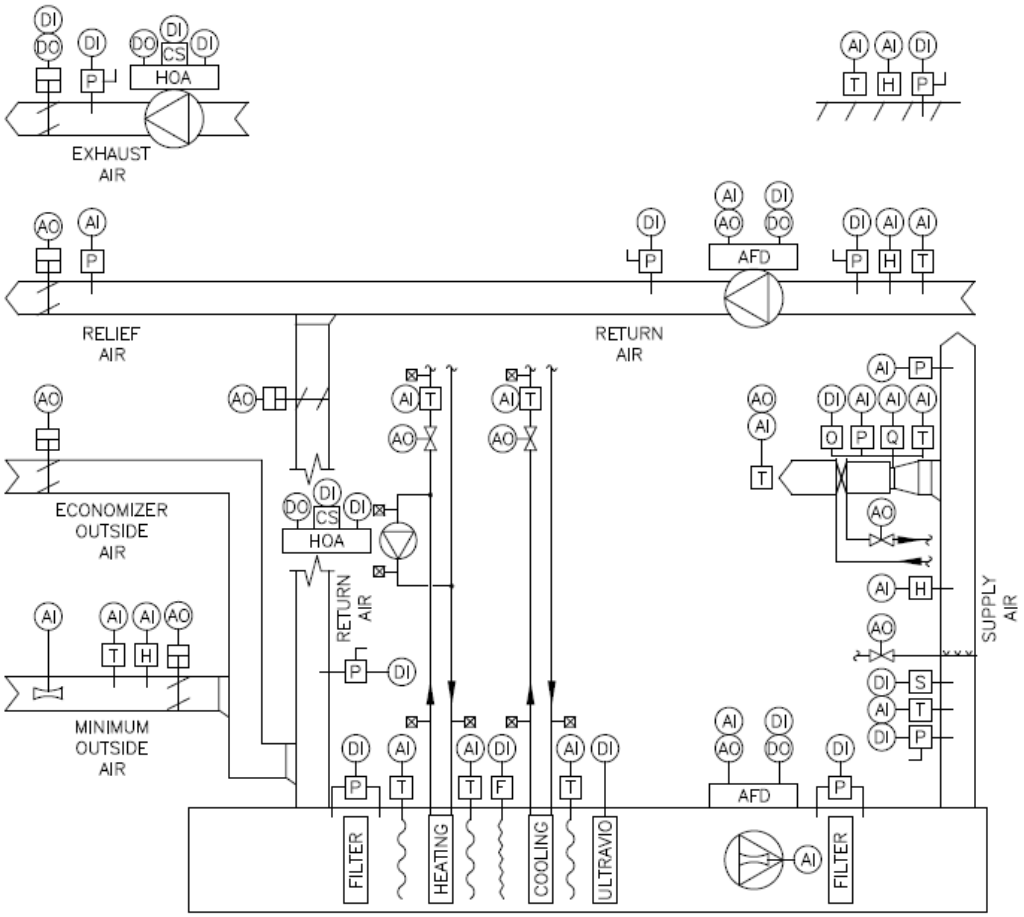
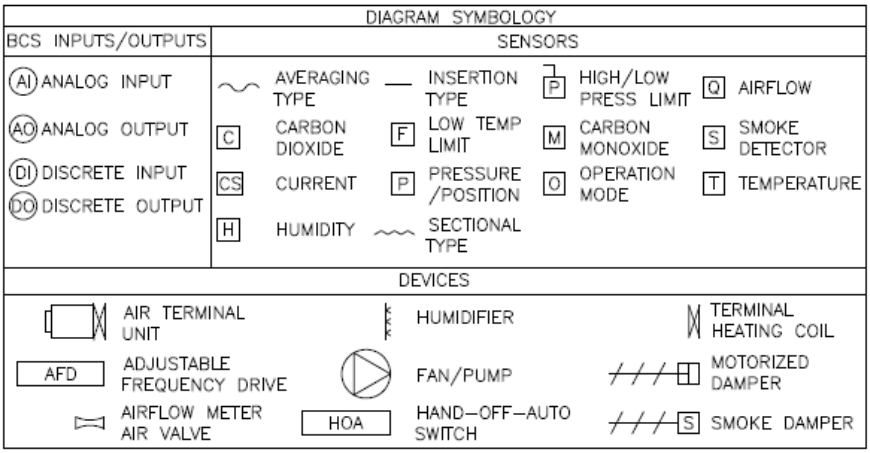
AIR HANDLING UNIT – VARIABLE-VOLUME – RETURN AIR FAN

1. INTRODUCTION

This sample functional performance test (FPT) procedure is for a hypothetical variable-air-volume air handling unit system with return air fan.

The following system diagram is intended to communicate information about this hypothetical system and is not required to be included as part of any FPT.





2. NOTABLE SYSTEM FEATURES

The purpose of this section is to identify notable system features to facilitate an understanding of system operation.

Notable system features include:

a. Supply air fan is selected to meet block load equivalent to 85-percent of peak requirements.

b. Return air fan is selected to meet block load equivalent to 85-percent of peak requirements minus minimum outside air airflow.

c. Cooling coil is selected to meet block load equivalent to 85-percent of peak demand.

d. Pre-heat coil is selected to meet 100-percent of peak demand.

e. Supply air fan control algorithm includes supply air fan pressure reset based on air valve position of terminal equipment to minimize fan energy usage.

f. Return air fan control algorithm includes varying return air fan speed to obtain / maintain setpoint static pressure as measured by static pressure sensor located in relief air ductwork. Setpoint static pressure set equivalent to that required to obtain minimum outside air setpoint airflow. Initial system set-up included:
   - Commanding supply air fan and return air fans to their minimum allowed motor speeds
   - Commanding return air control damper to its 100-percent open position
   - Commanding economizer outside air and relief air control dampers to their 0-percent open position
   - Allowing minimum outside air control damper to stabilize under normal control and recording its position
   - For outside air control damper initially being commanded to equal to or less than its 95-percent open position and minimum outside air actual airflow being equivalent to setpoint, programming relief air setpoint static pressure and programming return air control damper maximum open position
   - For outside air control damper initially being commanded to greater than its 95-percent open position, progressively commanding return air control damper from its 100-percent open position until minimum outside air control damper was commanded to its 95-percent open position such that minimum outside air actual airflow was equivalent to setpoint and then programming relief air setpoint static pressure and programming return air control damper maximum open position

g. Minimum outside air and economizer control algorithms include time delays allowing other control loops to stabilize to help prevent low limit temperature (freezestat) alarm conditions.

h. Minimum outside air control algorithm includes modulating minimum outside air control damper to fine tune outside airflow after repositioning return air control damper to minimize fan energy usage by minimizing suction static pressure noting minimum outside control air damper is significantly smaller than return air control damper.

i. Economizer control algorithm is based on dry-bulb temperature sensors due their reliability over relative humidity and wet-bulb temperature sensors. This operation mode is activated upon detection of outside air dry-bulb temperature being equal to or less than actual return air dry-bulb temperature minus five degrees allowing a reasonable number of annual operating hours when outside air relative humidity results in an outside air enthalpy being less than return air enthalpy.

j. Economizer control algorithm includes first modulating minimum outside air control damper, followed by modulating return air control damper, followed by modulating economizer outside air control damper to maintain minimum outside air setpoint airflow followed by mixed air setpoint temperature to minimize fan energy usage by minimizing suction static pressure noting minimum outside control air damper is significantly smaller than economizer and return air control dampers.

k. Pre-occupied operation mode includes enabling terminal equipment featuring a fan prior to commanding supply air fan to its active status. Near completion of operation mode, supply air fan is commanded to its inactive status and associated external energy recovery equipment featuring a fan is enabled to prevent excessive current inrush for this associated equipment.

l. Pre-heat coil brine temperature and cooling coil brine temperature alarm conditions include visual indication of coils whose water-side temperature change is significantly less than design thus negatively impacting central plant efficiency.

m. Low limit temperature (freezestat) alarm condition includes disabling associated external energy recovery equipment featuring a fan upon activation of algorithm to prevent low temperature air being introduced into this equipment.

n. Fire alarm condition includes disabling associated external energy recovery equipment featuring a fan upon activation of algorithm to prevent oxygen from being introduced into this equipment and to meet requirements of life safety codes.

3. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this section is to identify conclusions and recommendations based on control system feature observations, point-to-point observations, actuator observations, and system operation observations.

