Functional Test

Project ________________________________

FT- CHILLERS 1 thru 3

And Chiller System Including:
Cooling Towers 1 thru 3
CHW Pumps 1 thru 8, including variable speed drives
CD Pumps 1 thru 9 and Piping
HE-1 (heat exchanger)

Related Tests: ____

1. Participants

Party	Participation

Party filling out this form and witnessing testing ______________________________
Dates of tests ______________________
Dates of tests ______________________
Dates of tests ______________________
Dates of tests ______________________

2. Test Prerequisites

a. __ The following have been started up and startup reports* and prefunctional checklists submitted and approved ready for functional testing:

__ Chiller	__ Condenser water pumps
__ Chilled water pumps	__ Chilled water piping and valves
__ Cooling towers	__ Variable speed drives for pumps

*The written chiller startup report must contain a full listing of all adjustable internal program settings.

Notes:

b. __ All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules and with debugging, loop tuning and sensor and device calibrations completed. ______________________________ ______________________

Controls Contractor Signature or Verbal Date

c. __ Piping system flushing complete and required report approved.
d. __ Water treatment system complete and operational.
e. __ Vibration control report approved (if required).
f. __ Test and balance (TAB) complete and approved for the hydronic system.
g. __ All A/E punchlist items for this equipment corrected.
h. __ These functional test procedures reviewed and approved by installing contractor.
i. __ Safeties and operating ranges reviewed.
j. __ Test requirements and sequences of operation attached.
k. __ Schedules and setpoints attached.
l. __ False loading equipment, system and procedures ready (cross-over piping, preheat or reheat coils, control loops, over-ride on OSA dampers, etc.)
m. __ Sufficient clearance around equipment for servicing.
n. __ Sump or crankcase heaters have been on long enough to allow immediate starting of chillers.
o. __ Have all energy savings control strategies, setpoints and schedules been incorporated that this chiller and control system are capable of? If not, list recommendations below.
p. **__ Control Program Review.** Review the software control program(s) for this equipment. Parameters, setpoints and logic sequences appear to follow the specified written sequences.

Notes:

q. __ Record made of All Values for Current Setpoints (SPt), Control Parameters, Limits, Delays, Lockouts, Schedules, Etc. Changed to Accomodate Testing:

Parameter	Pre-Test Values	Returned to Pre-Test Values √
Space Temp. Setpts		
Economizer damper and changeover settings		
Preheat coil valve (auto, manual)		
Min. OSA preheat coil DAT setpoint		
Boiler enable, heating water temp. etc.		
CHWS SPt temp		
Lead chiller ID: Lag 1 ID: Lag 2 ID:		

Parameter	Pre-Test Values	Returned to Pre-Test Values √
Primary CHW Pumps CHWP-1 CHWP-2 CHWP-3 CHWP-4 CHWP-5 (hand, off, auto)		
Manual piping & valving for standby PCHWP		
EF-10 (hand, off, auto)		
Secondary CHW Pumps CHWP-6 CHWP-7 CHWP-8 (hand, off, auto)		
Condenser Pumps CDP-1 CDP-2 CDP-3 CDP-4 CDP-5 CDP-6 CDP-7 CDP-8 CDP-9 (hand, off, auto)		
VFD CHWP-6 CHWP-7 CHWP-8 (hand, off, auto)		
Demand Limit CH-1: CH-2: CH-3:		

Notes:

Parameter	Pre-Test Values	Returned to Pre-Test Values √
Lead CD pump ID: Lag 1 ID: Lag 2 ID:		
Safety Overrides		
Lead CHW pump ID: Lag 1 ID: Lag 2 ID:		
Chillers CH-1: CH-2: CH-3: (hand, off, auto)		
Chiller flow switches CH-1: CH-2: CH-3: (normal, jumped)		
CHW diff. press. Spt Across pump: Out in system:		
Delays		

Parameter	Pre-Test Values	Returned to Pre-Test Values √
CT fans CT-1 CT-2 CT-3 (hand, off, auto)		
CT vibration sensors CT-1 CT-2 CT-3 (normal, jumped)		
CT sump overflow CT-1 CT-2 CT-3 (normal, plugged)		
CT makeup valve CT-1 CT-2 CT-3 (auto, manual)		
Occupied schedule Start Stop		

Notes:

3. Sensor Calibration Checks. The sensors listed below checked for calibration and adequate location. This is a spot check on a sample of the calibrations done during prefunctional checklisting.*

"In calibration" means making a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) compared to the test instrument-measured value is within the tolerances specified in the prefunctional checklist requirements. If not, install offset in BAS, calibrate or replace sensor. Use the same test instruments as used for the original calibration, if possible.

Test instrument, air pressure: ______________________________ ___ Certified calibration within last 12 mo's.

Test instrument, water pressure: ____________________________ ___ Certified calibration within last 12 mo's.

Test instrument, temperature: ______________________________ ___ Certified calibration within last 12 mo's.

Sensor & Location	Loc-ation OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?
ECDWT					
Pump dP sensor					
CT-1 sump T.					

Sensor & Location	Loc-ation OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?
CT-2 sump T.					
CHWST					

[1]Sensor location is appropriate and away from causes of erratic operation.

*For every sensor originally found out of calibration, check one additional sensor not listed.

