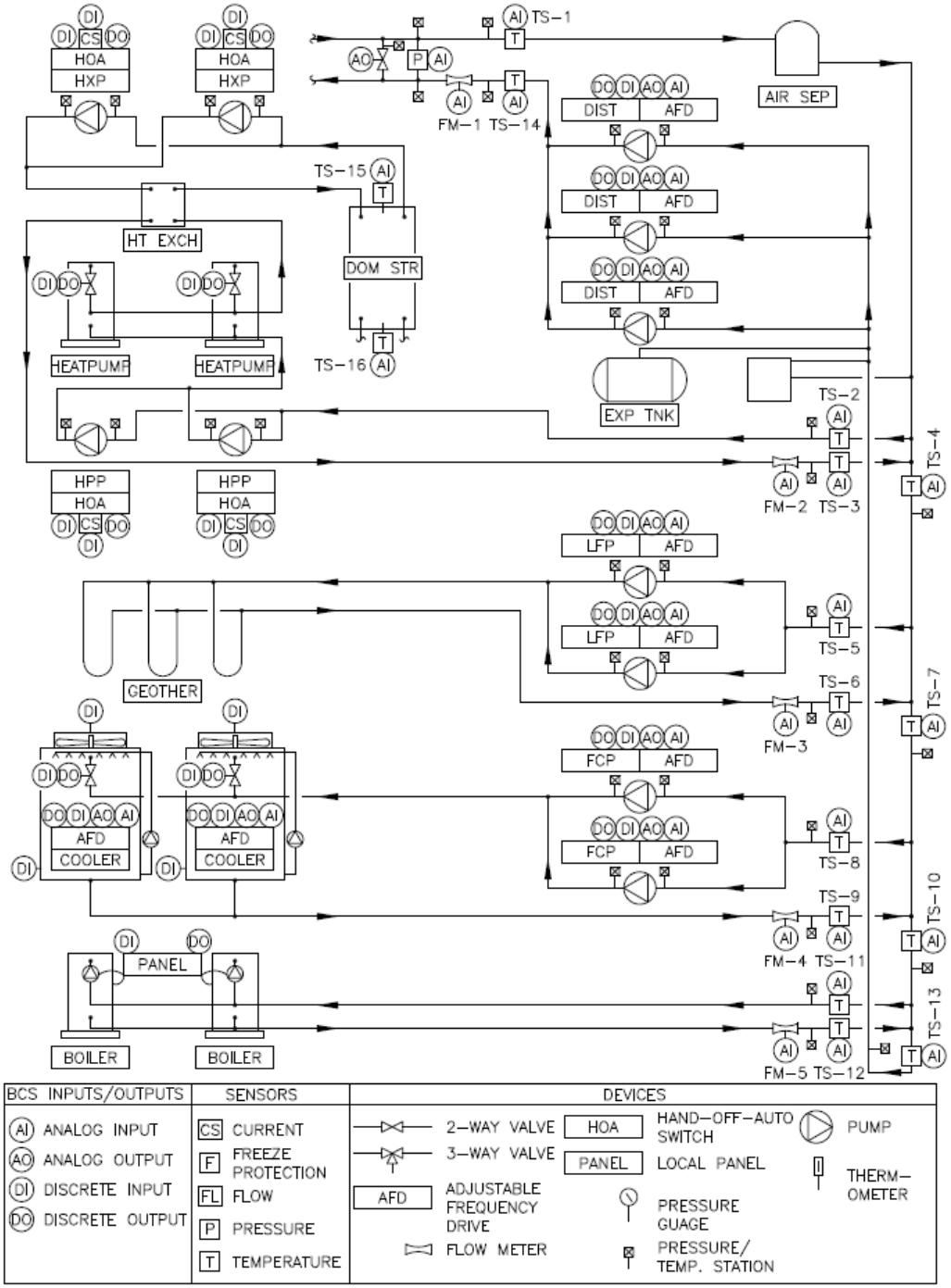
CONDENSER WATER PLANT – DOMESTIC HOT WATER, GEOTHERMAL, COOLER, AND BOILER

1. INTRODUCTION

This sample functional performance test (FPT) procedure is for a hypothetical condenser water system featuring domestic hot water, geothermal loop field, fluid coolers, and boiler loops.

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. This condenser water plant is designed to transfer heat between connected terminal equipment connected to the condenser water loop then provide supplemental cooling based on net system demand from the domestic hot water loop and supplemental heating or cooling from geothermal, fluid cooler, and boiler loops.

b. Condenser water supply temperature (TS-14) is maintained between 60 °F and 90 °F.

c. Each distribution pump is selected to meet 50-percent of system requirements yielding one redundant pump.

d. Each water-to-water heatpump is selected to meet 50-percent of domestic hot water requirements yielding no redundant heatpump.

e. Each heatpump loop pump is selected to meet 100-percent of a single water-to-water heatpump’s requirements yielding no redundant pump.

f. Each heat exchanger pump is selected to meet 100-percent of heat exchanger requirements yielding one redundant pump.

g. Geothermal loop field is designed to reduce energy usage and is not designed to meet 100-percent of connected heating or cooling loads.

h. Each geothermal loop pump is selected to meet 100-percent of geothermal loop field requirements yielding one redundant pump.

i. Each fluid cooler is selected to meet 50-percent of net system cooling requirements without credit for geothermal loop field yielding no redundant cooler.

j. Each fluid cooler loop pump is selected to meet 100-percent of fluid cooler requirements yielding one redundant pump.

k. Each boiler is selected to meet 50-percent of net system heating requirements without credit for geothermal loop field yielding no redundant boiler and is controlled by the boiler control panel.

l. Each boiler circulating pump is selected to meet 100-percent of a single boiler’s requirements yielding no redundant pump and is provided and controlled by the boiler control panel.

m. Distribution pumping optimization control algorithm resets pump speed based on valve position of terminal equipment to minimize distribution pump energy usage.

n. Condenser water bypass control algorithm maintains minimum flow equivalent to flow required by the number of active distribution pumps.

o. Geothermal loop and fluid cooler loop control algorithms will result in loop supply water being short-circuited back into loop return water when minimum required flow for enabled loop pump(s) exceeds condenser water loop actual flow.

p. Geothermal loop, domestic hot water loop, and fluid cooler loop control algorithms inherently include duty status rotation for all equipment by setting next active equipment equivalent to the inactive equipment with shortest runtime.

q. Geothermal loop, domestic hot water loop, and fluid cooler loop, and boiler control algorithms include heat transfer calculations.

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.

Heatpump: _____

Heatpump: _____

Heat exchanger: _____

Domestic storage tank: _____

Fluid cooler: _____

Fluid cooler: _____

Boiler: _____

Boiler: _____

Distribution pump: _____

Distribution pump: _____

Distribution pump: _____

Heatpump loop pump: _____
Heatpump loop pump: _____
Heat exchanger pump: _____
Heat exchanger pump: _____
Geothermal loop pump: _____
Geothermal loop pump: _____
Fluid cooler loop pump: _____
Fluid cooler loop pump: _____
Fluid cooler spray pump: _____
Fluid cooler spray pump: _____
Boiler circulating pump: _____
Boiler circulating 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:			
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**	
Heatpump (___):								
Status					-	-	-	
Percent output					-	-	-	
Valve position	% Open				-	-	-	
Valve position confirmation					-			
Heatpump (___):								
Status					-	-	-	
Percent output					-	-	-	
Valve position	% Open				-	-	-	
Valve position confirmation					-			
Fluid cooler (___):								
Status					-	-	-	
Speed					-	-	-	
Fan vibration					-	-	-	
Basin heater					-	-	-	
Valve position	% Open				-	-	-	
Valve position confirmation					-			
Fluid cooler (___):								
Status					-	-	-	
Speed					-	-	-	
Fan vibration					-	-	-	
Basin heater					-	-	-	
Valve position	% Open				-	-	-	
Valve position confirmation					-			
Boiler (___):								
Status					-	-	-	
Percent output					-	-	-	
Entering temp					-	-	-	

CONTROL SYSTEM FEATURES								
POINT DESCRIPTION	UNIT	VISIBLE / IMBEDDED	TYPE	VALUE / STATUS	SETPT / ALARM			NOTES
					ALARM MIN	SETPT	ALARM MAX	
Leaving temp					-	-		
Boiler (___):								
Status					-	-	-	
Percent output					-	-	-	
Entering temp					-	-	-	
Leaving temp					-	-		
Distribution pump (___):								
Status					-	-	-	
Speed					-	-	-	
Distribution pump (___):								
Status					-	-	-	
Speed					-	-	-	
Distribution pump (___):								
Status					-	-	-	
Speed					-	-	-	
Heatpump loop pump (___):								
Status					-	-	-	
Heatpump loop pump (___):								
Status					-	-	-	
Heat exchanger pump (___):								
Status					-	-	-	
Heat exchanger pump (___):								
Status					-	-	-	
Geothermal loop pump (___):								
Status					-	-	-	
Speed					-	-	-	
Geothermal loop pump (___):								
Status					-	-	-	
Speed					-	-	-	
Fluid cooler loop pump (___):								
Status					-	-	-	
Speed					-	-	-	
Fluid cooler loop pump (___):								
Status					-	-	-	
Speed					-	-	-	
Fluid cooler spray pump (___):								
Status					-	-	-	
Fluid cooler spray pump (___):								
Status					-	-	-	
Boiler circulating pump (___):								
Status					-	-	-	