It is concluded that this system [does / does not perform] in accordance with contract requirements.

It is recommended that this system [be / not be] accepted by the government.

The following system control enhancements are recommended:

4. TEST CONDITIONS

The purpose of this section is to identify conditions occurring at time of testing.

Test date: _____
Test begin time: _____
Test end time: _____
Test begin outside air temp: _____
Test end outside air temp: _____

5. EQUIPMENT IDENTIFICATION

The purpose of this section is to identify equipment included in this system.

Air handling unit: _____
Return air fan: _____
Exhaust air fan: _____
Pre-heat coil circ. pump: _____

6. ATTENDEES

The purpose of this section is to identify persons present during system functional performance testing.

ATTENDEES			
REPRESENTING	**NAME**	**COMPANY**	**TELEPHONE NUMBER**
Mechanical Commissioning Specialist:			
Owner’s Representative:			
Mechanical Contractor:			

ATTENDEES			
REPRESENTING	**NAME**	**COMPANY**	**TELEPHONE NUMBER**
Controls Contractor:			
Test & Balance Contractor:			

7. CONTROL SYSTEM FEATURE OBSERVATIONS

The purpose of this section is to identify control system features including control point description, imbedded / visible type, adjustable / monitoring type, actual value, setpoint value / alarm range.

Abbreviations used in the matrix below include:

a. Unit:

Unit of measure for control point.

b. Imbedded / Visible:

I - Imbedded such that control point is not observable by Operator.

V - Visible such that control point is observable by Operator.

c. Type:

A1 - Both setpoint and minimum / maximum alarm or alarm range are adjustable by Operator.

A2 - Only minimum / maximum alarm or alarm range is adjustable by Operator.

A3 - Only setpoint is adjustable by Operator.

M - Control point is visible, but not adjustable by Operator.

d. Value / Status:

As-found imbedded or visible value or status of control point observed prior to control point(s) manipulation.

A - Status of control point is in alarm.

N - Status of control point is normal operation.

e. Setpt / Alarm Range:

Alarm Min - Alarm activated when actual value is equal to or less than alarm activation setpoint.

Setpt - Setpoint.

Alarm Max - Alarm activated when actual value is equal to or greater than alarm activation setpoint.

CONTROL SYSTEM FEATURES								
POINT DESCRIPTION	**UNIT**	**VISIBLE / IMBEDDED**	**TYPE**	**VALUE / STATUS**	**SETPT / ALARM**			**NOTES**
					ALARM MIN	**SETPT**	**ALARM MAX**	
Minimum outside air ductwork:								
Airflow								
Dry-bulb temp					-	-	-	
Relative humidity					-	-	-	
Damper position	% Open				-	-	-	

CONTROL SYSTEM FEATURES								
POINT DESCRIPTION	UNIT	VISIBLE / IMBEDDED	TYPE	VALUE / STATUS	SETPT / ALARM			NOTES
					ALARM MIN	SETPT	ALARM MAX	
Economizer outside air ductwork:								
Damper position	% Open				-	-	-	
Return air ductwork:								
Dry-bulb temp						-		
Relative humidity					-			
High limit static pressure						-		
High limit static pressure					-			
High limit static pressure					-			
Damper position	% Open				-	-	-	
Mixed air section:								
Filter differential pressure					-			
Dry-bulb temp					-		-	
Pre-heat coil:								
Dry-bulb temp								
Low limit temp					-	-	-	
Valve position	% Open				-	-	-	
Leaving water / brine temp					-			
Cooling coil:								
Dry-bulb temp					-			
Valve position	% Open				-	-	-	
Leaving water / brine temp							-	
Ultraviolet light					-	-	-	
Supply air fan:								
Status					-	-	-	
Speed					-	-	-	
Airflow					-	-	-	
Discharge air section:								
Filter differential pressure					-			

CONTROL SYSTEM FEATURES								
POINT DESCRIPTION	UNIT	VISIBLE / IMBEDDED	TYPE	VALUE / STATUS	SETPT / ALARM			NOTES
					ALARM MIN	SETPT	ALARM MAX	
Discharge air ductwork:								
High limit static pressure					-			
Dry-bulb temp					-			
Smoke damper position confirmation					-			
Relative humidity					-		-	
Static pressure					-			
Relief air ductwork:								
Static pressure					-			
Damper position	% Open				-	-	-	
Return air fan:								
Status					-	-	-	
Speed					-	-	-	
Exhaust air ductwork:								
High limit static pressure					-			
Damper position	% Open				-	-	-	
Damper position confirmation					-			
Exhaust air fan:								
Status					-	-	-	
Pre-heat coil circulating pump:								
Status						-		
Facility:								
Outside dry-bulb temp					-	-	-	
Outside relative humidity					-	-	-	
Facility pressure								

8. POINT-TO-POINT OBSERVATIONS

The purpose of this section is to identify system meters and sensors have been calibrated.

Abbreviations used in the matrix below include:

a. Display:

As-found imbedded or visible value of control point documented at Operator workstation at same time measurement or observation occurred and prior to control point(s) manipulation.

Value / status is recorded for both locations when control point is displayed locally at equipment Operator workstation.

b. Measured / Observed:

As-found imbedded or visible value of control point measured or observed at same time documentation of value at Operator workstation occurred and prior to control point(s) manipulation.

POINT-TO-POINT			
POINT DESCRIPTION	**DISPLAY (LOCAL / CONTROL SYSTEM)**	**MEASURED / OBSERVED**	**NOTES**
Minimum outside air ductwork:			
Airflow	/		
Dry-bulb temp			
Relative humidity			
Return air ductwork:			
Dry-bulb temp			
Relative humidity			
High limit static pressure			
Mixed air section:			
Filter differential pressure			
Dry-bulb temp			
Pre-heat coil:			
Dry-bulb temp			
Low limit temp	/		
Leaving water / brine temp			
Cooling coil:			
Dry-bulb temp			
Leaving water / brine temp			
Supply air fan:			
Airflow	/		
Discharge air ductwork:			
High limit static pressure			
Dry-bulb temp			
Relative humidity			
Static pressure			
Relief air ductwork:			
Static pressure			
Facility:			
Outside dry-bulb temp			
Outside relative humidity			
Facility pressure			

9. ACTUATOR AND MOTOR OBSERVATIONS

The purpose of this section is to identify actuator responses to commands from the control system.

Abbreviations used in the matrix below include:

a. Type:

A - Actuator / controlled device is controlled by an analog control signal.

D - Actuator / controlled device is controlled by a discrete (binary) control signal.

b. Maximum Command:

Control system command resulting in actuator moving controlled device to its full open position with maximum / full flow across device.

c. Minimum Command:

Control system command resulting in actuator moving controlled device to its full closed position with minimum / no flow across device.

d. Signal:

Output from control system measured in units of 0 to 100 percent, 0 to 10 volts, etc.

e. Position:

Position of controlled device (not actuator) physically observed that corresponds to control system signal observed in units of 0-percent open (minimum / no flow across device) and 100-percent open (maximum / full flow across device).

ACTUATORS AND MOTORS						
ACTUATOR DESCRIPTION	**TYPE**	**MAXIMUM COMMAND**		**MINIMUM COMMAND**		**NOTES**
		SIGNAL	**POSITION / SPEED**	**SIGNAL**	**POSITION / SPEED**	
Minimum outside air control damper						
Economizer outside air control damper						
Return air control damper						
Pre-heat coil control valve						
Cooling coil Control valve						
Supply air fan speed						
Return air fan speed						
Relief air control damper						
Exhaust air control damper						

10. VARIABLE FREQUENCY DRIVE OBSERVATIONS

The purpose of this section is to identify characteristics of variable frequency drives (VFD's).