4. Device Calibration Checks. The actuators or devices listed below checked for calibration. This is a spot check on a sample of the calibrations done during prefunctional checklisting and startup.**

"In calibration" means observing a readout in the BAS and going to the actuator or controlled device and verifying that the BAS reading is correct. For items out of calibration or adjustment, fix now if easy, via an offset in the BAS, or a mechanical fix.

Device or Actuator & Location	**1st** BAS Reading	Site Observ-ation	**Final** BAS Reading	Pass Y/N
CHWP-6 rpm				
CHWP-7 rpm				
CHWP-8 rpm				

Device or Actuator & Location	**1st** BAS Reading	Site Observ-ation	**Final** BAS Reading	Pass Y/N
CT-1	fan stage 1			
CT-1	fan stage 2			
CT-2	fan stage 1			
CT-2	fan stage 2			
CT-3	fan			

Notes:

Device or Actuator & Location	**1st** BAS Reading	Site Observ-ation	**Final** BAS Reading	Pass Y/N

Device or Actuator & Location	**1st** BAS Reading	Site Observ-ation	**Final** BAS Reading	Pass Y/N
	stage 1			
CT Bypass valve				

**For every actuator or device originally found out of calibration, check one additional one not listed.

5. Verification of Misc. Prefunctional Checks.

Misc. site checks of the prefunctional checklist and startup reports completed successfully. Pass? Y / N _______

V. Notes on Methods Used to False Load Chiller (for reference, see Note 6 at end of test)

____
____
____
____
____
____

6. Seasonal Testing and General Conditions of Test

Due to the building completion being during winter, this test will be completed in two stages. The first testing will occur prior to substantial completion, during cold weather. The objective of this first stage test is to provide reasonable assurance that the chiller will function properly during lower load conditions. This will prepare the chiller for operation during the beginning of the cooling season. As many of the test procedures as possible will be executed during this first test, through the use of the methods of false loading noted above and in Note 6 at the end of the test. Tests of all chillers close to full load and full cooling tower fan staging will not be able to be executed until summer. Chiller safeties will be tested prior to occupancy and cooling tower winter operation and sump heater tests will be performed during cold weather of the first test.

Notes:

At the beginning of the cooling season, the chiller will be started and operated, without further testing, unless problems arise. Then, when conditions are warmer (approximately 80F-85F), the second test will be performed. This will likely require some false loading to create close to full load conditions and subsequently may need to be executed on a weekend to minimize discomfort to occupants. During this second test, some of the sequences performed during the first test will be retested and recorded, as necessary, to get to the staging and full load tests not performed during the first test. Also, the benchmarking and trending will be completed during the second test period.

7. Test Procedure Table of Contents

Notes:

8. Testing Procedures and Record

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
CHILLER SYSTEM STARTUP AND STAGING					
1 Seq 1-4, 16, 20-23, 32	Specs 15682 3.3.; 15683 3.2	Startup Sequence. Lead = CH-____. (This is not the initial startup by factory reps). With chiller system off, with schedule allowing chillers ON and OSAT >56F, turn chillers and pumps to auto. Turn on AHUs and cause a call for cooling sufficient to call for chillers (see manually open preheat coil valve, lower space temperature SPt, etc. A call for the chillers will be made when any AHU fan is ON and its CCV is => 15% open for 10minutes. Vanes:	Observe that the lead primary CHW pump does not turn ON until a CCV on an ON AHU is => 15% [_______%] open for 10 min. [_______]. Observe lead secondary CHW pump start when a CCV is 15% [______] open for 10 [_______] minutes. Observe CHW primary and secondary pumps turning on, then the oil pump; then the CD pump (30-60s delay ea.) Observe that secondary pumps start at minimum RPM and slowly ramp up. Starting RPM = [__________]. Observe the lead chiller starting. Observe that the vanes start closed and begin to open. (max spd = 0-full open in ~3 min. and closed in ~1 minute)		
1 cont. Seq 1-4, 16, 20-23, 32		Cooling Tower: Specified Sequences: Poll ECDWT every 4 min. If > 2F above setpoint, increase CT stage by one. When < 1F below setpoint, lower CT stage one.	OSAT = [_______F]. OSAWB = [_______F]. Observe that when the lead chiller started the CT specified sequences followed, with delays between stages. Observe that the ECDWT SPt of OSA wet bulb + 7F is maintained (within 65F to 83F). Observe that the bypass valve is closed when the setpoint is exceeded [_______]. Observe that the cooling tower successively stages up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT Stage		
	15682 3.3.E	Maintain chiller load between 10-15% for 30 minutes.	Observe that there is no surging or abnormal vibration.		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
2 Seq 8	Specs 15682 3.3.; 15683 3.2	1st Lag Chiller Staging ON. Staging sequence: CH-___ -->CH-___ -->CH-___ With chillers in auto, and loaded such that only lead chiller is running, lower space setpoints so CCVs open. Wait ~10 minutes. Record time that primary flow and secondary flow become equal. Wait 20 minutes.	Total primary flow = [________gpm]. Secondary CHW flow => primary CHW flow = [______gpm] and lead chiller is at least 95% loaded (by % of rated current), [________ amps]. Time: [___________]. After 20 minutes, 1st lag chiller should start (PCHWP - oil pump - CDP - chiller). Time when 1st lag chiller started = [__________]. Observe that the amps on both chillers are within 5% of each other.		
3 Seq 8; 32-34	Specs 15683 3.3.F. 2	1st Lag Secondary CHWP Staging ON. Continue increasing cooling load, if necessary, to cause CCVs to open further.	Observe that after total SCHW flow [_____gpm, _____rpm] > total design flow of ON SCHW pumps (765 gpm), and the SCHW pump dP drops 2 psi [______] below SPt for 10 minutes, the first lag SCHWP turns ON. Observe that the 2 pumps' rpm are aprox. equal and at aprox. 50% (880 rpm), [CHWP-______ rpm, CHWP- _______ rpm] and that total flow is just over previous gpm (765) [_______gpm], and that after ~ 2 minutes, pump dP is maintained at SPt _____ [______] and remote dP is maintained at SPt _____ [_____].		
4 Seq 8; 21-24	Specs 15682 3.3.; 15683 3.2	1st Lag Cooling Tower Staging ON. During the preceding sequences:	OSAT = [_______F]. OSAWB = [_______F]. Observe that the cooling tower successively stages up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT Stage		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
5 Seq 8	Specs 15682 3.3.; 15683 3.2	2nd Lag Chiller Staging ON Cont. After second chiller starts, continue calling for more cooling to start third chiller.	Total primary flow = [________gpm]. Observe until secondary CHW flow => primary CHW flow = [______gpm] and both chillers are at least 95% loaded (by % of rated current), [________amps]. Time: [___________]. After 20 minutes, 2nd lag chiller should start (PCHWP - oil pump - CDP – chiller). Time when 2nd lag chiller started = [__________]. Observe that the amps on all running chillers are within 5% of each other.		
6 Seq 8; 32-34	Specs 15682 3.3.; 15683 3.2	2nd Lag Secondary CHWP Staging ON Cont. Continue increasing cooling load, if necessary, to cause CCVs to open further.	Observe that after total SCHW flow [_______gpm, CHWP- _______rpm, CHWP- _______rpm] is greater than total design flow of ON SCHW pumps (1530 gpm), and the SCHW pump dP drops 2 psi [______] below SPt [______], for 10 minutes, the 2nd lag SCHWP turns ON. Observe that the 3 pumps' rpm are aprox. equal and at aprox. 67% (1170 rpm), [CHWP- ______ rpm, CHWP- _______ rpm, CHWP- _______ rpm] and that total flow is just over previous gpm (1530) [_______gpm], and that after ~ 2 minutes, pump dP is maintained at SPt _____ [______] and remote dP is maintained at SPt _____ [_____].		
7 Seq 8; 21-24	Specs 15682 3.3.; 15683 3.2	2nd Lag Cooling Tower Staging ON. During the preceding sequences:	OSAT = [_______F]. OSAWB = [_______F]. Observe that the cooling tower successively stages up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT Stage		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
8 Seq 9, 10; 35	Specs 15682 3.3.; 15683 3.2	<u>Chillers Staging OFF.</u> Raise space setpoints so CCVs close, or shut off some or all AHU's. Wait ~5 minutes. Record time that primary flow exceeds secondary flow by capacity of last selected pump. Wait thru any delay. (CHWP 1-3 = 675 gpm ea., CHWP 4; 5 = 180gpm ea.) Repeat to see 1st lag chiller stage off. Repeat to see lead chiller stage off.	<u>2nd Lag Chiller Staging OFF*</u> Observe that when the total SCHW gpm has reduced to be <= the sum of the first two selected SCHW pumps, that the second lag SCHW pump shuts OFF. Primary CHW flow > secondary flow by ________ [______] gpm. Time: [___________]. After 20 minutes, 2nd lag chiller and pumps should stop. Time when 2nd lag chiller stops = [_______________]. Cooling tower fans shut down as expected: Main fan—pony motor--all OFF. <u>First Lag Chiller Staging OFF*</u> Observe that when the total SCHW gpm has reduced to be <= the lead SCHW pump for 10 minutes, that the first lag SCHW pump shuts OFF. Primary CHW flow > secondary flow by ________ gpm. Time: [___________]. After 20 minutes, 1st lag chiller and pumps should stop. Time when 1st lag chiller stops = [_______________]. Cooling tower fans shut down as expected: Main fan--pony motor--all OFF. <u>Lead Chiller Staging OFF*</u> When all CCVs are < 15% open for 10 min. and after an additional 20 min. delay, lead chiller and all pumps should shut down. *No no-flow alarms should be generated during normal staging down.		
9 Seq 41-42	Specs 15682 3.3.; 15683 3.2	<u>CDP 6; 7 and HE-1.</u> Continuing with the last sequence of staging OFF the chillers: When the lead chiller shuts down CDP 6 or 7 still function.	Observe that the CDP-6 or 7 and CDP 8 or 9 still run and that the CDWT remains the constant.		