CONTROL SYSTEM FEATURES								
POINT DESCRIPTION	UNIT	VISIBLE / IMBEDDED	TYPE	VALUE / STATUS	SETPT / ALARM			NOTES
					ALARM MIN	SETPT	ALARM MAX	
Boiler circulating pump (___):								
Status					-	-	-	
Condenser water loop:								
Sup temp(TS-14)								
Ret temp(TS-1)						-		
Flow (FM-1)					-			
Heatpump loop:								
Sup temp(TS-3)								
Ret temp(TS-2)						-		
Flow (FM-2)					-			
Geothermal loop:								
Sup temp(TS-6)								
Ret temp(TS-5)						-		
Flow (FM-3)					-			
Fluid cooler loop:								
Sup temp(TS-9)								
Ret temp(TS-8)						-		
Flow (FM-4)					-			
Boiler loop:								
Sup temp(TS-12)								
Ret temp(TS-11)						-		
Flow (FM-5)					-			

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**
Heatpump (___):			
Status			
Percent output			
Heatpump (___):			
Status			
Percent output			
Boiler (___):			
Status			
Percent output			
Entering temp			
Leaving temp			
Boiler (___):			
Status			
Percent output			
Entering temp			
Leaving temp			
Condenser water loop:			
Supply temp (TS-14)			
Return temp (TS-1)			
Flow (FM-1)	/		
Heatpump loop:			
Supply temp (TS-3)			
Return temp (TS-2)			
Flow (FM-2)	/		
Geothermal loop:			
Supply temp (TS-6)			
Return temp (TS-5)			
Flow (FM-3)	/		
Fluid cooler loop:			
Supply temp (TS-11)			
Return temp (TS-9)			
Flow (FM-4)	/		
Boiler loop:			
Supply temp (TS-12)			
Return temp (TS-11)			
Flow (FM-5)	/		

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**	
Heatpump (___) isolation valve						
Heatpump (___) isolation valve						
Fluid cooler (___) isolation valve						
Fluid cooler (___) isolation valve						
Condenser water bypass valve						
Distribution pump (___) speed						
Distribution pump (___) speed						
Distribution pump (___) speed						
Geothermal loop pump (___) speed						

ACTUATORS AND MOTORS						
ACTUATOR DESCRIPTION	TYPE	MAXIMUM COMMAND		MINIMUM COMMAND		NOTES
		SIGNAL	POSITION / SPEED	SIGNAL	POSITION / SPEED	
Geothermal loop pump (___) speed						
Fluid cooler loop pump (___) speed						
Fluid cooler loop pump (___) speed						

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														

VARIABLE FREQUENCY DRIVE INFORMATION														
PARAMETER DESCRIPTION	**SERVED EQUIPMENT**													
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. Distribution pumping.
b. Domestic hot water loop.
c. Geothermal loop.
d. Fluid cooler loop.
e. Boiler loop.
f. Condenser water bypass.
g. Distribution pumping optimization.

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

a. Plant deactivation.
b. Plant activation.

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

a. High condenser water temperature.
b. Low condenser water temperature.
c. Heatpump general fault.
d. Heatpump failure type one.
e. Heatpump failure type two.
f. Fluid cooler general fault.
g. Fluid cooler failure type one.
h. Fluid cooler failure type two.
i. Boiler general fault.
j. Boiler failure type one.
k. Boiler failure type two.
l. Distribution pump general fault.
m. Distribution pump failure type one.
n. Distribution pump failure type two.
o. Heatpump loop pump failure type one.
p. Heatpump loop pump failure type two.
q. Heat exchanger pump failure.
r. Geothermal loop pump general fault.
s. Geothermal loop pump failure.
t. Fluid cooler loop pump general fault.
u. Fluid cooler loop pump failure.
v. Heatpump opposite status.
w. Fluid cooler opposite status.
x. Distribution pump opposite status.
y. Geothermal loop pump opposite status.
z. Fluid cooler loop pump 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 system is activated • Record observations in expected response /comments columns prior to manipulating parameters	Heatpump (___): Status: _____ % Output: _____ Valve position: _____		
02				
03				
04				
05		Heatpump (___): Status: _____ % Output: _____ Valve position: _____		
06				
07				
08				

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
09		Fluid cooler (___):		
10		Status: _____		
11		Fan speed: _____		
12		Basin heater: _____		
13		Valve position: _____		
14		Fluid cooler (___):		
15		Status: _____		
16		Fan speed: _____		
17		Basin heater: _____		
18		Valve position: _____		
19		Boiler (___):		
20		Status: _____		
21		% Output: _____		
22		Boiler (___):		
23		Status: _____		
24		% Output: _____		
25		Distribution pump (___):		
26		Status: _____		
27		Speed: _____		
28		Distribution pump (___):		
29		Status: _____		
30		Speed: _____		
31		Distribution pump (___):		
32		Status: _____		
33		Speed: _____		
34		Heatpump loop pump (___):		
35		Status: _____		
36		Heatpump loop pump (___):		
37		Status: _____		
38		Heat exchanger pump (___):		
39		Status: _____		
40		Heat exchanger pump (___):		
41		Status: _____		
42		Geothermal loop pump (___):		
43		Status: _____		
44		Speed: _____		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
45		Geothermal loop pump (___):		
46		Status: _____		
47		Speed: _____		
48		Fluid cooler loop pump (___):		
49		Status: _____		
50		Speed: _____		
51		Fluid cooler loop pump (___):		
52		Status: _____		
53		Speed: _____		
54		Fluid cooler spray pump (___):		
55		Status: _____		
56		Fluid cooler spray pump (___):		
57		Status: _____		
58		Boiler circulating pump (___):		
59		Status: _____		
60		Boiler circulating pump (___):		
61		Status: _____		
62		Condenser water loop:		
63		Sup tmp (TS-14): _____		
64		Ret tmp (TS-1): _____		
65		Flow (FM-1): _____		
66		Condenser water bypass:		
67		Valve position: _____		
68		Heatpump loop:		
69		Sup tmp (TS-2): _____		
70		Ret tmp (TS-3): _____		
71		Flow (FM-2): _____		
72		Geothermal loop:		
73		Sup tmp (TS-5): _____		
74		Ret tmp (TS-6): _____		
75		Flow (FM-3): _____		
76		Fluid cooler loop:		
77		Sup tmp (TS-8): _____		
78		Ret tmp (TS-9): _____		
79		Flow (FM-4): _____		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
80		Boiler loop:		
81		Sup tmp (TS-11): _____		
82		Ret tmp (TS-12): _____		
83		Flow (FM-5): _____		

Distribution Pumping Control Algorithm

Design Control Sequence:

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

- Set setpoint pressure equivalent to 15 psid when distribution pumping optimization control algorithm is inactive and equivalent to that set by distribution pumping optimization control algorithm when it is active
- Continuously set distribution pump disable setpoint flow (FM-1) equivalent to 90-percent of capacity of enabled distribution pumps minus one distribution pump
- Continuously set next active distribution pump equivalent to the inactive distribution pump with shortest runtime
- Continuously set next inactive distribution pump equivalent to the active distribution pump with longest runtime
- Monitor pressure sensor located is system loop
- Command enabled distribution pump(s) toward their maximum allowed motor speed upon detection of actual pressure being less than setpoint
- Enable next active distribution pump upon detection of enabled distribution pumps having been commanded to their maximum allowed motor speed and actual pressure being less than setpoint for a two-minute period
- Enabled distribution pumps equally share load
- Command enabled distribution pump(s) toward their minimum allowed motor speed upon detection of actual pressure being greater than setpoint
- Disable next inactive distribution pump upon detection of condenser water actual flow (FM-1) being equal to or less than distribution pump disable setpoint flow for a two-minute period
- Disable all distribution pumps upon detection of this control algorithm having been deactivated

84	To prepare for system response: • Deactivate distribution pumping optimization • Observe system status	Setpoint pressure set	CS of _____	
85		Distribution pump disable setpoint flow set	CS of _____	
86		Next active distribution pump set	CS of _____	
87		Next inactive distribution pump set	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
88		Pressure sensor monitored	CS of _____	
89	To observe system response to deficient capacity: • Override setpoint pressure to slightly greater than actual pressure	Enabled distribution pump(s) commanded towards their maximum allowed motor speed	CS of _____	
90	To observe system response to continued deficient capacity: • Override setpoint pressure to significantly greater than actual pressure	Two-minute period passes without control system action		
91		Next active distribution pump enabled	CS of _____	
92		Enabled distribution pump drives indicate nominally equivalent output	CS of _____	
93	To observe system response to excessive capacity: • Override setpoint pressure to slightly less than actual pressure	Enabled distribution pumps commanded towards their minimum allowed motor speed	CS of _____	
94	To observe system response to continued excessive capacity: • Override set load to significantly less than set distribution pump disable setpoint flow	Two-minute period passes without control system action		
95		Next inactive distribution pump disabled	CS of _____	
96	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**