Procedure for obtaining characteristics included:

a. Procedure for documenting maximum motor speed allowed by VFD included:
   - Record served motor's nameplate full load current
   - Confirm / manually set VFD's maximum allowed speed of 60 Hz
   - Manually set VFD hand-off-auto switch to "hand" position
   - Manually set VFD to maximum allowed speed of 60 Hz
   - Record served motor's running load current at motor conductors

b. Procedure for documenting minimum safe motor speed allowed by VFD included:
   - Manually set VFD speed to 24 Hz
   - Repeatedly decreased VFD speed by 3 Hz and recorded served motor's running load amperes until running load amperes increases
   - Set VFD's minimum allowed speed equivalent to speed at which running load amperes increased plus 3 Hz
   - Manually set VFD speed to VFD's minimum allowed speed
   - Record served motor's running load amperes at motor conductors

VARIABLE FREQUENCY DRIVE INFORMATION														
PARAMETER DESCRIPTION	**SERVED EQUIPMENT**													
Data for maximum motor speed allowed by VFD:														
Motor nameplate full load current														
VFD maximum allowed speed (Hz)														
Running load current with VFD at 60 Hz														
Data for minimum safe motor speed allowed by VFD:														
Current at 24 Hz														
Current at 21 Hz														
Current at 18 Hz														
Current at 15 Hz														
Current at 12 Hz														
Current at 9 Hz														
Current at 6 Hz														
Minimum allowed speed (Hz)														
Current at minimum allowed speed (Amps)														

11. SYSTEM OPERATION OBSERVATIONS

The purpose of this section is to document results from system-based testing of responses for each control algorithm, operation mode, and alarm condition resulting from manipulated control point(s).

Testing is sequentially grouped based on similar functions to maximize testing efficiency and is categorized as follows:

a. As-found conditions.
b. Control algorithms.
c. Operation modes.
d. Alarm conditions.

Control algorithms initiated by operation modes are tested prior to testing operation modes.
Operation modes initiated by alarm conditions are tested prior to testing alarm conditions.

Because point-to-point and actuator observations were physically made, system responses are observed from Operator workstation unless indicated otherwise.

Some equipment / component responses may be combined in a single test.

The following control algorithm testing is provided in the matrix below:

a. Supply air fan.
b. Return air fan.
c. Pre-heat coil / cooling coil.
d. Minimum outside air.
e. Economizer.
f. Facility pressurization.
g. Exhaust air fan.
h. Pre-heat coil circulating pump.
i. Humidifier.

The following operation mode testing is provided in the matrix below:

a. Unoccupied.
b. Timed override.
c. Pre-occupied.
d. Occupied.

The following alarm condition testing is provided in the matrix below:

a. Pre-filter high static pressure.
b. Pre-heat coil brine temperature.
c. Pre-heat coil air temperature.
d. Pre-heat coil circulating pump failure.
e. Cooling coil brine temperature.
f. Cooling coil air temperature.
g. Final filter high static pressure.
h. Return air relative humidity.
i. Return air fan general fault.
j. Return air fan failure.
k. Exhaust air fan failure.
l. High relief air ductwork static pressure.
m. High exhaust air ductwork static pressure.
n. Facility relative pressure.
o. Supply air fan general fault.
p. Supply air fan failure.
q. High supply air ductwork static pressure.
r. High return air ductwork number one static pressure.
s. High return air ductwork number two static pressure.
t. Low limit temperature (freezestat).
u. Fire.
v. Emergency air distribution shutoff.

w. Pre-heat coil circulating pump opposite status.
x. Supply air fan opposite status.
y. Return air fan opposite status.
z. Exhaust air fan opposite status.

Abbreviations used in the matrix below include:

a. Test Method:
   Manipulated parameter(s) necessary to produce expected system response.
b. Expected Response:
   Anticipated system reaction to manipulated parameter(s).
c. Comments:
   Commissioning specialist's issues related to observations.
d. Pass / Fail:
   P - Expected response is observed without issues of concern.
   F - Expected response is not observed resulting in noted issues of concern.
e. Miscellaneous:
   CS - Control signal.

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
As-Found Conditions				
01	To observe as-found conditions: • Confirm / initiate air handling unit's active status • Record observations in expected response /comments columns prior to manipulating parameters	Supply air fan speed	CS of _____	
02		Return air fan speed	CS of _____	
03		Minimum outside air control damper position	CS of _____	
04		Return air control damper position	CS of _____	
05		Economizer outside air control damper position	CS of _____	
06		Relief air control damper position	CS of _____	
07		Pre-heat coil control valve position	CS of _____	
08		Cooling coil control valve position	CS of _____	
09		Exhaust air control damper position	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
10		Exhaust air fan status	CS of _____	
11		Pre-heat coil circulating pump status	CS of _____	
12		Minimum outside air setpoint maintained	CS of _____	
13		Facility setpoint pressure relative to the outside maintained	CS of _____	

Supply Air Fan Control Algorithm

Design Control Sequence:

Upon detection of this algorithm having been activated, the control system shall:

- Set minimum supply air ductwork setpoint static pressure equivalent to 0.75 INWG
- Set maximum supply air ductwork setpoint static pressure equivalent to 2.50 INWG
- Poll each air terminal unit's air valve position every five-minutes
- Monitor supply air ductwork static pressure sensor
- Command supply air fan to its minimum allowed motor speed
- Command supply air fan towards its maximum allowed motor speed upon detection of actual supply air ductwork static pressure being equal to or less than maximum setpoint and any air valve having been commanded to greater than its 95-percent open position
- Command supply air fan towards its minimum allowed motor speed upon detection of actual supply air ductwork static pressure being equal to or greater than minimum setpoint and no air valve having been commanded to greater than its 80-percent open position
- Command supply air fan to its inactive status upon detection of this control algorithm having been deactivated

14	To prepare for system response: • Override scheduled unoccupied time to be slightly after actual time • Wait for overridden unoccupied time to occur	Minimum supply air ductwork setpoint static pressure set	CS of _____	
15		Maximum supply air ductwork setpoint static pressure set	CS of _____	
16		Supply air ductwork static pressure sensor monitored	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
17	• Override scheduled occupied time to be slightly after actual time • Observe system status	Supply air fan commanded to its minimum allowed motor speed	CS of _____	
18	To observe system response to air valve based deficient static pressure: • Override one air valve to its 97-percent open position	Supply air fan commanded towards its maximum allowed motor speed	CS of _____	
19		Supply air ductwork static pressure maximum setpoint obtained	CS of _____	
20	To observe system response to air valve based excessive static pressure: • Override all air valves to their 50-percent open position	Supply air fan commanded towards its minimum allowed motor speed	CS of _____	
21		Supply air ductwork static pressure minimum setpoint obtained	CS of _____	
22	To observe system response to static pressure based deficient static pressure: • Command all air valves to their 50-percent open position • Override minimum supply air ductwork setpoint static pressure setpoint to slightly greater than actual pressure	Supply air fan commanded towards its maximum allowed motor speed	CS of _____	
23	To observe system response to static pressure based excessive static pressure: • Command all air valves to their 100-percent open position • Override maximum supply air ductwork setpoint static pressure setpoint to slightly less than actual pressure	Supply air fan commanded towards its minimum allowed motor speed	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
24	Release all overrides	System returns to pre-test conditions		

Return Air Fan Control Algorithm

Design Control Sequence:

Upon detection of this algorithm having been activated, the control system shall:

- Set return air fan setpoint static pressure equivalent to that determined during system set-up for return air fan
- Take no action for a one-minute period
- Monitor relief air ductwork static pressure sensor
- Enable and command return air fan to its minimum allowed motor speed upon detection of this control algorithm having been activated
- Command return air fan towards its maximum allowed motor speed upon detection of actual static pressure being less than setpoint
- Command return air fan towards its minimum allowed motor speed upon detection of actual static pressure being greater than setpoint
- Disable return air fan upon detection of this control algorithm having been deactivated

