary charge levels as stated in Test Approach o Monitor the following parameters to determine operation under each charge condition. Tevap Tsh Tcond Tsc Tdisch Tcex-Tamb Tra-Tsa (from table on 4/2005 ASHRAE journal article on Automated FDD) Test Setup o Weigh factory refrigerant charge		

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			o Install a charging port in Refrig sys (should already have one)		
11-06	The ARTU controller will be able to diagnose and send a fault signal for the following faults: **Severe faults:**				Diagnostics will be displayed on FDSI interface (for the indicated severe and degradation faults) and a fault condition will be identified when appropriate. FDSI diagnostic system will not distinguish between failed evaporator fan motor and failed fan belt (one fault).
	• Failed compressor	Determine if the compressor is not operating when it should be operating	Three failure possibilities: 1. No power 2. No communication 3. Mechanical failure Test Procedure ▪ Remove power leads from compressor motor ▪ Generate a call for cooling		How will the fault be imposed? Interface will include display of the following Carrier unit parameters: Current alarms (CURR) T051 Compressor fault

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			▪ Log for 5 mins to verify FDSI controller has detected the fault		
	• Failed evaporator fan motor	Determine if the fan motor is not operating when it should be operating	Three failure possibilities: 1. No power 2. No communication 3. Mechanical failure Test Procedure ▪ Remove power leads from fan motor ▪ Generate a call for evap fan to run ▪ Log for 5 mins to verify FDSI controller has detected the fault		How will the fault be imposed? Interface will include display of the following Carrier unit parameters: Current alarms (CURR) T409 Fan status fault
	• Failed evaporator fan belt	Determine if the evap fan belt is broken	Test Procedure ▪ Remove belt from fan motor ▪ Generate a call for evap fan to run ▪ Monitor fan motor power ▪ Monitor air flow ▪ Log for 5 mins to verify FDSI controller has detected the fault		How will the fault be imposed? Refer to failed evaporator fan motor.

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	• Failed condenser fan motor	Determine if the cond fan motor is not operating when it should be operating	Two failure possibilities: 1. No power 2. Mechanical failure Test Procedure ▪ Remove power leads from condenser motor ▪ Generate a call for cooling ▪ Log for 5 min to verify FDSI controller has detected the fault		How will the fault be imposed?
	Degradation faults:				FDSI diagnostic system will not distinguish between dirty air filter and dirty evaporator coil (one fault).
	• Dirty air filter	Determine if the air filter is too dirty	Test Procedure ▪ Block ¼ of air filter and monitor for fault ▪ Block ½ of air filter and monitor for fault ▪ Block ¾ of air filter and monitor for fault ▪ Block entire air filter and monitor for fault		How will the fault be imposed? Interface will include display of the following Carrier unit parameters: Current alarms (CURR) T408 Dirty filter

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	• Dirty condenser coil	Determine if the cond coil is dirty which restricts air flow and impedes heat transfer.	Test Setup ▪ Install dP sensor across the filter Test Approach ▪ Apply material to restrict airflow and impede heat transfer simultaneously. Test Procedure ▪ Run the unit in cooling mode and establish parameters of normal airflow ▪ Apply the material incrementally and monitor the following variables: Tevap Tcond Tsc Tdisch Tcex-Tamb Cond Air Flow Disch Press ▪ Log data for 5 minutes between adding the material Test Setup ▪ Install Pressure sensor on high side of refrig sys ▪ Install Temp sensor at outlet of condenser		We do not monitor dirty condensers and evaporator coils - DL

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
	• Dirty evaporator coil	Determine if the evap coil is dirty which restricts air flow and impedes heat transfer.	Test Approach ▪ Apply material to restrict airflow and impede heat transfer simultaneously. Test Procedure ▪ Run the unit in cooling mode and establish parameters of normal airflow ▪ Apply the material incrementally and monitor the following variables: Tevap Tsh Tcond Tsc Tdisch Tcex-Tamb Tra-Tsa CFM Tsa-Tevap (from table on 4/2005 ASHRAE journal article on Automated FDD) ▪ Log data for 5 minutes between adding the material Test Setup		

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			o Install CFM or velocity sensors before & after the coil		
	• Failed relief damper	Monitor controls and movement of relief damper.	No test because it is not clear what should be monitored and how the fault is to be detected.		
	• Restriction in refrigeration loop	Detect and indicate a restriction in the refrigerant loop.	Test Protocol Test Approach ▪ Impose artificial mechanical restriction in multiple steps in the following areas: o High side o Low side o Both High & Low sides ▪ Monitor the following key operational parameters to determine if FDD detects faults accurately: dTair of evap superheat Psuction Tevap SAT		

Category – Feature No.	CATEGORY, DESCRIPTION	Test Objective	Test Approach/Procedure	Responsibility	Comments
			Pdischarge subcooling superheat Test Procedure • Run Test unit and monitor the following parameters to establish operation under normal charge. o Incrementally adjust the adjustable valve installed in the refrigerant line (1/4, ½, ¾ closed) and monitor fault signal corresponding to various valve positions. o Log data for 10 mins for each valve position Test Setup o Install an adjustable valve on the high & low sides of the refrigerant system Install pressure and temperature sensors on the high & low sides of the refrig sys		