Domestic Hot Water Loop Control Algorithm

Design Control Sequence:

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

- Set domestic storage tank activation setpoint temperature equivalent to 120 °F
- Set domestic storage tank deactivation setpoint temperature equivalent to 125 °F
- Continuously set domestic hot water storage tank actual temperature equivalent to the average of domestic hot water storage tank sensors (TS-15) and (TS-16)
- Continuously set response activation temperature equivalent to condenser water supply temperature (TS-14) plus 5.0 °F
- Continuously set response activation flow (FM-1) equivalent to the product of the number of active heatpumps plus one and 90 gpm
- Continuously set response deactivation flow (FM-1) equivalent to the product of the number of active heatpumps and 90 gpm
- Continuously set next active heatpump equivalent to the inactive heatpump with shortest runtime
- Continuously set next inactive heatpump equivalent to the active heatpump with longest runtime
- Continuously set next active heatpump loop pump equivalent to the inactive heatpump loop pump with shortest runtime
- Continuously set next inactive heatpump loop pump equivalent to the active heatpump loop pump with longest runtime
- Continuously set next active heat exchanger pump equivalent to the inactive heat exchanger pump with shortest runtime
- Continuously set next inactive heat exchanger pump equivalent to the active heat exchanger pump with longest runtime
- Monitor heatpump loop return temperature sensor (TS-2)
- Monitor heatpump loop supply temperature sensor (TS-3)
- Monitor heatpump loop water flow meter (FM-2)
- Monitor condenser water supply temperature sensor (TS-4)
- Monitor condenser water supply temperature sensor (TS-14)
- Monitor condenser water flow meter (FM-1)
- Continuously calculate heat transfer equivalent to (500) (FM-2) (ABS(TS-2 – TS-3))
- Command next active heatpump’s isolation valve to its 100-percent open position upon detection of all of the following having occurred for a five-minute period:
  - Condenser water return temperature (TS-1) being equal to or greater than response activation setpoint
  - Condenser water flow (FM-1) being equal to or greater than response activation setpoint
  - Domestic hot water tank actual temperature being equal to or less than domestic hot water tank activation setpoint temperature
  - Domestic hot water tank actual temperature being less than domestic hot water tank deactivation setpoint temperature

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Design Control Sequence (Concluded): • Command next active heatpump loop pump to operate at constant speed upon detection of next active heatpump's isolation valve having been confirmed to have been commanded to its 100-percent open position • Command next active heat exchanger pump to operate at constant speed upon detection of next active heatpump's isolation valve having been confirmed to have been commanded to its 100-percent open position • Enabled heatpumps equally share load • Disable next inactive heatpump upon detection of any of the following having occurred for a five-minute period: – Domestic hot water tank actual temperature being equal to greater than domestic hot water tank deactivation setpoint temperature – Condenser water return temperature (TS-1) being less than response activation setpoint – Condenser water flow (FM-1) being less than response deactivation setpoint • Command next inactive heatpump loop pump to inactive status upon detection of next inactive heatpump having been disabled for a five-minute period • Command next inactive heatpump isolation valve to its 0-percent open position upon detection of heatpump loop pump having been commanded to its inactive status • Command next inactive heat exchanger pump to its inactive status upon detection of all heatpumps having been disabled for a five-minute period			
97	To prepare for system response: • Observe system status	Domestic hot water storage tank activation setpoint temperature set	CS of _____	
98		Domestic hot water storage tank deactivation setpoint temperature set	CS of _____	
99		Domestic hot water storage tank actual temperature set	CS of _____	
100		Response activation setpoint temperature set	CS of _____	
101		Response activation setpoint flow set	CS of _____	
102		Response deactivation setpoint flow set	CS of _____	
103		Next active heatpump set	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
104		Next inactive heatpump set	CS of _____	
105		Next active heatpump loop pump set	CS of _____	
106		Next inactive heatpump loop pump set	CS of _____	
107		Next active heat exchanger pump set	CS of _____	
108		Next inactive heat exchanger pump set	CS of _____	
109		Heatpump loop return temperature sensor (TS-2) monitored	CS of _____	
110		Heatpump loop supply temperature sensor (TS-3) monitored	CS of _____	
111		Heatpump loop water flow meter (FM-2) monitored	CS of _____	
112		Condenser water supply temperature sensor (TS-4) monitored	CS of _____	
113		Condenser water supply temperature sensor (TS-14) monitored	CS of _____	
114		Condenser water flow meter (FM-1) monitored	CS of _____	
115	To observe system response to deficient heating capacity:	Five-minute period passes without control system action		
116	• Override domestic hot water activation temperature to significantly less than actual temperature • Override domestic hot water deactivation temperature to slightly greater than actual temperature	Next active heatpump's isolation valve commanded to its 100-percent open position	CS of _____	
117		Next active heatpump's isolation valve confirmed to have been commanded to its 100-percent open position	CS of _____	
118		Next active heatpump loop pump commanded to constant speed	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
119	• Initiate condenser water return temperature (TS-1) to be equal to or greater than response activation setpoint	Next active heat exchanger pump commanded to constant speed	CS of _____	
120		Next active heatpump enabled	CS of _____	
121	• Initiate condenser water flow (FM-1) to be equal to or greater than response activation setpoint	Heat transfer calculated	CS of _____	
122	To observe system response to continued deficient heating capacity:	Next active heatpump's isolation valve commanded to its 100-percent open position	CS of _____	
123	• Confirm domestic hot water activation temperature to significantly less than actual temperature	Next active heatpump loop pump commanded to constant speed	CS of _____	
124		Heat exchanger pump status maintained	CS of _____	
125	• Confirm domestic hot water deactivation temperature to slightly greater than actual temperature • Confirm condenser water return temperature (TS-1) to be equal to or greater than response activation setpoint • Initiate condenser water flow (FM-1) to be equal to or greater than response activation setpoint	Next active heatpump enabled	CS of _____	
126	To observe system response to excessive heating capacity:	Five-minute period passes without control system action		
127	• Override domestic hot water deactivation temperature to significantly less than actual temperature	Next inactive heatpump disabled	CS of _____	
128		Five-minute period passes without control system action		
129		Next inactive heatpump loop pump commanded to inactive status	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
130		Next inactive heatpump's isolation valve commanded to its 0-percent open position	CS of _____	
131		Heat exchanger pump status maintained	CS of _____	
132	To observe system response to continued excessive heating capacity: • To no action beyond observing system status	Five-minute period passes without control system action		
133		Next inactive heatpump disabled	CS of _____	
134		Five-minute period passes without control system action		
135		Next inactive heatpump loop pump commanded to inactive status	CS of _____	
136		Next inactive heatpump's isolation valve commanded to its 0-percent open position	CS of _____	
137		Heat exchanger pump status maintained	CS of _____	
138	To prepare for system response to deficient available condenser loop heat: • Override domestic hot water activation temperature to significantly less than actual temperature • Override domestic hot water deactivation temperature to slightly greater than actual temperature	Five-minute period passes without control system action		
139		Next active heatpump's isolation valve commanded to its 100-percent open position	CS of _____	
140		Next active heatpump's isolation valve confirmed to have been commanded to its 100-percent open position	CS of _____	
141		Next active heatpump loop pump commanded to constant speed	CS of _____	
142		Next active heat exchanger pump commanded to constant speed	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
143	• Initiate condenser water return temperature (TS-1) to be equal to or greater than response activation setpoint • Initiate condenser water flow (FM-1) to be equal to or greater than response activation setpoint	Next active heatpump enabled	CS of _____	
144	To observe system response to deficient available condenser loop heat: • Override response activation temperature equivalent to condenser water supply temperature (TS-14) plus 50.0 °F	Five-minute period passes without control system action		
145		Next inactive heatpump disabled	CS of _____	
146		Five-minute period passes without control system action		
147		Next inactive heatpump loop pump commanded to inactive status	CS of _____	
148		Next inactive heatpump's isolation valve commanded to its 0-percent open position	CS of _____	
149		Heat exchanger pump status maintained	CS of _____	
150	To prepare for system response to deficient condenser loop flow: • Confirm domestic hot water activation temperature to significantly less than actual temperature • Confirm domestic hot water deactivation temperature to slightly greater than actual temperature • Release response activation temperature calculation override	Five-minute period passes without control system action		
151		Next active heatpump's isolation valve commanded to its 100-percent open position	CS of _____	
152		Next active heatpump's isolation valve confirmed to have been commanded to its 100-percent open position	CS of _____	
153		Next active heatpump loop pump commanded to constant speed	CS of _____	
154		Next active heat exchanger pump commanded to constant speed	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
155	• Confirm condenser water return temperature (TS-1) to be equal to or greater than response activation setpoint • Confirm condenser water flow (FM-1) to be equal to or greater than response activation setpoint	Next active heatpump enabled	CS of _____	
156	To observe system response to deficient condenser loop flow:	Five-minute period passes without control system action		
157	• Override condenser water flow (FM-1) to be less than response deactivation setpoint	Next inactive heatpump disabled	CS of _____	
158		Five-minute period passes without control system action		
159		Next inactive heatpump loop pump commanded to inactive status	CS of _____	
160		Next inactive heatpump's isolation valve commanded to its 0-percent open position	CS of _____	
161		Heat exchanger pump status maintained	CS of _____	
162	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**