25	To prepare for system response: • Override scheduled unoccupied time to be slightly after actual time	Return air fan setpoint static pressure set	CS of _____	
26		Relief air ductwork static pressure monitored	CS of _____	
27	• Wait for overridden unoccupied time to occur	One-minute period passes without control system action		
28	• Override scheduled occupied time to be slightly after actual time • Observe system status	Return air fan commanded to its minimum allowed motor speed	CS of _____	
29	To observe system response to deficient static pressure: • Override setpoint static pressure to slightly greater than actual pressure	Return air fan commanded towards its maximum allowed motor speed	CS of _____	
30	To observe system response to excessive static pressure: • Override setpoint static pressure to slightly less than actual pressure	Return air fan commanded towards its minimum allowed motor speed	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
31	To observe system response to deficient relative pressure: • Override outside airflow to minimum demand • Override facility setpoint relative pressure to slightly greater than actual pressure	Relief air control damper maintained in its 100-percent open position	CS of _____	
32		Return air fan commanded to its minimum allowed motor speed, then	CS of _____	
33		Return air fan maintained at its minimum allowed motor speed	CS of _____	
34		Relief air control damper commanded to its 10-percent open position	CS of _____	
35	To observe system response to continued deficient relative pressure: • Override facility actual relative pressure to less than deactivation setpoint	Return air fan disabled	CS of _____	
36		Relief air control damper commanded to its 0-percent open position	CS of _____	
37	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Pre-Heat Coil Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Set pre-heat coil discharge setpoint temperature equivalent to cooling coil discharge air setpoint temperature minus 2.0 °F • Monitor temperature sensor located immediately downstream of this coil • Command control valve towards its 100-percent open position upon detection of pre-heat coil discharge air temperature being less than setpoint • Command control valve towards its 0-percent open position upon detection of pre-heat coil discharge air temperature being greater than setpoint				
Cooling Coil Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Monitor temperature sensor located immediately downstream of this coil • Command control valve towards its 100-percent open position upon detection of cooling coil discharge air temperature being greater than setpoint of 55.0 °F • Command control valve towards its 0-percent open position upon detection of cooling coil discharge air temperature being less than setpoint of 55.0 °F				
38	To prepare for system response: • Observe system status	Pre-heat coil discharge setpoint temperature	CS of _____	
39		Cooling coil discharge setpoint temperature	CS of _____	
40	To observe system response to deficient heating / excessive cooling capacities: • Override cooling coil discharge air setpoint temperature to a significantly greater value such that pre-heat setpoint temperature is slightly greater than actual temperature	Pre-heat coil discharge setpoint temperature set	CS of _____	
41		Cooling coil discharge setpoint temperature set	CS of _____	
42		Pre-heat coil control valve commanded towards its 100-percent open position	CS of _____	
43		Cooling coil control valve commanded towards its 0-percent open position	CS of _____	
44	To observe system response to excessive heating / deficient	Pre-heat coil discharge setpoint temperature set	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
45	cooling capacities: • Override cooling coil discharge air setpoint temperature to a significantly lesser value such that pre-heat setpoint temperature is slightly less than actual temperature	Cooling coil discharge setpoint temperature set	CS of _____	
46		Pre-heat coil control valve commanded towards its 0-percent open position	CS of _____	
47		Cooling coil control valve commanded towards its 100-percent open position	CS of _____	
48	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Minimum Outside Air Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Set outside air setpoint airflow equivalent to 1,000 cfm • Take no action for a five-minute period • Maintain economizer outside air control damper in its 0-percent open position • Continuously set return air control damper's minimum open position equivalent to 10-percent open upon detection of relief air control damper having been commanded to its 0-percent open position and equivalent to 0-percent open upon detection of relief air control damper having been commanded equal to or greater than 10-percent open • Command minimum outside air control damper towards its 100-percent open position until outside air actual airflow is equal to setpoint • Momentarily maintain minimum outside air control damper in its current position and command return air control damper towards its minimum open position until outside air actual airflow is equal to 110 percent of setpoint upon detection of outside air actual airflow being less than setpoint and minimum outside air control damper having been commanded to its 100-percent open position • Temporarily maintain return air control damper in its current position and command minimum outside air control damper up to an additional 20-percent towards its 10-percent open position upon detection of outside air actual airflow being greater than setpoint and return air control damper having been repositioned • Temporarily maintain return air control damper in its current position and command minimum outside air control damper towards its 100-percent open position upon detection of outside air actual airflow being less than setpoint and return air control damper having been repositioned • Momentarily maintain minimum outside air control damper in its current position and command return air control damper towards its maximum open position until outside air actual airflow is equal to 90 percent of setpoint upon detection of outside air actual airflow being greater than setpoint and minimum outside air control damper having been commanded an additional 20-percent towards its 10-percent open position			
49	To prepare for system response: • Override scheduled unoccupied time to be slightly after actual time	Outside air setpoint airflow set	CS of _____	
50		Return air control damper commanded to its maximum open position	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
51	• Wait for overridden unoccupied time to occur • Override economizer operation mode to inactive • Override relief air control damper to its 10-percent open position	Minimum outside air control damper commanded to its 0-percent open position	CS of _____	
52		Economizer outside air control damper maintained in its 0-percent open position	CS of _____	
53		Return air control damper's minimum open position set to 0-percent open	CS of _____	
54	To observe system stabilization: • Override scheduled occupied time to be slightly after actual time • Override supply fan to minimum demand • Override relief air control damper to its 0-percent open position	Five-minute period passes without control system action		
55		Minimum outside air control damper commanded towards its 100-percent open position	CS of _____	
56		Return air control damper maintained in its 0-percent open position	CS of _____	
57		Minimum outside air setpoint airflow obtained	CS of _____	
58		Return air control damper's minimum open position set to 10-percent open	CS of _____	
59	To observe system response to deficient outside air airflow: • Override supply fan to minimum demand • Override outside air setpoint airflow to slightly greater than actual airflow	Minimum outside air control damper maintained in its 100-percent open position	CS of _____	
60		Return air control damper commanded towards its minimum open position	CS of _____	
61		Minimum outside air actual airflow of 110-percent of setpoint obtained	CS of _____	
62	To observe system response to excessive outside air airflow: • Override supply fan to maximum demand • Override outside air setpoint airflow to significantly less	Return air control damper maintained in its current position	CS of _____	
63		Minimum outside air control damper commanded an additional 20-percent towards its 10-percent open position, then	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
64	than actual airflow	Minimum outside air control damper maintained in its current position	CS of _____	
65		Return air control damper commanded towards its maximum open position	CS of _____	
66	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Economizer Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Continuously set economizer activation setpoint temperature equivalent to actual return air dry-bulb temperature minus five degrees • Set economizer setpoint temperature equivalent to cooling coil discharge air setpoint temperature • Set minimum outside air setpoint airflow equivalent to 1,000 cfm • Take no action for a five-minute period • Continuously set return air control damper's minimum open position equivalent to 10-percent open upon detection of relief air control damper having been commanded to its 0-percent open position and equivalent to 0-percent open upon detection of relief air control damper having been commanded equal to or greater than 10-percent open • Initiate economizer response, deactivate minimum outside air control algorithm, maintain economizer outside air control damper in its 0-percent open position, and command return air control damper to its maximum open position upon detection of outside air dry-bulb temperature being equal to or less than economizer activation setpoint temperature • Maintain economizer outside air control damper in its 0-percent open position, maintain return air control damper in its maximum open position, and command minimum outside air control damper towards its 100-percent open position upon detection of minimum outside air actual airflow being less than setpoint or actual mixed air temperature being greater than economizer setpoint temperature • Maintain economizer outside air control damper in its 0-percent open position, maintain minimum outside air control damper in its 100-percent open position, and command return air control damper towards its minimum open position until minimum outside air actual airflow is equal to setpoint upon detection of minimum outside air control damper having been commanded to its 100-percent open position and minimum outside air actual airflow being less than setpoint • Maintain minimum outside air control damper in its 100-percent open position and command return air control damper towards its maximum open position upon detection of minimum outside air control damper having been commanded to its 100-percent open position, actual mixed air temperature being equal to or greater than economizer setpoint temperature, and minimum outside air actual airflow being greater than setpoint			