<u>Notes:</u>

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure**[3] (including special conditions)	**Expected and Actual Response**[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
10 Seq 41	Specs 15755 3.3	**Heat Exchanger HE-1.** With the chillers off, generate a significant load call from ACU's served by HE-1. Take temp. readings of entering and exiting HE water.	Observe the temperature differences of the CDW and the ACU supply water across the heat exchanger. Verify that they are in line with the manufacturer's specs. Attach specs. Water Temps (F) CDW In / CDW Out / ACU In / ACU Out [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____] [_____]		
11 Seq 33-35	Specs 15682 3.3.; 15683 3.2	**Variable Speed Drive (VFD) on CHWP-6.** (Note: VFD operation with multiple SCHW pumps operating is tested in procedure 3 and 6. a. Perform an amps vs hz test to establish how low the pump speed can safely go by: putting the chiller in operation at its lowest setting: ie, one CCV 15% open. Manually successively lower the pump speed starting at 60 Hz and record the motor amps at each step. When the amps begin to increase, the lowest safe motor speed has been found.	Hz / CHWP-6 Amps / CHWP-7 Amps / CHWP-8 Amps 60 50 40 35 30 25 20 15 10 Motor manufacturer's recommended or site tested low speed limit = [________ Hz].		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure**[3] (including special conditions)	**Expected and Actual Response**[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
11 cont. Seq 33-35	Specs 15682 3.3.; 15683 3.2	1. Carefully go over prefunctional checklist and programming record and identify anomalies. Record the low limits. 2. With only chiller associated with CHWP-6 running and other chillers manually OFF, reduce all cooling load or manually lower pump and remote differential pressure setpoints. See how low VFD will go. 3. Call for moderate cooling or increase differential pressure setpoints. 4. Call for maximum cooling or increase differential pressure setpoints (keeping only 1 chiller ON).	1. Low limit setting in drive: [_______Hz, rpm = ______% of maximum]. Provide reasons for low limit not being at motor mfr's low limit. List any anomalies noticed in programming: 2. Lowest speed drive will go: [_______Hz, rpm]. Is this within 3 Hz of the low limit setting (or within a range equal to 5% of maximum speed)? Is pump and remote dP SP maintained without hunting? 3. Does VFD motor ramp up accordingly in a reasonable time? Is pump and remote dP SPt maintained without hunting? 4. Does VFD motor ramp to full speed in a reasonable time? Is pump and remote dP SPt maintained without hunting?		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
12 Seq 33-35	Specs 15682 3.3.; 15683 3.2	**<u>Variable Speed Drive (VFD) on CHWP-7.</u>** (Note: VFD operation with multiple SCHW pumps operating is tested in procedure 3 and 6. Perform and record amps vs Hz test in Procedure 11.	Motor manufacturer's recommended or site tested low speed limit = [________ Hz].		
		1. Carefully go over prefunctional checklist and programming record and identify anomalies. Record the low limits.	1. Low limit setting in drive: [_______Hz, rpm = ______% of maximum]. Provide reasons for low limit not being at motor mfr's low limit. List any anomalies noticed in programming:		
		2. With only chiller associated with CHWP-7 running and other chillers manually OFF, reduce all cooling load or manually lower pump and remote differential pressure setpoints. See how low VFD will go.	2. Lowest speed drive will go: [_______Hz, rpm]. Is this within 3 Hz of the low limit setting (or within a range equal to 5% of maximum speed)? Is pump and remote dP SP maintained without hunting?		
		3. Call for moderate cooling or increase differential pressure setpoints.	3. Does VFD motor ramp up accordingly in a reasonable time? Is pump and remote dP SPt maintained without hunting?		
		4. Call for maximum cooling or increase differential pressure setpoints (keeping only 1 chiller ON).	4. Does VFD motor ramp to full speed in a reasonable time? Is pump and remote dP SPt maintained without hunting?		

<u>Notes:</u>

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
13 Seq 33-35	Specs 15682 3.3.; 15683 3.2	**<u>Variable Speed Drive (VFD) on CHWP-8.</u>** (Note: VFD operation with multiple SCHW pumps operating is tested in procedure T-3 and T-6. Perform and record amps vs Hz test in Procedure 11. 1. Carefully go over prefunctional checklist and programming record and identify anomalies. Record the low limits. 2. With only chiller associated with CHWP-8 running and other chillers manually OFF, reduce all cooling load or manually lower pump and remote differential pressure setpoints. See how low VFD will go. 3. Call for moderate cooling or increase differential pressure setpoints. 4. Call for maximum cooling or increase differential pressure setpoints (keeping only 1 chiller ON).	Motor manufacturer's recommended or site tested low speed limit = [________ Hz]. 1. Low limit setting in drive: [_______Hz, rpm = ______% of maximum]. Provide reasons for low limit not being at motor mfr's low limit. List any anomalies noticed in programming: 2. Lowest speed drive will go: [_______Hz, rpm]. Is this within 3 Hz of the low limit setting (or within a range equal to 5% of maximum speed)? Is SP maintained without hunting? 3. Does VFD motor ramp up accordingly in a reasonable time? Is SP SPt maintained without hunting? 4. Does VFD motor ramp to full speed in a reasonable time? Is SP SPt maintained without hunting?		