Geothermal Loop Control Algorithm

Design Control Sequence:

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

- Set heating activation setpoint temperature equivalent to 62 °F
- Set condenser supply water heating setpoint temperature equivalent to 65 °F
- Set cooling activation setpoint temperature equivalent to 70 °F
- Set condenser supply water cooling setpoint temperature equivalent to 68 °F
- Continuously set geothermal loop setpoint flow equivalent to the maximum of condenser water actual flow and the product of the number of active geothermal pumps and 25-percent of pump maximum flow
- Continuously set geothermal loop minimum setpoint flow equivalent to the number of active geothermal pumps and 25-percent of pump maximum flow
- Continuously set next active geothermal pump equivalent to the inactive geothermal loop pump with shortest runtime
- Activate geothermal loop heating mode upon detection of condenser water return temperature (TS-1) being less than condenser water supply temperature (TS-14)
- Activate geothermal loop cooling mode upon detection of condenser water return temperature (TS-1) being equal to or greater than condenser water supply temperature (TS-14)
- Continuously set next inactive geothermal loop pump equivalent to the active geothermal loop pump with longest runtime
- Monitor geothermal loop return temperature sensor (TS-5)
- Monitor geothermal loop supply temperature sensor (TS-6)
- Monitor geothermal loop water flow meter (FM-3)
- Monitor condenser water supply temperature sensor (TS-7)
- Monitor condenser water flow meter (FM-1)
- Continuously calculate heat transfer equivalent to (500) (FM-3) (ABS(TS-5 – TS-6))
- Enable next active geothermal loop pump upon detection of actual condenser water supply temperature (TS-7) being equal to or less than heating activation temperature for a five-minute period
- Enable next active geothermal loop pump upon detection of actual condenser water supply temperature (TS-7) being equal to or greater than cooling activation setpoint temperature for a five-minute period
- Command enabled geothermal loop pumps toward geothermal loop setpoint flow upon detection of actual temperature (TS-7) being less than heating setpoint or condenser supply water actual temperature (TS-7) being greater than cooling setpoint

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Design Control Sequence (Concluded): • Command enabled geothermal loop pumps toward minimum setpoint flow (FM-2) upon detection of heating mode having been activated and condenser supply water actual temperature (TS-7) being greater than heating setpoint or cooling mode having been activated and condenser supply water actual temperature (TS-7) being less than cooling setpoint • Disable next inactive geothermal loop pump upon detection condenser supply water actual temperature (TS-7) being greater than heating activation setpoint for a five-minute period and condenser supply water actual temperature (TS-7) being less than cooling activation setpoint for a five-minute period • Disable all geothermal loop pumps upon detection of this control algorithm having been deactivated				
163	To prepare for system response: • Observe system status	Heating activation setpoint temperature set	CS of _____	
164		Condenser supply water heating setpoint temperature set	CS of _____	
165		Cooling activation setpoint temperature set	CS of _____	
166		Condenser supply water cooling setpoint temperature set	CS of _____	
167		Geothermal loop setpoint flow set	CS of _____	
168		Geothermal loop minimum setpoint flow set	CS of _____	
169		Geothermal loop heating / cooling mode set	CS of _____	
170		Next active geothermal pump set	CS of _____	
171		Next inactive geothermal loop pump set	CS of _____	
172		Geothermal loop return temperature sensor (TS-5) monitored	CS of _____	
173		Geothermal loop supply temperature sensor (TS-6) monitored	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
174		Geothermal loop water flow meter (FM-3) monitored	CS of _____	
175		Condenser water supply temperature sensor (TS-7) monitored	CS of _____	
176		Condenser water flow meter (FM-1) monitored	CS of _____	
177	To observe system response to deficient heating capacity: • Initiate condenser water return temperature (TS-1) to be less than condenser water supply temperature (TS-14) • Override heating activation setpoint temperature to significantly greater than actual temperature (TS-7) • Override supply water heating setpoint temperature to significantly greater than actual temperature (TS-7)	Five-minute period passes without control system action		
178		Next active geothermal loop pump enabled	CS of _____	
179		Enabled geothermal loop pump commanded to its setpoint flow	CS of _____	
180		Heat transfer calculated	CS of _____	
181	To observe system response to excessive heating capacity: • Override supply water heating setpoint temperature to significantly less than actual temperature (TS-7)	Enabled geothermal loop pump commanded to its minimum setpoint flow	CS of _____	
182	To observe system response to continued excessive heating capacity: • Override supply water heating activation setpoint temperature to significantly less than actual temperature (TS-7)	Next inactive geothermal loop pump disabled	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
183	Release all overrides	System returns to pre-test conditions		
184	To observe system response to deficient cooling capacity: • Initiate condenser water return temperature (TS-1) to be greater than condenser water supply temperature (TS-14) • Override cooling activation setpoint temperature to significantly less than actual temperature (TS-7) • Override supply water cooling setpoint temperature to significantly less than actual temperature (TS-7)	Five-minute period passes without control system action		
185		Next active geothermal loop pump enabled	CS of _____	
186		Enabled geothermal loop pump commanded to its setpoint flow	CS of _____	
187		Heat transfer calculated	CS of _____	
188	To observe system response to excessive cooling capacity: • Override supply water cooling setpoint temperature to significantly greater than actual temperature (TS-7)	Enabled geothermal loop pump commanded to its minimum setpoint flow	CS of _____	
189	To observe system response to continued excessive cooling capacity: • Override supply water cooing activation setpoint temperature to significantly greater than actual temperature (TS-7)	Next inactive geothermal loop pump disabled	CS of _____	
190	To prepare for system response to fluctuating condenser water flow:	Five-minute period passes without control system action		
191		Next active geothermal loop pump enabled	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
192	• Initiate condenser water return temperature (TS-1) to be greater than condenser water supply temperature (TS-14) • Override cooling activation setpoint temperature to significantly less than actual temperature (TS-7) • Override supply water cooling setpoint temperature to significantly less than actual temperature (TS-7)	Enabled geothermal loop pump commanded to its setpoint flow	CS of _____	
193	To observe system response to reduced condenser water flow:	Geothermal loop minimum setpoint flow set	CS of _____	
194	• Command one terminal equipment to cooling demand • Command all terminal equipment to no heating or cooling demand	Enabled geothermal loop pump commanded to its minimum setpoint flow	CS of _____	
195	To observe system response to increased condenser water flow:	Geothermal loop setpoint flow set	CS of _____	
196	• Command all terminal equipment to cooling demand	Enabled geothermal loop pump commanded to its setpoint flow	CS of _____	
197	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**

Fluid Cooler Loop Control Algorithm

Design Control Sequence:

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

- Set fluid cooler staging setpoint temperature (TS-10) equivalent to 90 °F
- Set condenser supply water control setpoint temperature (TS-10) equivalent to 88 °F
- Continuously set fluid cooler loop setpoint flow (FM-4) equivalent to the maximum of:
  - Condenser water actual flow (FM-1)
  - Product of the number of fluid cooler isolation valves confirmed in their 100-percent open position and 550 gpm
  - Product of the number of active fluid cooler loop pumps and 25-percent of pump maximum flow
- Continuously set next active fluid cooler equivalent to the inactive fluid cooler with shortest runtime
- Continuously set next inactive fluid cooler equivalent to the active fluid cooler with longest runtime
- Continuously set next active fluid cooler loop pump equivalent to the inactive fluid cooler loop pump with shortest runtime
- Continuously set next inactive fluid cooler loop pump equivalent to the active fluid cooler loop pump with longest runtime
- Monitor fluid cooler loop return temperature sensor (TS-8)
- Monitor fluid cooler loop supply temperature sensor (TS-9)
- Monitor fluid cooler loop water flow meter (FM-4)
- Monitor condenser water supply temperature sensor (TS-10)
- Monitor condenser water flow meter (FM-1)
- Continuously calculate heat transfer equivalent to (500) (FM-4) (ABS(TS-8 – TS-9))
- Command next active fluid cooler’s isolation valve to its 100-percent open position upon detection of actual condenser water supply temperature (TS-10) being greater than staging setpoint for a five-minute period
- Enable next active fluid cooler loop pump and command to setpoint flow upon detection of next active fluid cooler’s isolation valve having been confirmed to have been commanded to its 100-percent open position
- Enabled fluid cooler’s output matches load
- Command next active fluid cooler’s isolation valve to its 100-percent open position upon detection of one fluid cooler’s isolation valve having been commanded to its 100-percent open position and actual condenser water supply temperature (TS-10) being greater than staging setpoint for a five-minute period
- Enabled fluid coolers equally share load
- Command first fluid cooler spray pump to operate at constant speed upon detection of all fluid cooler isolation valves having been commanded to their 100-percent open position and actual condenser water supply temperature (TS-10) being greater than staging setpoint for a five-minute period