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Design Control Sequence (Concluded): • Maintain return air control damper in its maximum open position and command minimum outside air control damper towards its 0-percent open position upon detection of return air control damper having been commanded to its maximum open position, minimum outside air actual airflow being greater than setpoint, and actual mixed air temperature being equal to or less than economizer setpoint temperature minus 1.0 °F • Maintain minimum outside air control damper in its 100-percent open position and command economizer outside air control damper towards its 100-percent open position upon detection of minimum outside air control damper having been commanded to its 100-percent open position and actual mixed air temperature being greater than economizer setpoint temperature • Maintain economizer outside air control damper in its 100–percent open position and command return air control damper towards its minimum open position upon detection of economizer outside air control damper having been commanded to its 100–percent open position and actual mixed air temperature being greater than economizer setpoint temperature		• Maintain minimum outside air control damper in its 100-percent open position, maintain economizer outside air control damper in its current position, and command return air control damper towards its maximum open position upon detection of actual mixed air temperature being equal to or less than economizer setpoint temperature minus 1.0 °F • Maintain minimum outside air control damper in its 100-percent open position, maintain return air control damper in its maximum open position, and command economizer outside air control damper towards its 0-percent open position upon detection of return air control damper having been commanded to its maximum open position and actual mixed air temperature being equal to or less than economizer setpoint temperature minus 1.0 °F • Maintain return air control damper in its maximum open position, and maintain economizer outside air control damper in its 0-percent open position, and command minimum outside air control towards its 0-percent open position upon detection of return air control damper having been commanded to its maximum open position, minimum outside air actual flow being greater than setpoint, and actual mixed air temperature being equal to or less than economizer setpoint temperature minus 1.0 °F • Cancel economizer response and activate minimum outside air control algorithm upon detection of outside air dry-bulb temperature being greater than economizer activation setpoint temperature		
67	To prepare for system response:	Economizer activation setpoint temperature set	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
68	• Override economizer activation setpoint temperature equivalent to actual return air dry-bulb temperature plus 50.0 °F • Override relief air control damper to its 10-percent open position	Economizer setpoint temperature set	CS of _____	
69		Minimum outside air setpoint airflow set	CS of _____	
70		Five-minute period passes without control system action		
71		Return air control damper's minimum open position set to 0-percent open	CS of _____	
72		Economizer response initiated		
73		Minimum outside air control algorithm deactivated	CS of _____	
74		Economizer outside air control damper maintained in its 0-percent open position	CS of _____	
75		Return air control damper commanded to its maximum open position	CS of _____	
76	To observe system response to deficient minimum outside air airflow: • Override economizer setpoint temperature to significantly less than actual temperature • Override supply air airflow to minimum demand • Override minimum outside air setpoint airflow to significantly greater than actual airflow	Supply air fan commanded to minimum allowed motor speed	CS of _____	
77		Economizer outside air control damper maintained in its 0-percent open position	CS of _____	
78		Return air control damper maintained in its maximum open position	CS of _____	
79		Minimum outside air control damper commanded to its 100-percent open position, then	CS of _____	
80		Return air control damper commanded to its minimum open position	CS of _____	
81	To observe system response to excessive minimum outside air	Supply air fan commanded to maximum allowed motor speed	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
82	airflow: • Override economizer setpoint temperature to significantly greater than actual temperature • Override supply air airflow to maximum demand • Override minimum outside air setpoint airflow to significantly less than actual airflow	Economizer outside air control damper maintained in its 0-percent open position	CS of _____	
83		Minimum outside air control damper maintained in its 100-percent open position	CS of _____	
84		Return air control damper commanded to its maximum open position, then	CS of _____	
85		Minimum outside air control damper commanded towards its 0-percent open position	CS of _____	
86	To prepare for additional system response: • Release economizer setpoint temperature override • Release supply air airflow override • Release minimum outside air setpoint airflow • Override relief air control damper to its 0-percent open position	Economizer setpoint temperature returned to pre-test conditions	CS of _____	
87		Supply air airflow returned to pre-test conditions	CS of _____	
88		Minimum outside air setpoint airflow returned to pre-test conditions	CS of _____	
89		Return air control damper’s minimum open position set to 10-percent open	CS of _____	
90	To observe system response to deficient cooling: • Override mixed air setpoint temperature to significantly less than actual temperature	Economizer outside air control damper maintained in its 0-percent open position	CS of _____	
91		Return air control damper maintained in its maximum open position	CS of _____	
92		Minimum outside air control damper commanded to its 100-percent open position, then	CS of _____	
93		Economizer outside air control damper commanded to its 100-percent open position, then	CS of _____	
94		Return air control damper commanded to its minimum open position	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
95	To observe system response to excessive cooling: • Override mixed air setpoint temperature to significantly greater than actual temperature • Override minimum outside air setpoint airflow to significantly less than actual airflow	Minimum outside air control damper maintained in its 100-percent open position	CS of _____	
96		Economizer outside air control damper maintained in its current position	CS of _____	
97		Return air control damper commanded to its maximum open position, then	CS of _____	
98		Economizer outside air control damper commanded to its 0-percent open position, then	CS of _____	
99		Minimum outside air control damper commanded towards its 0-percent open position	CS of _____	
100	To observe system response to economizer cancellation: • Override economizer activation setpoint temperature to significantly less than outside air actual dry-bulb temperature	Economizer response cancelled	CS of _____	
101		Minimum outside air control algorithm activated	CS of _____	
102	Release all overrides	System returns to pre-test conditions		
Facility Pressurization Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Continuously set facility relative pressure control setpoint equivalent to 0.02 INWG • Monitor facility relative pressure sensor located across facility envelope • Command relief air control damper towards its 100-percent open position upon detection of facility actual relative pressure being equal to or greater than facility relative pressure control setpoint • Command relief air control damper towards its 0-percent open position upon detection of facility actual relative pressure being less than facility relative pressure control setpoint				
103	To prepare for system response: • Observe system status	Facility relative pressure monitored	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
104	To observe system response to excessive relative pressure: • Override facility setpoint relative pressure to slightly less than actual pressure	Relief air control damper commanded towards its 100-percent open position	CS of _____	
105	To observe system response to deficient relative pressure: • Override facility setpoint relative pressure to slightly greater than actual pressure	Relief air control damper commanded towards its 0-percent open position	CS of _____	
106	Release all overrides	System returns to pre-test conditions		

Exhaust Air Fan Control Algorithm

Design Control Sequence:

Upon detection of this algorithm having been activated, the control system shall:

- Command exhaust air damper to its 100-percent open position
- Command exhaust air fan to operate at constant speed
- Confirm exhaust air damper in its 100-percent open position

Upon detection of this algorithm having been deactivated, the control system shall:

- Command exhaust air fan to its inactive status
- Command exhaust air damper to its 0-percent open position