<u>Notes:</u>

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
14 Seq 8, 21-24; 32-35	Specs 15682 3.3.; 15683 3.2	General Staging. **By Monitoring:** For each chiller, trend the status of CH, PCHWP, SCHWP, CDWP, CT pony fan, CT main fan, OSAT, CHWST, ECDWT, primary gpm, secondary gpm, VFD rpm for each pump. (Start all points simultaneously, 5 min. time step for 3 days, including weekend during a period of significant cooling. Provide text file (ASCII).	Observe that there are no anomalies in operation, comparing to the specified sequences and staging. This is not a detailed "to the minute" staging verification, which was done manually above. Attach representative graphs or columnar data and explanatory analysis to this test report.		
MISC. CHILLER SYSTEM FUNCTIONS					
15 Seq 13	Specs 15682 3.3.; 15683 3.2	Demand Limiting. With one chiller running, enable the demand limiting routine and temporarily reduce the limiting delay from 1 hour to 20 minutes. Lower the kW limit to be equal to 90% of the lead chiller design kW. Initiate sufficient load to call for two chillers.	Observe that CCV's run to 100% open, indicating a call for cooling and an unsatisfied condition. Note that the lag chiller is called for, but does not turn on until the programmed delay is over.		
16 Seq 1	Specs 15682 3.3.; 15683 3.2	OSAT Lockout. With chiller(s) running in auto, overwrite OSAT sensor to be 55F.	Observe a shutdown of the chillers, including secondary CHW pumps..		
17 Seq 1	Specs 15682 3.3.; 15683 3.2	OSAT Lockout. **By Monitoring.** During chilled water pressure control monitoring:	Observe a shutdown of the chillers, including secondary CHW pumps, whenever the OSAT is less than 55F Attach representative graphs or columnar data and explanatory analysis to this test report.		
18 Seq 19	Specs 15682 3.3.; 15683 3.2	Primary CHW Pump Failure, CH-1; 2. With only the lead chiller running (in auto), manually shut off the lead primary CHW pump .	Operating chiller should stop and go into failure alarm. The lag chiller then becomes the lead chiller and should start.		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
19 Seq 19	Specs 15682 3.3.; 15683 3.2	Primary CHW Pump Failure, CH-3. With the chiller running in auto, manually shut off the primary CHW pump. .	An alarm should register and the standby primary CHW pump should start automatically.		
20 Seq 22	Specs 15682 3.3.; 15683 3.2	CD Pump Failure, CH-1; 2. With only the lead chiller running (in auto), manually shut off the CD pump.	Operating chiller should stop and go into failure alarm. The lag chiller then becomes the lead chiller and should start.		
21 Seq 22	Specs 15682 3.3.; 15683 3.2	CD Pump Failure, CH-3. With the chiller running in auto, manually shut off the primary CD pump. .	An alarm should register and the standby CD pump should start automatically.		
22 Seq 37	Specs 15682 3.3.; 15683 3.2	Secondary CHWP Failure. With at least one chiller and pumps in auto, and running, shut off variable speed drive to lead SCHWP.	Observe that lag or standby SCHWP starts.		
23	Specs 15682 3.3.; 15683 3.2	Chiller Standby 1. With chillers manually OFF, turn 1st lag chiller to Auto and cause a call for the chillers.	Lead primary CHWP pump should start and orig. lead chiller should try and start, but fail. CHWP should shut off. After ____ [_____] minutes DDC should start the lag CHW pump, etc. and 1st lag chiller and function as lead. (shorten delays for test, if desired)		
24	Specs 15682 3.3.; 15683 3.2	Chiller Standby 2. Repeat above to test 2nd lag chiller as lead.	First two chillers remain off. 2nd lag chiller starts.		
25 Seq 21	Specs 15682 3.3.; 15683 3.2	Manual Standby CDP- for CH-1 & 2. With chillers OFF, manually operate valves to allow standby CDP to function and assign as lead pump. Turn chillers to auto with CH-1 or 2 as lead. Initiate a call for the chillers.	Observe that standby CDP operates and that gpm is as per design, 1350 gpm [___________gmp].		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure**[3] (including special conditions)	**Expected and Actual Response**[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
26 Seq 18	Specs 15682 3.3.; 15683 3.2	Manual Standby PCHWP- for CH-1 & 2. With chillers OFF, manually operate valves to allow standby primary CHWP to function and assign it as lead pump. Turn chillers to auto with CH-1 or 2 as lead. Initiate a call for the chillers.	Observe that standby PCHWP operates as lead and that gpm is as per design, 675 gpm [___________gpm].		
27 Seq 43	Specs 15682 3.3.; 15683 3.2	CDP 6; 7 Failure Lead = CDP-____ (6 or 7) With system in auto and running, manually shut down lead pump. CDP 8; 9 Failure Lead = CDP-____ (8 or 9) With system in auto and running, manually shut down lead pump.	Observe that an alarm is registered and that the lag pump starts. Observe that an alarm is registered and that the lag pump starts.		
28 Seq 6;7	Specs 15682 3.3.; 15683 3.2	CHWS Reset. With one or more chillers running in auto, change conditions to provide data points near both ends of the line and one near the middle of the chart below. A. Mark current SPt conditions on chart with a star and CHWSTemp with a dot. B. Increase cooling demand by lowering space setpoints 8°F in all zones or by manually opening preheat coil valves. Observe that the system pipe pressure is not reset upward until the CHWST is at its maximum. In BAS, observe CCV's opening for AHU 1, 2, 3; 4 and CHWS setpoint lowering. Mark SPt values on chart with a star. Observe that the CHWST meets setpoint w/o excessive hunting. Mark CHWST values on chart with a dot.	Current CHWST setpoint: ____________ A. Values in middle of chart; near line. B. DP pressure setpoint does not increase until CHWST is at its maximum. [___________________________________] Values in the bottom right of chart; near the line.		

Notes:

<table>
<tr><th>Proced. No. & Spec. Seq. ID[1]</th><th>Req ID No.[2]</th><th>Test Procedure[3]
(including special conditions)</th><th>Expected and Actual Response[4]
[Write ACTUAL response in brackets or circle]</th><th>Pass
Y/N</th><th>Note #</th></tr>
<tr><td>28 cont.