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Design Control Sequence (Concluded): • Command second fluid cooler spray pump to operate at constant speed upon detection of first fluid cooler spray pump having been commanded to its active status and actual condenser water supply temperature (TS-10) being greater than staging setpoint for a five-minute period • Enable first fluid cooler fan and command to its minimum allowed motor speed upon detection of all fluid cooler spray pumps having been commanded to their active status and actual condenser water supply temperature (TS-10) being greater than staging setpoint for a five-minute period • Enable second fluid cooler fan and command to its minimum allowed motor speed upon detection of first fluid cooler fan having been enabled and actual condenser water supply temperature (TS-10) being greater than staging setpoint for a five-minute period • Command enabled fluid cooler fans equally toward their maximum allowed motor speed upon detection of actual condenser water supply temperature (TS-10) being greater than setpoint • Command enabled fluid cooler fans equally toward their minimum allowed motor speed upon detection of actual condenser water supply temperature (TS-10) being equal to or less than setpoint • Disable all fluid cooler fans upon detection of fans having been commanded to their minimum allowed motor speed and actual condenser water supply temperature (TS-10) being equal to or less than setpoint for a five-minute period • Command all fluid spray pumps to their inactive status upon detection of fans having been disabled and actual condenser water supply temperature (TS-10) being equal to or less than setpoint for a five-minute period • Command next inactive fluid cooler's isolation valve to its 0-percent open position upon detection of fluid spray pumps having commanded to their inactive status and actual condenser water supply temperature (TS-10) being equal to or less than setpoint for a five-minute period • Enabled fluid cooler's output matches load • Disable next inactive fluid cooler loop pump upon detection of only one fluid cooler status being active and actual condenser water supply temperature (TS-10) being equal to or less than setpoint for a five-minute period • Command next inactive fluid cooler's isolation valve to its 0-percent open position upon detection of next inactive fluid cooler loop pump having been disabled • Disable all fluid cooler loop pumps, fluid cooler spray pumps, fluid coolers, and command fluid cooler isolation valves to their 0-percent open position upon detection of this control algorithm having been deactivated			
198	To prepare for system response:	Fluid cooler staging setpoint temperature set	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
199	• Observe system status	Condenser supply water setpoint temperature set	CS of _____	
200		Fluid cooler loop setpoint flow set	CS of _____	
201		Next active fluid cooler set	CS of _____	
202		Next inactive fluid cooler set	CS of _____	
203		Next active fluid cooler loop pump set	CS of _____	
204		Next inactive fluid cooler loop pump set	CS of _____	
205		Fluid cooler loop return temperature sensor (TS-8) monitored	CS of _____	
206		Fluid cooler loop supply temperature sensor (TS-9) monitored	CS of _____	
207		Fluid cooler loop water flow meter (FM-4) monitored	CS of _____	
208		Condenser water supply temperature sensor (TS-10) monitored	CS of _____	
209		Condenser water flow meter (FM-1) monitored	CS of _____	
210	To observe system response to deficient cooling capacity:	Five-minute period passes without control system action		
211	• Override fluid cooler staging temperature to significantly less than actual temperature (TS-10)	Next active fluid cooler's isolation valve commanded to its 100-percent open position	CS of _____	
212	• Override fluid cooler supply water setpoint temperature to significantly less than actual temperature (TS-10)	Next active fluid cooler's isolation valve confirmed in its 100-percent open position	CS of _____	
213		Next active fluid cooler loop pump enabled	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
214		Enabled geothermal pump commanded to its setpoint flow	CS of _____	
215		Five-minute period passes without control system action		
216		Next active fluid cooler's isolation valve commanded to its 100-percent open position	CS of _____	
217		Five-minute period passes without control system action		
218		First fluid cooler spray pump commanded to operate at constant speed	CS of _____	
219		Five-minute period passes without control system action		
220		Second fluid cooler spray pump commanded to operate at constant speed	CS of _____	
221		Five-minute period passes without control system action		
222		First fluid cooler fan enabled and commanded to minimum allowed motor speed	CS of _____	
223		Five-minute period passes without control system action		
224		Second fluid cooler fan enabled and commanded to minimum allowed motor speed	CS of _____	
225		Enabled fluid cooler fans commanded to maximum allowed motor speed	CS of _____	
226		Heat transfer calculated	CS of _____	
227	To observe system response to excessive cooling capacity:	Enabled fluid cooler fans commanded to their minimum allowed motor speed	CS of _____	
228		Five-minute period passes without control system action		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
229	• Override supply water setpoint temperature to significantly greater than actual temperature (TS-10)	Fluid cooler fans disabled	CS of _____	
230		Five-minute period passes without control system action		
231		Fluid cooler spray pumps commanded to their inactive status	CS of _____	
232		Five-minute period passes without control system action		
233		Next inactive fluid cooler’s isolation valve commanded to its 0-percent open position	CS of _____	
234		Fluid cooler loop setpoint flow set	CS of _____	
235		Enabled geothermal pump commanded to its setpoint flow	CS of _____	
236		Five-minute period passes without control system action		
237		Next inactive fluid cooler loop pump disabled	CS of _____	
238		Next inactive fluid cooler’s isolation valve commanded to its 0-percent open position	CS of _____	
239	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Boiler Loop Control Algorithm Design Control Sequence: Upon detection of this control algorithm having been activated, the control system shall: • Set boiler staging setpoint temperature equivalent to 60 °F • Set condenser supply water setpoint temperature equivalent to 65 °F • Monitor boiler loop return temperature sensor (TS-11) • Monitor boiler loop supply temperature sensor (TS-12) • Monitor boiler loop water flow meter (FM-5) • Monitor condenser water supply temperature sensor (TS-13) • Continuously calculate heat transfer equivalent to (500) (FM-5) (ABS(TS-11 – TS-12)) • Transmit activation signal to boiler control panel upon detection of actual condenser water supply temperature (TS-13) being less than boiler staging temperature for a five-minute period • Transmit condenser supply water setpoint temperature (TS-13) to boiler control panel • Boiler control panel shall enable first boiler circulating pump and first enable boiler upon detection of boiler activation signal having been received and actual condenser water supply temperature (TS-13) being less than setpoint temperature • Enabled boiler output matches load • Boiler control panel shall enable second boiler circulating pump and enable second boiler upon detection of first boiler having been activated and actual condenser water supply (TS-13) temperature being less than setpoint temperature • Enabled boilers equally share load • Boiler control panel shall disable first boiler and disable first boiler circulating pump upon detection of actual load being equal to or less than 90-percent of capacity of enabled boilers minus capacity of one boiler • Boiler control panel shall disable second boiler and second boiler circulating pump upon detection of second boiler having been commanded to minimum output and condenser supply water actual temperature being (TS-13) equal to or greater than setpoint • Transmit deactivation signal to boiler control panel upon detection of actual condenser water supply (TS-13) temperature being equal to or greater than boiler staging temperature for a five-minute period • Transmit boiler deactivation signal to boiler control panel upon detection of this control algorithm having been deactivated			
240	To prepare for system response: • Observe system status	Boiler staging setpoint temperature set	CS of _____	
241		Condenser supply water setpoint temperature set	CS of _____	
242		Boiler loop return temperature sensor (TS-11) monitored	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
243		Boiler loop supply temperature sensor (TS-12) monitored	CS of _____	
244		Boiler loop water flow meter (FM-5) monitored	CS of _____	
245		Condenser water supply temperature sensor (TS-13) monitored	CS of _____	
246	To observe system response to deficient heating capacity: • Override boiler staging setpoint temperature to slightly greater than actual temperature (TS-13) • Override supply water setpoint temperature to slightly greater than actual temperature (TS-13)	Five-minute period passes without control system action		
247		Activation signal transmitted to boiler control panel	CS of _____	
248		Supply water setpoint temperature transmitted to boiler control panel	CS of _____	
249		Boiler control panel enables first boiler circulating pump and first boiler	CS of _____	
250		First boiler output matches load	CS of _____	
251		Heat transfer calculated	CS of _____	
252	To observe system response to continued deficient heating capacity: • Override supply water setpoint temperature to significantly greater than actual temperature (TS-13)	Boiler control panel enables second boiler circulating pump and second boiler	CS of _____	
253		Enabled boilers equally share load	CS of _____	
254	To observe system response to excessive heating capacity: • Override supply water heating setpoint temperature to slightly less than actual temperature (TS-13)	Boiler control panel disables first boiler and first boiler circulating pump	CS of _____	
255	To observe system response to continued	Deactivation signal transmitted to boiler control panel	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
256	excessive heating capacity: • Override boiler staging setpoint temperature to significantly less than actual temperature (TS-13)	Boiler control panel disables second boiler and second boiler circulating pump	CS of _____	
257	Release all overrides	System returns to pre-test conditions		
Condenser Water Bypass Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Set bypass water setpoint flow equivalent to the number of active distribution pumps and 25-percent of pump maximum flow • Monitor condenser water flow meter (FM-1) • Command condenser water bypass valve towards its 100-percent open position upon detection of actual flow being less than setpoint • Command condenser water bypass valve towards its 0-percent open position upon detection of actual flow being greater than setpoint				
258	To prepare for system response: • Initiate at least one terminal equipment control valve to its 100-percent open position • Observe system status	Condenser water bypass setpoint flow set	CS of _____	
259		Water flow meter monitored	CS of _____	
260	To observe system response to deficient flow: • Override setpoint water flow to slightly greater than actual flow (FM-1)	Condenser water bypass valve commanded towards its 100-percent open position	CS of _____	
261	To observe system response to excessive flow: • Override setpoint water flow to slightly less than actual flow (FM-1)	Condenser water bypass valve commanded towards its 0-percent open position	CS of _____	
262	To observe system response to increased	Bypass water setpoint flow reset	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
263	number of active distribution pumps: • Initiate increased number of active distribution pumps	Enabled distribution pumps commanded towards their maximum allowed motor speed	CS of _____	
264	To observe system response to decreased number of active distribution pumps: • Initiate decreased number of active distribution pumps	Next inactive chiller circuit disabled	CS of _____	
265		Bypass water setpoint flow reset	CS of _____	
266	Release all overrides	System returns to pre-test conditions		
Distribution Pumping Optimization Control Algorithm Design Control Sequence: Upon detection of this algorithm having been activated, the control system shall: • Monitor each terminal equipment's control valve position • Command enabled pump(s) toward their maximum allowed motor speed upon detection of any control valve having been commanded to greater than its 95-percent open position • Command enabled pump(s) toward their minimum allowed motor speed upon detection of no control valve having been commanded to greater than its 80-percent open position and no control valve having been commanded to greater than its 95-percent open position				
267	To prepare for system response: • Observe system status	Each terminal equipment's control valve position monitored	CS of _____	
268	To observe system response to deficient pressure: • Override one control valve to its 97-percent open position	Enabled pump(s) commanded towards their maximum allowed motor speed	CS of _____	
269	To observe system response to excessive pressure: • Override all control valves to their 50-percent open position	Enabled pump(s) commanded towards their minimum allowed motor speed	CS of _____	
270	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Plant Deactivation Operation Mode Design Control Sequence: Upon detection of completion of plant activation operation mode and all terminal control valves having been commanded to their 0-percent open position for a five-minute period, the control system shall: • Deactivate boiler loop control algorithm • Deactivate fluid cooler loop control algorithm • Deactivate geothermal loop control algorithm • Deactivate domestic hot water loop control algorithm • Deactivate distribution pumping control algorithm • Deactivate condenser water bypass control algorithm • Deactivate distribution pumping optimization control algorithm				
271	To observe system response: • Override all terminal equipment control valves to their 0-percent open position	Five-minute period passes without control system action		
272		Boiler loop control algorithm deactivated	CS of _____	
273		Fluid cooler loop control algorithm deactivated		
274		Geothermal loop control algorithm deactivated	CS of _____	
275		Domestic hot water loop control algorithm deactivated	CS of _____	
276		Distribution pumping control algorithm deactivated	CS of _____	
277		Condenser water bypass control algorithm deactivated	CS of _____	