107	To observe system response to activated Control Algorithm	Exhaust air fan control algorithm initiated		
108	• Confirm / initiate activation of this control algorithm	Exhaust air damper commanded to its 100-percent open position	CS of _____	
109		Exhaust air damper confirmed in its 100-percent open position	CS of _____	
110		Exhaust air fan commanded to operate at constant speed	CS of _____	
111	To observe system response to deactivated Control Algorithm	Exhaust air fan commanded to inactive status		
112	• Deactivate this control algorithm	Exhaust air damper commanded to its 0-percent open position	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Pre-Heat Coil Circulating Pump Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Command pre-heat coil circulating pump to operate at constant speed upon detection of outside air temperature being equal to or less than activation setpoint of 38.0 °F • Command pre-heat coil circulating pump to its inactive status upon detection of outside air temperature being greater than deactivation setpoint of 38.0 °F				
113	To observe system response to activation: • Override activation setpoint temperature to significantly less than actual outside air temperature	Pre-heat coil circulating pump control algorithm initiated		
114		Pre-heat coil circulating pump commanded to active status	CS of _____	
115	To observe system response to deactivation: • Override activation setpoint temperature to significantly greater than actual outside air temperature	Pre-heat coil circulating pump commanded to inactive status	CS of _____	
116	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Humidifier Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Monitor return air relative humidity sensor located in return air ductwork • Monitor supply air relative humidity sensor located downstream of humidifier distribution manifold • Enable humidifier upon detection of return air relative humidity being equal to or less than enable setpoint of 25-percent • Command humidifier control valve towards its 100-percent open position upon detection of supply air actual relative humidity being equal to or less than control setpoint of 80-percent • Command humidifier control valve towards its 0-percent open position upon detection of supply air actual relative humidity being greater than control setpoint of 80-percent • Disable humidifier upon detection of supply air relative humidity being equal to or greater than high-limit setpoint of 90-percent • Disable humidifier upon detection of return air relative humidity being greater than disable setpoint of 30-percent				
117	To observe system response to being enabled: • Override humidifier enable setpoint to significantly less than return air actual relative humidity	Humidifier enabled	CS of _____	
118	To observe system response to deficient capacity: • Override control setpoint relative humidity to slightly greater than actual relative humidity	Humidifier coil control valve commanded towards its 100-percent open position	CS of _____	
119	To observe system response to excessive capacity: • Override control setpoint relative humidity to slightly less than actual relative humidity	Humidifier coil control valve commanded towards its 0-percent open position	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
120	To observe system response to capacity in excess of high-limit: • Override humidifier high-limit setpoint to significantly less than supply air actual relative humidity	Humidifier disabled	CS of _____	
121	To prepare to observe system response to being disabled: • Release humidifier high-limit setpoint override	Humidifier enabled	CS of _____	
122	To observe system response to being disabled: • Release humidifier enable setpoint override • Override humidifier disable setpoint to significantly greater than return air actual relative humidity	Humidifier disabled	CS of _____	
123	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Unoccupied Operation Mode Design Control Sequence: Upon detection of unoccupied time having occurred, the control system shall: • Deactivate supply air fan control algorithm • Deactivate return air fan control algorithm • Command minimum outside air control damper to its 0-percent open position • Command return air control damper to its 100-percent open position • Command economizer outside air control damper to its 0-percent open position • Command relief air control damper to its 0-percent open position • Deactivate pre-heat coil control algorithm • Deactivate cooling coil control algorithm • Deactivate minimum outside air control algorithm • Deactivate economizer control algorithm • Deactivate facility pressurization control algorithm • Deactivate exhaust air fan control algorithm • Deactivate pre-heat coil circulating pump control algorithm • Deactivate humidifier control algorithm Upon detection of five zones' actual temperatures being either greater than or less than respective unoccupied setpoint temperature, the control system shall: • Activate supply air fan control algorithm • Maintain return air fan control algorithm inactive status • Maintain minimum outside air control damper in its 0-percent open position • Maintain return air control damper in its 100-percent open position • Maintain economizer outside air control damper in its 0-percent open position • Maintain relief air control damper in its 0-percent open position • Activate pre-heat coil control algorithm • Activate cooling coil control algorithm • Maintain minimum outside air control algorithm inactive status • Maintain economizer control algorithm inactive status • Maintain facility pressurization control algorithm inactive status • Maintain exhaust air fan control algorithm inactive status • Activate pre-heat coil circulating pump control algorithm • Maintain humidifier control algorithm inactive status			
124	To observe system response to no heating / cooling demand: • Override scheduled unoccupied time to be slightly after actual	Supply air fan control algorithm deactivated	CS of _____	
125		Return air fan control algorithm deactivated	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
126	time	Minimum outside air control damper commanded to its 0-percent open position	CS of _____	
127		Return air control damper commanded to its 100-percent open position	CS of _____	
128		Economizer outside air control damper commanded its 0-percent open position	CS of _____	
129		Relief air control damper commanded its 0-percent open position	CS of _____	
130		Pre-heat coil control algorithm deactivated	CS of _____	
131		Cooling coil control algorithm deactivated	CS of _____	
132		Minimum outside air control algorithm deactivated	CS of _____	
133		Facility pressurization control algorithm deactivated	CS of _____	
134		Economizer control algorithm deactivated	CS of _____	
135		Exhaust air fan control algorithm deactivated	CS of _____	
136		Pre-heat coil circulating pump control algorithm deactivated	CS of _____	
137		Humidifier control algorithm deactivated	CS of _____	
138	To observe system response: • Override appropriate number of zones' unoccupied heating setpoint temperature to significantly greater than zone actual temperatures • Override appropriate	Supply air fan control algorithm activated	CS of _____	
139		Return air fan control algorithm maintained inactive	CS of _____	
140		Minimum outside air control damper maintained in its 0-percent open position	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
141	number of zones' unoccupied cooling setpoint temperature to significantly less than zone actual temperatures	Return air control damper maintained in its 100-percent open position	CS of _____	
142		Economizer outside air control damper maintained in its 0-percent open position	CS of _____	
143		Relief air control damper maintained in its 0-percent open position	CS of _____	
144		Pre-heat coil control algorithm activated	CS of _____	
145		Cooling coil control algorithm activated	CS of _____	
146		Minimum outside air control algorithm maintained inactive	CS of _____	
147		Economizer control algorithm maintained inactive	CS of _____	
148		Facility pressurization control algorithm maintained inactive	CS of _____	
149		Exhaust air fan control algorithm maintained inactive	CS of _____	
150		Pre-heat coil circulating pump control algorithm activated	CS of _____	
151		Humidifier control algorithm maintained inactive	CS of _____	
152	Release selected overrides	Selected components return to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Timed Override Operation Mode Design Control Sequence: Upon detection of any single timed override switch having been activated, the control system shall: • Maintain return air control damper in its 100-percent open position • Maintain minimum outside air control damper in its 0-percent open position • Maintain economizer outside air control damper in its 0-percent open position • Maintain relief air control damper in its 0-percent open position • Activate supply air fan control algorithm • Maintain return air fan control algorithm inactive status • Activate pre-heat coil control algorithm • Activate cooling coil control algorithm • Maintain minimum outside air control algorithm inactive status • Maintain economizer control algorithm inactive status • Maintain facility pressurization control algorithm inactive status • Maintain exhaust air fan control algorithm inactive status • Activate pre-heat coil circulating pump control algorithm • Maintain humidifier control algorithm inactive status				
153	To observe system response: • Activate one timed override switch to active	Timed override operation mode initiated		
154		Return air control damper maintained in its 100-percent open position	CS of _____	
155		Minimum outside air control damper maintained in its 0-percent open position	CS of _____	
156		Economizer outside air control damper maintained in its 0-percent open position	CS of _____	
157		Relief air control damper maintained in its 0-percent open position	CS of _____	
158		Supply air fan control algorithm activated	CS of _____	
159		Return air fan control algorithm maintained inactive	CS of _____	
160		Pre-heat coil control algorithm activated	CS of _____	
161		Cooling coil control algorithm activated	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
162		Minimum outside air control algorithm maintained inactive	CS of _____	
163		Economizer control algorithm maintained inactive	CS of _____	
164		Facility pressurization control algorithm maintained inactive	CS of _____	
165		Exhaust air fan control algorithm maintained inactive	CS of _____	
166		Pre-heat coil circulating pump control algorithm activated	CS of _____	
167		Humidifier control algorithm maintained inactive	CS of _____	
168	Release selected overrides	Selected components return to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Pre-Occupied Operation Mode Design Control Sequence: Upon detection of learned system start-up time in advance of occupied time having occurred, the control system shall: • Enable associated terminal equipment featuring a fan • Take no action for a two-minute period • Maintain minimum outside air control damper in its 0-percent open position • Maintain return outside air control damper in its 100-percent open position • Maintain economizer outside air control damper in its 0-percent open position • Maintain relief air control damper in its 0-percent open position • Activate supply air fan control algorithm • Maintain return air fan control algorithm inactive status • Activate pre-heat coil control algorithm • Activate cooling coil control algorithm • Maintain minimum outside air control algorithm inactive status • Maintain economizer control algorithm inactive status • Maintain facility pressurization control algorithm inactive status • Maintain exhaust air fan control algorithm inactive status • Activate pre-heat coil circulating pump control algorithm • Maintain humidifier control algorithm inactive status • Deactivate supply air fan control algorithm upon detection of five-minutes prior to occupied time having occurred • Command minimum outside air control damper to its 10-percent open position • Enable associated external energy recovery equipment featuring a fan				