Seq 6;7</td><td>Specs 15682 3.3.; 15683 3.2</td><td><u>CHWS Reset cont.</u>

C. Remove cooling demand by raising space setpoints 8°F above normal in all zones or by other suitable method. Observe secondary pump speed lowering and that CHWT setpoint doesn't change until pumps are at their minimum.
Observe CCV's closing for AHU 1, 2, 3; 4 and CHWS setpoint raising. Mark SPt values on chart with a star.
Observe that the CHWST meets setpoint w/o excessive hunting. Mark CHWT values on chart with a dot.

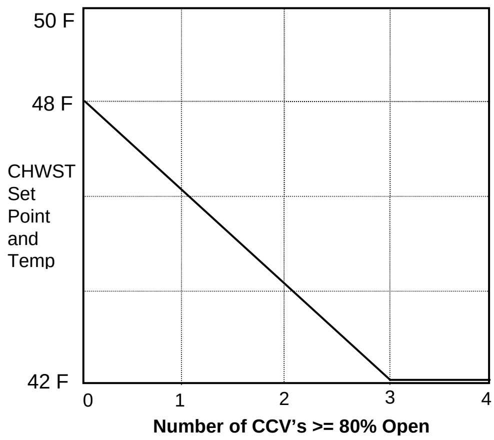
D. In condition B, Overwrite RA RH to be 53%.</td><td>C. CHWST setpoint does not raise until all secondary pumps are at min. speed.
[________________________]

Values in the top left of chart; near the line.

D. Observe that the SPt does not change further.</td><td></td><td></td></tr>
<tr><td colspan="6"><u>CHWST Reset Chart.</u>

For each observation, mark CHWS temp with a dot and the current CHWS temperature setpoint with a star.
After system settles, all values should fall within 1F of the line and the actual temp. should be within 1F of setpoint.

Note how many minutes after the call for a change was made, that readings were recorded.


</td></tr>
<tr><td>29

Seq 6</td><td>Specs 15682 3.3.; 15683 3.2</td><td><u>CHWS Temperature Reset.</u>
By Monitoring:
Trend CHWST setpoint, CHWS temperature, CCV positions for AHU 1, 2, 3; 4. (Start all points simultaneously, 5 min. time step for 5 days, including weekend. Provide text file (ASCII).</td><td>Make similar observations as for the manual test. Observe that the CHWS SPt changes as expected and CHWST meets setpoint w/o excessive hunting.

Attach representative graphs or columnar data and explanatory analysis to this test report.</td><td></td><td></td></tr>
</table>