278		Distribution pumping optimization control algorithm deactivated	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Plant Activation Operation Mode Design Control Sequence: Upon detection of any single terminal control valve having been commanded towards its 100-percent open position for a five-minute period, the control system shall: • Activate distribution pumping control algorithm • Activate domestic hot water loop control algorithm • Activate geothermal loop control algorithm • Activate fluid cooler loop control algorithm • Activate boiler loop control algorithm • Activate condenser water bypass control algorithm • Activate distribution pumping optimization control algorithm				
279	To observe system response: • Override one terminal equipment control valve to its 100-percent open position	Five-minute period passes without control system action		
280		Distribution pumping control algorithm activated	CS of _____	
281		Domestic hot water loop control algorithm activated	CS of _____	
282		Geothermal loop control algorithm activated	CS of _____	
283		Fluid cooler loop control algorithm activated	CS of _____	
284		Boiler loop control algorithm activated	CS of _____	
285		Condenser water bypass control algorithm activated	CS of _____	
286		Distribution pumping optimization control algorithm activated	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
High Condenser Water Temperature Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode, the control system shall: • Set stage one alarm setpoint temperature equivalent to 100 °F • Set stage two alarm setpoint temperature equivalent to 110 °F • Monitor condenser water supply temperature sensor (TS-14) • Initiate visual alarm at Operator workstation upon detection of condenser water temperature being equal to or greater than stage one alarm setpoint temperature • Initiate audible and visual alarms at Operator workstation upon detection of condenser water temperature being equal to or greater than stage two alarm setpoint temperature				
287	To prepare for system response: • Observe system status	Stage one alarm setpoint temperature set	CS of _____	
288		Stage two alarm setpoint temperature set	CS of _____	
289	To observe system response to stage one alarm: • Override stage one alarm setpoint temperature to slightly less than actual temperature	Visual alarm initiated at Operator workstation		
290	To observe system response to stage two alarm: • Override stage two alarm setpoint temperature to significantly less than actual temperature	Audible and visual alarms initiated at Operator workstation		
291	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Low Condenser Water Temperature Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode, the control system shall: • Set low condenser water alarm setpoint temperature equivalent to 50 °F • Monitor condenser water supply temperature sensor (TS-14) • Initiate audible and visual alarms at Operator workstation upon detection of actual supply water temperature being equal to or less than alarm setpoint temperature				
292	To prepare for system response: • Observe system status	Alarm setpoint temperature set	CS of _____	
293		Condenser water supply temperature monitored	CS of _____	
294	To observe system response: • Override low supply water alarm setpoint temperature to significantly greater than actual temperature	Audible and visual alarms initiated at Operator workstation		
295	Release all overrides	System returns to pre-test conditions		
Heatpump (___) General Fault Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and heatpump general fault alarm, the control system shall: • Initiate visual alarm at Operator workstation • Maintain heatpump loop active status				
296	To observe system response: • Initiate heatpump fault at heatpump's control panel	Visual alarm initiated at Operator workstation		
297		Heatpump loop status maintained	CS of _____	
298	Release all overrides	System returns to pre-test conditions		
Heatpump (___) General Fault Alarm Condition				
299	To observe system response: • Initiate heatpump fault at heatpump's control panel	Visual alarm initiated at Operator workstation		
300		System status maintained	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
301	Release all overrides	System returns to pre-test conditions		
Heatpump (___) Failure Type One Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and a heatpump failure alarm status without all heatpumps being active, the control system shall: • Continuously set next active heatpump equivalent to the inactive heatpump with shortest runtime • Initiate audible and visual alarms at Operator workstation • Disable failed heatpump • Enable next active heatpump • Maintain heatpump loop pump statuses				
302	To prepare for system response: • Initiate only one heatpump to active status • Observe system status	Next active heatpump set	CS of _____	
303		Only one heatpump's status active	CS of _____	
304	To observe system response: • Manually turn heatpump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
305		Failed heatpump disabled	CS of _____	
306		Next active heatpump enabled	CS of _____	
307		Heatpump loop pump statuses maintained	CS of _____	
308	Release all overrides	System returns to pre-test conditions		
Heatpump (___) Failure Type One Alarm Condition				
309	To observe system response: • Manually turn heatpump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
310		Failed heatpump disabled	CS of _____	
311		Next active heatpump enabled	CS of _____	
312		Heatpump loop pump statuses maintained	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
313	Release all overrides	System returns to pre-test conditions		
Heatpump (___) Failure Type Two Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and a heatpump failure alarm status with all heatpumps being active, the control system shall: • Continuously set next inactive heatpump loop pump equivalent to the active heatpump loop pump with longest runtime • Initiate audible and visual alarms at Operator workstation • Disable failed heatpump • Command failed heatpump's isolation valve to its 0-percent open position • Disable next inactive heatpump loop pump				
314	To prepare for system response: • Initiate all heatpumps to active status • Observe system status	All heatpump statuses active	CS of _____	
315		Next inactive heatpump loop pump set	CS of _____	
316	To observe system response: • Manually turn heatpump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
317		Failed heatpump disabled	CS of _____	
318		Failed heatpump's isolation valve commanded to its 0-percent open position	CS of _____	
319		Next inactive heatpump loop pump disabled	CS of _____	
320	Release all overrides	System returns to pre-test conditions		
Fluid Cooler (___) General Fault Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and fluid cooler general fault alarm, the control system shall: • Initiate visual alarm at Operator workstation • Maintain fluid cooler loop active status				
321	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
322		Fluid cooler loop status maintained	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
323	Release all overrides	System returns to pre-test conditions		
Fluid Cooler (___) General Fault Alarm Condition				
324	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
325		System status maintained	CS of _____	
326	Release all overrides	System returns to pre-test conditions		
Fluid Cooler (___) Failure Type One Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and a fluid cooler failure alarm status without all fluid cooler being active, the control system shall: • Continuously set next active fluid cooler circuit equivalent to the inactive fluid cooler with shortest runtime • Initiate audible and visual alarms at Operator workstation • Disable failed fluid cooler • Command failed fluid cooler's isolation valve to its 0-percent open position • Command next active fluid cooler's isolation valve to its 100-percent open position • Enable next active fluid cooler • Maintain fluid cooler loop pump statuses				
327	To prepare for system response: • Initiate only one fluid cooler to active status • Observe system status	Next active fluid cooler circuit set	CS of _____	
328		Only one fluid cooler's status active	CS of _____	
329	To observe system response: • Manually turn fluid cooler's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
330		Failed fluid cooler disabled	CS of _____	
331		Failed fluid cooler's isolation valve commanded to its 0-percent open position	CS of _____	
332		Next active fluid cooler's isolation valve commanded to its 100-percent open position	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
333		Next active fluid cooler enabled	CS of _____	
334		Chiller statuses maintained	CS of _____	
335		Fluid cooler loop pump statuses maintained	CS of _____	
336	Release all overrides	System returns to pre-test conditions		
Fluid Cooler (___) Failure Type One Alarm Condition				
337	To observe system response: • Manually turn fluid cooler's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
338		Failed fluid cooler disabled	CS of _____	
339		Failed fluid cooler's isolation valve commanded to its 0-percent open position	CS of _____	
340		Next active fluid cooler's isolation valve commanded to its 100-percent open position	CS of _____	
341	Release all overrides	System returns to pre-test conditions		
Fluid Cooler (___) Failure Type Two Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and a fluid cooler failure alarm status with all coolers being active, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable failed fluid cooler • Command failed fluid cooler's isolation valve to its 0-percent open position • Command associated fluid cooler spray pump to inactive status				
342	To prepare for system response: • Initiate all fluid coolers to active status • Observe system status	All fluid cooler statuses active	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
343	To observe system response: • Manually turn fluid cooler's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
344		Failed fluid cooler disabled	CS of _____	
345		Failed fluid cooler's isolation valve commanded to its 0-percent open position	CS of _____	
346		Associated fluid cooler spray pump commanded to inactive status	CS of _____	
347	Release all overrides	System returns to pre-test conditions		
Boiler (___) General Fault Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and boiler general fault alarm, the control system shall: • Receive general alarm signal from boiler control panel • Initiate visual alarm at Operator workstation • Maintain boiler loop active status				
348	To observe system response: • Initiate boiler fault at boiler's control panel	Receive general alarm signal from boiler control panel		
349		Visual alarm initiated at Operator workstation		
350		Boiler loop status maintained	CS of _____	
351	Release all overrides	System returns to pre-test conditions		
Boiler (___) General Fault Alarm Condition				
352	To observe system response: • Initiate boiler fault at boiler's control panel	Receive alarm signal from boiler control panel		
353		Visual alarm initiated at Operator workstation		
354		Boiler loop status maintained	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
355	Release all overrides	System returns to pre-test conditions		
Boiler (___) Failure Type One Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and a boiler failure alarm status without all boilers being active, the control system shall: • Receive failure alarm signal from boiler control panel • Initiate audible and visual alarms at Operator workstation • Receive signal of failed boiler deactivation • Receive signal of failed boiler's boiler circulating pump deactivation • Receive signal of next available boiler's boiler circulating pump activation • Receive signal of next available boiler activation				
356	To prepare for system response: • Initiate only one boiler to active status • Observe system status	Only one boiler's status active	CS of _____	
357	To observe system response: • Manually turn a boiler's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
358		Boiler control panel deactivated failed boiler		
359		Signal of failed boiler deactivation received		
360		Boiler control panel deactivated failed boiler's boiler circulating pump		
361		Signal of failed boiler's boiler circulating pump deactivation received		
362		Boiler control panel activated next available boiler's boiler circulating pump		
363		Signal of next available boiler's boiler circulating pump activation received		
364		Boiler control panel activated next available boiler		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
365		Signal of next available boiler activation received		
366	Release all overrides	System returns to pre-test conditions		
Boiler (___) Failure Type One Alarm Condition				
367	To observe system response: • Manually turn a boiler's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
368		Boiler control panel deactivated failed boiler		
369		Signal of failed boiler deactivation received		
370		Boiler control panel deactivated failed boiler's boiler circulating pump		
371		Signal of failed boiler's boiler circulating pump deactivation received		
372		Boiler control panel activated next available boiler's boiler circulating pump		
373		Signal of next available boiler's boiler circulating pump activation received		
374		Boiler control panel activated next available boiler		
375		Signal of next available boiler activation received		
376	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Boiler (___) Failure Type Two Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and a heatpump failure alarm status with all boilers being active, the control system shall: • Receive failure alarm signal from boiler control panel • Initiate audible and visual alarms at Operator workstation • Receive signal of failed boiler deactivation • Receive signal of failed boiler's boiler circulating pump deactivation				
377	To prepare for system response: • Initiate all boilers to active status • Observe system status	All boiler statuses active	CS of _____	
378	To observe system response: • Manually turn a boiler's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
379		Boiler control panel deactivated failed boiler		
380		Signal of failed boiler deactivation received		
381		Boiler control panel deactivated failed boiler's boiler circulating pump		
382		Signal of failed boiler's boiler circulating pump deactivation received		
383	Release all overrides	System returns to pre-test conditions		
Distribution Pump (___) General Fault Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and distribution pump general fault alarm, the control system shall: • Initiate visual alarm at Operator workstation • Maintain system active status				
384	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
385		System status maintained	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
386	Release all overrides	System returns to pre-test conditions		