169	To observe system response: • Override learned system start-up time to slightly after actual time • Wait for overridden system start-up time to occur	Pre-occupied operation mode initiated		
170		Associated terminal equipment featuring a fan enabled	CS of _____	
171		Two-minute period passes without control system action		
172		Minimum outside air control damper maintained in its 0-percent open position	CS of _____	
173		Return air control damper maintained in its 100-percent open position	CS of _____	
174		Economizer outside air control damper maintained in its 0-percent open position	CS of _____	
175		Relief air control damper maintained in its 0-percent open position	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
176		Supply air fan control algorithm activated	CS of _____	
177		Return air fan control algorithm maintained inactive	CS of _____	
178		Pre-heat coil control algorithm activated	CS of _____	
179		Cooling coil control algorithm activated	CS of _____	
180		Minimum outside air control algorithm maintained inactive	CS of _____	
181		Economizer control algorithm maintained inactive	CS of _____	
182		Facility pressurization control algorithm maintained inactive	CS of _____	
183		Exhaust air fan control algorithm maintained inactive	CS of _____	
184		Pre-heat coil circulating pump control algorithm activated	CS of _____	
185		Humidifier control algorithm maintained inactive	CS of _____	
186		Deactivate supply air fan control algorithm	CS of _____	
187		Minimum outside air control damper commanded its 10-percent open position	CS of _____	
188		Associated external energy recovery equipment featuring a fan enabled	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Occupied Operation Mode Design Control Sequence: Upon detection of completion of pre-occupied operation mode, the control system shall: • Activate supply air fan control algorithm • Activate return air fan control algorithm • Maintain pre-heat coil control algorithm active status • Maintain cooling coil control algorithm active status • Activate minimum outside air control algorithm • Activate economizer control algorithm • Activate facility pressurization control algorithm • Activate exhaust air fan control algorithm • Maintain pre-heat coil circulating pump control algorithm active status • Activate humidifier control algorithm				
189	To observe system response: Take no action beyond documenting control algorithm statuses	Supply air fan control algorithm activated	CS of _____	
190		Return air fan control algorithm activated	CS of _____	
191		Pre-heat coil control algorithm maintained active	CS of _____	
192		Cooling coil control algorithm maintained active	CS of _____	
193		Minimum outside air control algorithm activated	CS of _____	
194		Economizer control algorithm activated	CS of _____	
195		Facility pressurization control algorithm activated	CS of _____	
196		Exhaust air fan control algorithm activated	CS of _____	
197		Pre-heat coil circulating pump control algorithm maintained active	CS of _____	
198		Humidifier control algorithm activated	CS of _____	
199	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Pre-Filter High Static Pressure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and pre-filter actual static pressure being equal to or greater than alarm setpoint of 1.0 INWG, the control system shall: • Initiate visual alarm at Operator workstation • Maintain system active status				
200	To observe system response: • Force air pressure on high pressure side of differential pressure switch sampling tube	Visual alarm initiated at Operator workstation		
201		System active status maintained	CS of _____	
202	Release air pressure and return sampling tube to its original position	System returns to pre-test conditions		
Pre-Heat Coil Brine Temperature Alarm Condition Design Control Sequence: Upon detection of receiving enable command, the control system shall: • Set pre-heat coil high limit alarm setpoint temperature equivalent to plant actual supply temperature minus 10.0 °F • Monitor temperature sensor located in this coil's return piping • Initiate visual alarm at Operator workstation upon detection of control valve having been commanded towards its 100-percent open position and temperature in this coil's return piping being equal to or greater than high limit alarm setpoint temperature for a five-minute period • Maintain system active status				
203	To observe system response to excessive heating: • Override high limit alarm setpoint temperature to significantly less than actual temperature	Five-minute period passes without control system action		
204		Visual alarm initiated at Operator workstation		
205		System active status maintained	CS of _____	
206	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Pre-Heat Coil Air Temperature Alarm Condition Design Control Sequence: Upon detection of receiving enable command, the control system shall: • Set pre-heat coil low limit alarm setpoint temperature equivalent to pre-heat coil setpoint temperature minus 8.0 °F • Set pre-heat coil high limit alarm setpoint temperature equivalent to pre-heat coil setpoint temperature plus 15.0 °F • Monitor temperature sensor located immediately downstream of this coil		• Initiate visual alarm at Operator workstation upon detection of temperature immediately downstream of this coil being equal to or less than low limit alarm setpoint temperature for a five-minute period • Maintain system active status • Initiate visual alarm at Operator workstation upon detection of temperature immediately downstream of this coil being equal to or greater than high limit alarm setpoint temperature for a five-minute period • Maintain system active status		
207	To observe system response to deficient heating: • Override low limit alarm setpoint temperature to significantly greater than actual temperature	Five-minute period passes without control system action		
208		Visual alarm initiated at Operator workstation		
209		System active status maintained	CS of _____	
210	To observe system response to excessive heating: • Override high limit alarm setpoint temperature to significantly less than actual temperature	Five-minute period passes without control system action		
211		Visual alarm initiated at Operator workstation		
212		System active status maintained	CS of _____	
213	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Pre-Heat Coil Circulating Pump Failure Alarm Condition Design Control Sequence: Upon detection of control algorithm being activated, pre-heat coil circulating pump active status being initiated, and pre-heat coil circulating pump status being inactive, the control system shall: • Initiate visual alarm at Operator workstation • Command pre-heat coil circulating pump to inactive status • Maintain system active status				
214	To observe system response: • Manually set pump disconnect switch to “off” position • Override pump activation setpoint temperature to significantly less than actual outside air temperature	Visual alarm initiated at Operator workstation		
215		Pre-heat coil circulating pump commanded to inactive status	CS of _____	
216		System active status maintained	CS of _____	
217	Release all overrides	System returns to pre-test conditions		
Cooling Coil Brine Temperature Alarm Condition Design Control Sequence: Upon detection of receiving enable command, the control system shall: • Set cooling coil low limit alarm setpoint temperature equivalent to plant actual supply temperature plus 8.0 °F • Monitor temperature sensor located in this coil’s return piping • Initiate visual alarm at Operator workstation upon detection of control valve having been commanded towards its 100-percent open position and temperature in this coil’s return piping being equal to or less than high limit alarm setpoint temperature for a five-minute period • Maintain system active status				
218	To observe system response to excessive heating: • Override low limit alarm setpoint temperature to significantly greater than actual temperature	Five-minute period passes without control system action		
219		Visual alarm initiated at Operator workstation		
220		System active status maintained	CS of _____	
221	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Cooling Coil Air Temperature Alarm Condition Design Control Sequence: Upon detection of receiving enable command, the control system shall: • Set cooling coil high limit alarm setpoint temperature equivalent to cooling coil setpoint temperature plus 10.0 °F • Monitor temperature sensor located immediately downstream of this coil • Initiate visual alarm at Operator workstation upon detection of temperature immediately downstream of this coil being equal to or greater than high limit alarm setpoint temperature for a five-minute period • Maintain system active status				
222	To observe system response to excessive heating: • Override high limit alarm setpoint temperature to significantly less than actual temperature	Five-minute period passes without control system action		
223		Visual alarm initiated at Operator workstation		
224		System active status maintained	CS of _____	
225	Release all overrides	System returns to pre-test conditions		
Final Filter High Static Pressure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and final filter actual static pressure being equal to or greater than alarm setpoint of 1.5 INWG, the control system shall: • Initiate visual alarm at Operator workstation • Maintain system active status				
226	To observe system response: • Force air pressure on high pressure side of differential pressure switch sampling tube	Visual alarm initiated at Operator workstation		
227		System active status maintained	CS of _____	
228	Release air pressure and return sampling tube to its original position	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Return Air Relative Humidity Alarm Condition Design Control Sequence: Upon detection of receiving enable command, the control system shall: • Set return air high limit alarm setpoint relative humidity equivalent to return air setpoint relative humidity plus 15-percent • Monitor relative humidity sensor located in return air ductwork • Initiate visual alarm at Operator workstation upon detection of relative humidity in return air ductwork being equal to or greater than high limit alarm setpoint temperature for a five-minute period • Maintain system active status				
229	To observe system response to excessive heating: • Override high limit alarm setpoint temperature to significantly less than actual temperature	Five-minute period passes without control system action		
230		Visual alarm initiated at Operator workstation		
231		System active status maintained	CS of _____	
232	Release all overrides	System returns to pre-test conditions		
Return Air Fan General Fault Alarm Condition Design Control Sequence: Upon detection of receiving enable command and return air fan general fault alarm, the control system shall: • Initiate visual alarm at Operator workstation • Maintain system active status				
233	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
234		System active status maintained	CS of _____	
235	Release all overrides	System returns to pre-test conditions		
Return Air Fan Failure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and return air failure alarm status, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable return air fan • Maintain system active status				
236	To observe system response:	Audible and visual alarms initiated at Operator workstation		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
237	• Manually turn return air fan's disconnect switch to off position	Return air fan disabled	CS of _____	
238		System active status maintained	CS of _____	
239	Release all overrides	System returns to pre-test conditions		
Exhaust Air Fan Failure Alarm Condition Design Control Sequence: Upon detection of control algorithm being activated, exhaust air fan active status being initiated, and exhaust air fan status being inactive, the control system shall: • Initiate visual alarm at Operator workstation • Command exhaust air fan to inactive status • Maintain system active status				