<u>Notes:</u>

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
30 Seq 33	Specs 15682 3.3.; 15683 3.2	Chilled Water Pressure Control. Setpoint is to have one CCV 90% open. With one or more chillers running in auto and with all CCV's less than 90% open. Increase the call for cooling by lowering DAT or space temperature setpoint. Increase the call for cooling by lowering DAT setpoint or space temperature setpoint. Significantly increase the call for cooling by lowering DAT or space temperature setpoint. Decrease the call for cooling so that no CCVs are more than 90% open.	Beginning pump dP SPt: [_______] Beginning remote dP SPt:[________] Observe that that when the first CCV opens more than 90% [_______%] the remote dP SPt increases relative to how much greater than 90% open the CCV is. New remote dP SPt = [________] and new dP = [________]. Observe that the pump dP SPt also increases. New pump dP SPt = [_______] and new dP = [_______]. Observe that the SCHW pump speed increases to meet the pump dP SPt and only one CCV at 90% open. Observe that after a forced 5 min. delay, if the most open CCV is less than 90% open [__________], the remote and pump dP SPt's decrease and SCHW pump speed decreases. Observe that as the load is increased substantially, that dP SPt's increase to try and maintain only one CCV greater than 90% open. More than one CCV may be open more than 90% at the same time, but not for more than 5-10 minutes. Observe that the dP SPt lowers from current [________] to [__________] until there is one CCV 90% open. Observe that the CHWST setpoint does not raise until the dP SPt is at its minimum.		
31 Seq 33	Specs 15682 3.3.; 15683 3.2	Chilled Water Pressure Control. **By Monitoring.** Trend all CCV positions, pump discharge differential pressure and setpoint, remote pressure and setpoint, VFD rpm on each CHW pump; OSAT. Trend during season of moderate to significant cooling for 3 days at a sampling rate of every 5 minutes; 24hrs per day with output in ASCII file columnar format.	Observe that there is generally only one CCV more than 90% open. At times, not lasting more than about 10 minutes, there could be more than one CCV more than 90% open. The goal is to have one, and only one, CCV 90% open at all times. Attach representative graphs or columnar data and explanatory analysis to this test report.		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
32 Seq 5	Specs 15682 3.3.; 15683 3.2	System Stabilization. Analyze CHW reset and pressure control monitoring data.	Verify that the CHWS temperature is stable and maintains the CHWS SPt within 0.5F over a range of conditions and days.		
33 Seq 40	Specs 15682 3.3.; 15683 3.2	Secondary Pumps for Freeze Protection. With chillers in auto, but not running, manually start smoke exhaust system EF-10 and overwrite OSAT to be 38F.	Observe that SCHW pumps operate normally. (EF-10-associated AHU CCV's should also be open).		
34 Seq 5	Specs 15683 3.2	CH-3 (Reciprocating) Staging. **By Monitoring.** Temporarily program the BAS to readout and trend the stage of CH-3. With CH-3 as lead chiller in auto, call for chillers using a suitable method. After CH-3 is fully loaded, remove all load. During the above, trend the CH-3 stage, the CHWST and the CHWST Spt at 2 min. intervals for 1 hour or until chiller is fully loaded and then unloads to stop. Provide tabular or graphical documentation.	Loading: The trends should follow the 8 staging sequences of stage vs CHWST offset from setpoint (accounting for programmed delays), etc. as per the programmed sequences. Unloading: The trends should follow the staging sequences of stage vs CHWST offset from setpoint (accounting for programmed delays), etc. as per the programmed sequences. Attach representative graphs or columnar data and explanatory analysis to this test report.		
35	--	For all chiller and cooling tower components, review current setpoints and sequences with specifications and control drawings. Submit approved differences to be incorporated in asbuilts.	Setpoints and sequences are the same as original specs. OR Differences submitted for asbuilts.		
CHILLER SAFETY CONTROLS					
36 Seq 2; 3	Specs 15682 3.3.; 15683 3.2	CHW Flow Switch CH-1. If PCHW pump is wired in series with proof of flow switch, jumper pump out of this loop. With chillers manually off, but under conditions that will call for chillers, manually turn off PCHW pump. Turn Chiller 1 to auto.	Observe that chiller won't start because of no CHW flow and that an alarm is generated.		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
37 Seq 2; 3	Specs 15682 3.3.; 15683 3.2	CHW Flow Switch CH-2. If PCHW pump is wired in series with proof of flow switch, jumper pump out of this loop. With chillers manually off, but under conditions that will call for chillers, manually turn off PCHW pump. Turn Chiller 2 to auto.	Observe that chiller won't start because of no CHW flow and that an alarm is generated.		
38 Seq 2; 3	Specs 15682 3.3.; 15683 3.2	CHW Flow Switch CH-3. If PCHW pump is wired in series with proof of flow switch, jumper pump out of this loop. With chillers manually off, but under conditions that will call for chillers, manually turn off PCHW pump. Turn Chiller 3 to auto.	Observe that chiller won't start because of no CHW flow and that an alarm is generated.		
39 McQuay O&M	Specs 15682 3.3.; 15683 3.2	Low evap. refrigerant temp/pressure TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		
40 McQuay O&M	Specs 15682 3.3.; 15683 3.2	High condenser pressure TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		
41 McQuay O&M	Specs 15682 3.3.; 15683 3.2	High motor winding temperature TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		
42 McQuay O&M	Specs 15682 3.3.; 15683 3.2	Low differential oil pressure TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure**[3] (including special conditions)	**Expected and Actual Response**[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
43 McQuay O&M	Specs 15682 3.3.; 15683 3.2	Low differential oil pressure TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		
44 McQuay O&M	Specs 15682 3.3.; 15683 3.2	Loss of any electrical power phase TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		
45 McQuay O&M	Specs 15682 3.3.; 15683 3.2	High oil temperataure TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		
46 McQuay O&M	Specs 15682 3.3.; 15683 3.2	High bearing temperature TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		
47 McQuay O&M	Specs 15682 3.3.; 15683 3.2	Ground fault protection TBD CH-1 CH-2 CH-3	Indicator lights for alarms, cutouts and normal running function properly. Compressor does not restart after cutout.		
48	Specs 15682 3.3.; 15683 3.2	Interlocking of chillers and pumps This is demonstrated in procedures above (not the safeties).			
OTHER COOLING TOWER FUNCTIONS					

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
49 Seq 28	Specs 15682 3.3.; 15710 2.2	CT-1 Fan Failure Alarm. With CT running, manually shut off either of its fan motors.	Observe that an alarm is registered. Lag CT comes on line automatically??? Manually???		
50 Seq 28	Specs 15682 3.3.; 15710 2.2	CT-2 Fan Failure Alarm. With CT running, manually shut off either of its fan motors.	Observe that an alarm is registered. Lag CT comes on line automatically??? Manually???		
51 Seq 28	Specs 15682 3.3.; 15710 2.2	CT-3 Fan Failure Alarm. With CT running, manually shut off either of its fan motors.	Observe that an alarm is registered. Lag CT comes on line automatically??? Manually???		
52 Seq 29	Specs 15682 3.3.; 15710 2.2	CT Vibration Alarm. (if not documented during startup) Jump the vibration sensor to simulate a vibration alarm. CT-1: CT-2: CT-3:	Observe that an alarm is registered and that the CT fan shuts off. Lag CT comes on line automatically??? Manually???		
53 Seq 25	Specs 15682 3.3.; 15710 2.2	CT High Water Alarm. Plug sump overflow and override the makeup valve, causing the CT sump to over-fill.	Observe that a high water limit alarm is registered.		
54 Seq 27	Specs 15682 3.3.; 15710 2.2	CT Low Water Alarm and Makeup Override the makeup valve, causing the CT sump to not-fill. Drain the sump below the alarm level. Return makeup valve to auto.	Observe that a low water limit alarm is registered. Observe makeup valve open slowly and fill sump until proper level; then close.		
55 Seq 30	Specs 15682 3.3.; 15710 2.2	Winter Operation. During weather with OSAT below 25F, inspect CT.	Observe the functioning of the heat tape, verify that the sump temperature is above setpoint, verify that freezing water on the media is not excessive. Be sure that the fans do not come on when water is going over the tower (as only 60F need be achieved).		