Distribution Pump (___) General Fault Alarm Condition				
387	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
388		System status maintained	CS of _____	
389	Release all overrides	System returns to pre-test conditions		
Distribution Pump (___) General Fault Alarm Condition				
390	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
391		System status maintained	CS of _____	
392	Release all overrides	System returns to pre-test conditions		
Distribution Pump (___) Failure Type One Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and distribution pump failure alarm status with more than one distribution pump being active, the control system shall: • Continuously set next active distribution pump equivalent to the inactive distribution pump with shortest runtime • Initiate audible and visual alarms at Operator workstation • Disable failed distribution pump • Enable next active distribution pump				
393	To prepare for system response: • Initiate more than one distribution pump to active status • Observe system status	More than one distribution pump's status active	CS of _____	
394		Next active distribution pump set	CS of _____	
395	To observe system response: • Manually turn distribution pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
396		Filed distribution pump disabled	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
397		Next active distribution pump enabled	CS of _____	
398	Release all overrides	System returns to pre-test conditions		
Distribution Pump (___) Failure Type One Alarm Condition				
399	To observe system response: • Manually turn distribution pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
400		Filed distribution pump disabled	CS of _____	
401		Next active distribution pump enabled	CS of _____	
402	Release all overrides	System returns to pre-test conditions		
Distribution Pump (___) Failure Type One Alarm Condition				
403	To observe system response: • Manually turn distribution pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
404		Filed distribution pump disabled	CS of _____	
405		Next active distribution pump enabled	CS of _____	
406	Release all overrides	System returns to pre-test conditions		
Distribution Pump (___) Failure Type Two Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and a distribution pump failure alarm status with one distribution pump being active, the control system shall: • Initiate audible and visual alarms at Operator workstation • Disable failed distribution pump • Initiate plant deactivation operation mode • Initiate plant activation operation mode				
407	To prepare for system response: • Initiate one distribution pump to active status • Observe system status	One distribution pump's status active	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
408	To observe system response: • Manually turn distribution pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
409		Failed distribution pump disabled	CS of _____	
410		Plant deactivation operation mode initiated	CS of _____	
411		Plant activation operation mode initiated	CS of _____	
412	Release all overrides	System returns to pre-test conditions		
Heatpump Loop Pump (___) Failure Type One Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and condenser water pump failure alarm status with more than one heatpump loop pump being active, the control system shall: • Continuously set next inactive heatpump equivalent to the inactive heatpump with longest runtime • Initiate audible and visual alarms at Operator workstation • Disable next inactive heatpump • Command failed heatpump loop pump to inactive status • Command next inactive heatpump's isolation valve to its 0-percent open position				
413	To prepare for system response: • Initiate only one heatpump loop pump to active status • Observe system status	Only one heatpump loop pump's status active	CS of _____	
414		Next inactive heatpump set	CS of _____	
415	To observe system response: • Manually turn heatpump loop pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
416		Next inactive heatpump disabled	CS of _____	
417		Failed heatpump loop pump disabled	CS of _____	
418		Next inactive heatpump's isolation valve commanded to its 0-percent open position	CS of _____	
419	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Heatpump Loop Pump (___) Failure Type Two Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and a heatpump loop pump failure alarm status with only one heatpump loop pump being active, the control system shall: • Continuously set next inactive heatpump equivalent to the active heatpump with longest runtime • Continuously set next active heatpump equivalent to the inactive heatpump with shortest runtime • Continuously set next active heatpump loop pump equivalent to the inactive heatpump loop pump with shortest runtime • Initiate audible and visual alarms at Operator workstation • Disable next inactive heatpump • Command failed heatpump loop pump to inactive status • Command next inactive heatpump's isolation valve to its 0-percent open position • Command next active heatpump's isolation valve to its 100-percent open position • Next active heatpump loop pump to operate at constant speed • Enable next active heatpump				
420	To prepare for system response: • Initiate only one heatpump loop pump to active status • Observe system status	Only one heatpump's status active	CS of _____	
421		Next inactive heatpump set	CS of _____	
422		Next active heatpump set	CS of _____	
423		Next active heatpump loop pump set	CS of _____	
424	To observe system response: • Manually turn heatpump loop pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
425		Failed heatpump loop pump commanded to inactive status	CS of _____	
426		Next inactive heatpump's isolation valve commanded to its 0-percent open position	CS of _____	
427		Next active heatpump's isolation valve commanded to its 100-percent open position	CS of _____	
428		Next active heatpump loop pump commanded to operate at constant speed	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
429		Next active heatpump enabled	CS of _____	
430	Release all overrides	System returns to pre-test conditions		
Heat Exchanger Pump (___) Failure Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and geothermal loop pump failure alarm status, the control system shall: • Continuously set next active heat exchanger loop pump equivalent to the inactive heat exchanger pump with shortest runtime • Initiate audible and visual alarms at Operator workstation • Disable failed heat exchanger pump • Command next active heat exchanger pump to operate at constant speed				
431	To prepare for system response: • Initiate heat exchanger pump to active status • Observe system status	Heat exchanger pump's status active	CS of _____	
432		Next active heat exchanger pump set	CS of _____	
433	To observe system response: • Manually turn heat exchanger pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
434		Filed heat exchanger pump disabled	CS of _____	
435		Next active heat exchanger pump commanded to operate at constant speed	CS of _____	
436	Release all overrides	System returns to pre-test conditions		
Heat Exchanger Pump (___) Failure Alarm Condition				
437	To prepare for system response: • Initiate heat exchanger pump to active status • Observe system status	Heat exchanger pump's status active	CS of _____	
438		Next active heat exchanger pump set	CS of _____	
439	To observe system response: • Manually turn heat exchanger pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
440		Filed heat exchanger pump disabled	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
441		Next active heat exchanger pump commanded to operate at constant speed	CS of _____	
442	Release all overrides	System returns to pre-test conditions		
Geothermal Loop Pump (___) General Fault Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and geothermal loop pump general fault alarm, the control system shall: • Initiate visual alarm at Operator workstation • Maintain geothermal loop active status				
443	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
444		Geothermal loop status maintained	CS of _____	
445	Release all overrides	System returns to pre-test conditions		
Geothermal Loop Pump (___) General Fault Alarm Condition				
446	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
447		Geothermal loop status maintained	CS of _____	
448	Release all overrides	System returns to pre-test conditions		
Geothermal Loop Pump (___) Failure Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and geothermal loop pump failure alarm status, the control system shall: • Continuously set next active geothermal loop pump equivalent to the inactive geothermal loop pump with shortest runtime • Initiate audible and visual alarms at Operator workstation • Disable failed geothermal loop pump • Enable next active geothermal loop pump				
449	To prepare for system response: • Initiate geothermal loop pump to active status • Observe system status	Geothermal loop pump’s status active	CS of _____	
450		Next active geothermal loop pump set	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
451	To observe system response: • Manually turn geothermal loop pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
452		Filed geothermal loop pump disabled	CS of _____	
453		Next active geothermal loop pump enabled	CS of _____	
454	Release all overrides	System returns to pre-test conditions		
Fluid Cooler Loop Pump (___) General Fault Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and fluid cooler loop pump general fault alarm, the control system shall: • Initiate visual alarm at Operator workstation • Maintain fluid cooler loop active status				
455	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
456		Fluid cooler loop status maintained	CS of _____	
457	Release all overrides	System returns to pre-test conditions		
Fluid Cooler Loop Pump (___) General Fault Alarm Condition				
458	To observe system response: • Initiate general fault at adjustable frequency drive	Visual alarm initiated at Operator workstation		
459		Fluid cooler loop status maintained	CS of _____	
460	Release all overrides	System returns to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Fluid Cooler Loop Pump (___) Failure Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and fluid cooler loop pump failure alarm status, the control system shall: • Continuously set next active fluid cooler loop pump equivalent to the inactive fluid cooler loop pump with shortest runtime • Initiate audible and visual alarms at Operator workstation • Disable failed fluid cooler loop pump • Enable next active fluid cooler loop pump				
461	To prepare for system response: • Initiate fluid cooler loop pump to active status • Observe system status	Fluid cooler loop pump's status active	CS of _____	
462		Next active fluid cooler loop pump set	CS of _____	
463	To observe system response: • Manually turn fluid cooler loop pump's disconnect switch to its off position	Audible and visual alarms initiated at Operator workstation		
464		Filed fluid cooler loop pump disabled	CS of _____	
465		Next active fluid cooler loop pump enabled	CS of _____	
466	Release all overrides	System returns to pre-test conditions		
Heatpump (___) Opposite Status Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and status being opposite command, the control system shall: • Initiate audible and visual alarms at Operator workstation • Maintain heatpump loop active status				
467	To observe system response to equipment off status: • Override system to inactive status • Manually set heatpump to "off" at heatpump control panel • Enable heatpump at control system	Audible and visual alarms initiated at Operator workstation		
468		Heatpump loop active status maintained	CS of _____	
469	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**
470	• Maintain system inactive status • Manually set heatpump to “on” at heatpump control panel • Disable heatpump at control system	Heatpump loop active status maintained	CS of _____	
471	Release selected overrides	Selected components return to pre-test conditions		
Heatpump (___) Opposite Status Alarm Condition				
472	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
473	• Override system to inactive status • Manually set heatpump to “off” at heatpump control panel • Enable heatpump at control system	Heatpump loop active status maintained	CS of _____	
474	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
475	• Maintain system inactive status • Manually set heatpump to “on” at heatpump control panel • Disable heatpump at control system	Heatpump loop active status maintained	CS of _____	
476	Release selected overrides	Selected components return to pre-test conditions		
Fluid Cooler (___) Opposite Status Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and status being opposite command, the control system shall: • Initiate audible and visual alarms at Operator workstation • Maintain fluid cooler loop active status				
477	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
478	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	Fluid cooler loop active status maintained	CS of _____	
479	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
480	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	Fluid cooler loop active status maintained	CS of _____	
481	Release selected overrides	Selected components return to pre-test conditions		
Fluid Cooler (___) Opposite Status Alarm Condition				
482	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
483	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	Fluid cooler loop active status maintained	CS of _____	
484	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
485	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	Fluid cooler loop active status maintained	CS of _____	
486	Release selected overrides	Selected components return to pre-test conditions		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
Distribution Pump (___) Opposite Status Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and status being opposite command, the control system shall: • Initiate audible and visual alarms at Operator workstation • Maintain system active status				
487	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
488	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	System status maintained	CS of _____	
489	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
490	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	System active status maintained	CS of _____	
491	Release selected overrides	Selected components return to pre-test conditions		
Distribution Pump (___) Opposite Status Alarm Condition				
492	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
493	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	System active status maintained	CS of _____	
494	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
495	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	System active status maintained	CS of _____	