240	To observe system response: • Manually set fan disconnect switch to "off" position	Visual alarm initiated at Operator workstation		
241		Exhaust air fan commanded to inactive status	CS of _____	
242		System active status maintained		
High Relief Air Ductwork Static Pressure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and return air ductwork actual static pressure being equal to or greater than alarm setpoint of absolute 2.0 INWG, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable return air fan • Maintain system active status				
243	To observe system response: • Override alarm setpoint static pressure to slightly less than actual pressure	Audible and visual alarms initiated at Operator workstation		
244		Return air fan disabled	CS of _____	
245		System active status maintained	CS of _____	
246	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
High Exhaust Air Ductwork Static Pressure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and exhaust air ductwork actual static pressure being equal to or greater than alarm setpoint of absolute 2.0 INWG, the control system shall: • Initiate visual alarm at Operator workstation • Command exhaust air fan to its inactive status • Maintain system active status				
247	To observe system response: • Override alarm setpoint static pressure to slightly less than actual pressure	Visual alarm initiated at Operator workstation		
248		Exhaust air fan commanded to its inactive status	CS of _____	
249		System active status maintained	CS of _____	
250	Release all overrides	System returns to pre-test conditions		
Facility Relative Pressure Alarm Condition Design Control Sequence: Upon detection of receiving enable command, the control system shall: • Initiate visual alarm at Operator workstation upon detection of facility actual pressure relative to the outside being greater than high alarm setpoint of 0.05 INWG for a five-minute period • Initiate visual alarm at Operator workstation upon detection of facility actual pressure relative to the outside being less than low alarm setpoint of 0.01 INWG for a five-minute period • Maintain system active status • Maintain system active status				
251	To observe system response: • Override high alarm setpoint to slightly less than actual facility actual pressure	Five-minute period passes without control system action		
252		Visual alarm initiated at Operator workstation		
253		System active status maintained	CS of _____	
254	To observe system response: • Override low alarm setpoint to slightly greater than actual facility actual	Five-minute period passes without control system action		
255		Visual alarm initiated at Operator workstation		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
256	pressure	System active status maintained	CS of _____	
257	Release all overrides	System returns to pre-test conditions		
Supply Air Fan General Fault Alarm Condition Design Control Sequence: Upon detection of receiving enable command and supply air fan general fault alarm, the control system shall: • Initiate visual alarm at Operator workstation • Maintain system active status				
258	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
259		System active status maintained	CS of _____	
260	Release all overrides	System returns to pre-test conditions		
Supply Air Fan Failure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and supply air failure alarm status, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable system				
261	To observe system response: • Initiate failure condition at adjustable frequency drive	Audible and visual alarms initiated at Operator workstation		
262		System disabled	CS of _____	
263	Release all overrides	System returns to pre-test conditions		
High Supply Air Ductwork Static Pressure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and supply air ductwork actual static pressure being equal to or greater than alarm setpoint of absolute 4.0 INWG, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable system				
264	To observe system response:	Audible and visual alarms initiated at Operator workstation		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
265	• Override alarm setpoint static pressure to slightly less than actual pressure	System disabled	CS of _____	
266	Release all overrides	System returns to pre-test conditions		
High Return Air Ductwork Number One Static Pressure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and return air ductwork actual static pressure being equal to or greater than alarm setpoint of absolute 2.0 INWG, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable system				
267	To observe system response: • Override alarm setpoint static pressure to slightly less than actual pressure	Audible and visual alarms initiated at Operator workstation		
268		System disabled	CS of _____	
269	Release all overrides	System returns to pre-test conditions		
High Return Air Ductwork Number Two Static Pressure Alarm Condition Design Control Sequence: Upon detection of receiving enable command and return air ductwork actual static pressure being equal to or greater than alarm setpoint of absolute 2.0 INWG, the control system shall: • Initiate audible and visual alarms at Operator workstation • System disabled				
270	To observe system response: • Override alarm setpoint static pressure to slightly less than actual pressure	Audible and visual alarms initiated at Operator workstation		
271		System disabled	CS of _____	
272	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Low Limit Temperature (Freezestat) Alarm Condition Design Control Sequence: Upon detection of receiving enable command and temperature downstream of pre-heat coil being equal to or less than alarm setpoint of 36.0 °F, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable air handling unit • Disable return air fan • Command exhaust air fan to inactive status • Command pre-heat coil control valve to its 100-percent open position • Command cooling coil control valve to its 100-percent open position • Activate pre-heat coil circulating pump control algorithm • Disable associated external energy recovery equipment featuring a fan • Disable associated terminal equipment featuring a fan				
273	To observe system response: • Manually place sensing element of low limit temperature sensor in ice water	Audible and visual alarms initiated at Operator workstation		
274		Air handling unit disabled	CS of _____	
275		Return air fan disabled	CS of _____	
276		Exhaust air fan commended to its inactive status	CS of _____	
277		Pre-heat coil control valve commanded to its 100-percent open position	CS of _____	
278		Cooling coil control valve commanded to its 100-percent open position	CS of _____	
279		Pre-heat coil circulating pump control algorithm activated	CS of _____	
280		Associated external energy recovery equipment featuring a fan disabled	CS of _____	
281		Associated terminal equipment featuring a fan disabled	CS of _____	
282	Remove sensing element of low limit temperature sensor from ice water and return to its original location	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Fire Alarm Condition Design Control Sequence: Upon detection of receiving enable command and supply air ductwork smoke detector sensing products of combustion, the fire alarm and control systems shall: • Initiate audible and visual alarms at Operator workstation • Disable air handling unit • Disable return air fan • Command exhaust air fan to inactive status • Disable associated external energy recovery equipment featuring a fan • Disable associated terminal equipment featuring a fan				
283	To observe system response: • Manually force artificial smoke through ductwork smoke detector sampling tube	Audible and visual alarms initiated at Operator workstation		
284		Air handling unit disabled	CS of _____	
285		Return air fan disabled	CS of _____	
286		Exhaust air fan commanded to inactive status	CS of _____	
287		Associated external energy recovery equipment featuring a fan disabled	CS of _____	
288		Associated terminal equipment featuring a fan disabled	CS of _____	
289	Clear smoke from ductwork smoke detector sampling tube	System returns to pre-test conditions		
Emergency Air Distribution Shutoff Alarm Condition Design Control Sequence: Upon detection of activation of emergency air distribution shutoff switch, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable air handling unit • Disable return air fan • Command exhaust air fan to inactive status • Disable associated terminal equipment featuring a fan				
290	To observe system response: • Activate emergency air distribution shutoff switch	Audible and visual alarms initiated at Operator workstation		
291		Air handling unit disabled	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
292		Return air fan disabled	CS of _____	
293		Exhaust air fan commanded to inactive status	CS of _____	
294		Associated terminal equipment featuring a fan disabled	CS of _____	
295	Deactivate emergency air distribution shutoff switch	System returns to pre-test conditions		
Pre-Heat Coil Circulating Pump Opposite Status Alarm Condition Design Control Sequence: Upon detection of receiving activation command and status being opposite command, the control system shall: • Initiate visual alarm at Operator workstation • Maintain system active status				
296	To observe system response to equipment off status:	Visual alarm initiated at Operator workstation		
297	• Enable / confirm system active status and manually set pump disconnect switch to “off” position	System active status maintained	CS of _____	
298	Release all overrides	System returns to pre-test conditions		
Supply Air Fan Opposite Status Alarm Condition Design Control Sequence: Upon detection of receiving enable command and status being opposite command, the control system shall: • Initiate audible and visual alarms at Operator workstation • Maintain system active status				
299	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
300	• Enable / confirm system active status and manually set hand-off-auto switch at adjustable frequency drive to “off” position	Equipment and system status maintained	CS of _____	
301	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
302	• Disable system and manually set hand-off-auto switch at adjustable frequency drive to “on” position	Equipment and system status maintained	CS of _____	
303	Release all overrides	System returns to pre-test conditions		
Return Air Fan Opposite Status Alarm Condition Design Control Sequence: Upon detection of receiving enable command and status being opposite command, the control system shall: • Initiate visual alarm at Operator workstation • Maintain system active status				
304	To observe system response to equipment off status:	Visual alarm initiated at Operator workstation		
305	• Enable / confirm system active status and manually set hand-off-auto switch at adjustable frequency drive to “off” position	Equipment and system status maintained	CS of _____	
306	To observe system response to equipment on status:	Visual alarm initiated at Operator workstation		
307	• Disable system and manually set hand-off-auto switch at adjustable frequency drive to “on” position	Equipment and system status maintained	CS of _____	
308	Release all overrides	System returns to pre-test conditions		
Exhaust Air Fan Opposite Status Alarm Condition Design Control Sequence: Upon detection of receiving activation command and status being opposite command, the control system shall: • Initiate visual alarm at Operator workstation • Maintain system active status				
309	To observe system response to equipment off status:	Visual alarm initiated at Operator workstation		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
310	• Enable / confirm system active status and manually set fan disconnect switch to “off” position	System active status maintained	CS of _____	
311	Release all overrides	System returns to pre-test conditions		

-- End of Test --