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
496	Release selected overrides	Selected components return to pre-test conditions		
Distribution Pump (___) Opposite Status Alarm Condition				
497	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
498	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	System active status maintained	CS of _____	
499	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
500	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	System active status maintained	CS of _____	
501	Release selected overrides	Selected components return to pre-test conditions		
Geothermal Loop Pump (___) Opposite Status Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and status being opposite command, the control system shall: • Initiate audible and visual alarms at Operator workstation • Maintain geothermal loop active status				
502	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
503	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	Geothermal loop active status maintained	CS of _____	
504	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**
505	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	Geothermal loop active status maintained	CS of _____	
506	Release selected overrides	Selected components return to pre-test conditions		
Geothermal Loop Pump (___) Opposite Status Alarm Condition				
507	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
508	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	Geothermal loop active status maintained	CS of _____	
509	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
510	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	Geothermal loop active status maintained	CS of _____	
511	Release selected overrides	Selected components return to pre-test conditions		
Fluid Cooler Loop Pump (___) Opposite Status Alarm Condition Design Control Sequence: Upon detection of initiation of plant activation operation mode and status being opposite command, the control system shall: • Initiate audible and visual alarms at Operator workstation • Maintain fluid cooler loop active status				
512	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		

SYSTEM OPERATION				
STEP	**TEST METHOD**	**EXPECTED RESPONSE**	**COMMENTS**	**PASS/ FAIL**
513	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	Fluid cooler loop active status maintained	CS of _____	
514	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
515	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	Fluid cooler loop active status maintained	CS of _____	
516	Release selected overrides	Selected components return to pre-test conditions		
Fluid Cooler Loop Pump (___) Opposite Status Alarm Condition				
517	To observe system response to equipment off status:	Audible and visual alarms initiated at Operator workstation		
518	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “off” position	Fluid cooler loop active status maintained	CS of _____	
519	To observe system response to equipment on status:	Audible and visual alarms initiated at Operator workstation		
520	• Maintain system inactive status • Manually set hand-off-auto switch at adjustable frequency drive to “on” position	Fluid cooler loop active status maintained	CS of _____	
521	Release selected overrides	Selected components return to pre-test conditions		

-- End of Test --