Notes:

Proced. No. & Spec. Seq. ID[1]	Req ID No.[2]	**Test Procedure[3]** (including special conditions)	**Expected and Actual Response[4]** [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
56 Seq 26	Specs 15682 3.3.; 15710 2.2	<u>CT Sump Heaters.</u> (if not documented during startup) Schedule: (setpoint = 45F) ON (F) OFF (F) Stage 1 45 43 Stage 2 47 45 Starting with sump heaters not running, overwrite sump temperature to be equal to stage 1 SPt. Then, lower to stage 2 SPt. Then raise to 1 F above 2nd stage OFF SPt. Then lower to 1st stage OFF SPt. Repeat for each CT.	<u>Actual:</u> ON (F) OFF (F) CT-1 Stage 1 [_____] [_____] Stage 2 [_____] [_____] CT-2 Stage 1 [_____] [_____] Stage 2 [_____] [_____] CT-3 Stage 1 [_____] [_____] Stage 2 [_____] [_____]		

<u>Notes:</u>

REPEAT PROCEDURES 1-8 WITH CHILLER 2 AS LEAD:

CHILLER SYSTEM STARTUP AND STAGING (2nd chiller as lead)

1b Seq 1-4, 16, 20-23; 32		Startup Sequence. Lead = CH-____. (This is not the initial startup by factory reps). With chiller system off, with schedule allowing chillers ON and OSAT >56F, turn chillers and pumps to auto. Turn on AHUs and cause a call for cooling sufficient to call for chillers (manually open preheat coil valve, lower space temperature SPt, etc. A call for the chillers will be made when any AHU fan is ON and its CCV is => 15% open for 10minutes.	Observe that the lead primary CHW pump does not turn ON until a CCV on an ON AHU is => 15% [_______%] open for 10 min. [_______]. Observe lead secondary CHW pump start when a CCV is 15% [______] open for 10 [_______] minutes. Observe CHW primary and secondary pumps turning on, then the oil pump; then the CD pump (30-60s delay ea.) Observe that secondary pumps start at minimum RPM and slowly ramp up. Starting RPM = [__________].		
		Vanes:	Observe the lead chiller starting. Observe that the vanes start closed and begin to open. (max spd = 0-full open in ~3 min. and closed in ~1 minute)		
		Cooling Tower: Specified Sequences: ECDWT Fan Spd / ON (F) / OFF (F) OFF / <69 / --- (bypass valve modulating) *Low / 69 / 75 *High / 73 / 69 * Bypass valve should be closed. Eight minute delay between stages.	OSAT = [_______F]. Observe that when the lead chiller started the CT specified sequences followed, with delays between stages. Observe that the ECDWT SPt of 65F is maintained, unless OSA conditions prohibit. Record various ECDW temps during lead chiller operation only: [______], [______], [______], [______], [______]. Record of Observed Sequences: ECDWT / Delay Fan Spd / ON (F) / OFF (F) / (min) OFF / [_____] / --- (bypass valve modulating) Low / [_____] / [_____] / [_____] High / [_____] / [_____] / [_____]		
		Maintain chiller load between 10-15% for 30 minutes.	Observe that there is no surging or abnormal vibration.		

Notes:

2b Seq 8		1st Lag Chiller Staging ON. Staging sequence: CH-___ -->CH-___ -->CH-___ With chillers in auto, and loaded such that only lead chiller is running, lower space setpoints so CCVs open. Wait ~10 minutes. Record time that primary flow and secondary flow become equal. Wait 20 minutes.	Total primary flow = [________gpm]. Secondary CHW flow => primary CHW flow = [______gpm] and lead chiller is at least 95% loaded (by % of rated current), [________ amps]. Time: [___________]. After 20 minutes, 1st lag chiller should start (PCHWP - oil pump - CDP - chiller). Time when 1st lag chiller started = [__________]. Observe that the amps on both chillers are within 5% of each other.		
3b Seq 8; 32-34		1st Lag Secondary CHWP Staging ON. Continue increasing cooling load, if necessary, to cause CCVs to open further.	Observe that after total SCHW flow [_____gpm, _____rpm] > total design flow of ON SCHW pumps (765 gpm), and the SCHW pump dP drops 2 psi [______] below SPt for 10 minutes, the first lag SCHWP turns ON. Observe that the 2 pumps' rpm are aprox. equal and at aprox. 50% (880 rpm), [CHWP-______ rpm, CHWP- _______ rpm] and that total flow is just over previous gpm (765) [_______gpm], and that after ~ 2 minutes, pump dP is maintained at SPt _____ [______] and remote dP is maintained at SPt _____ [_____].		
4b Seq 8; 21-24		1st Lag Cooling Tower Staging ON. During the preceding sequences:	OSAT = [_______F]. Observe that when the 1st lag chiller started the CT specified sequences followed, with delays between stages. Observe that the ECDWT SPt of 65F is maintained, unless OSA conditions prohibit. Record various ECDW temps when both chillers are operating: [______], [______], [______], [______], [______]. Record of Observed Sequences: Fan Spd / ECDWT ON (F) / ECDWT OFF (F) / Delay (min) OFF [_____] --- (bypass valve modulating) Low [_____] [_____] [_____] High [_____] [_____] [_____]		

Notes:

5b Seq 8		<u>2nd Lag Chiller Staging ON Cont.</u> After second chiller starts, continue calling for more cooling to start third chiller.	Total primary flow = [________gpm]. Observe until secondary CHW flow => primary CHW flow = [______gpm] and both chillers are at least 95% loaded (by % of rated current), [________amps]. Time: [___________]. After 20 minutes, 2nd lag chiller should start (PCHWP - oil pump - CDP - chiller). Time when 2nd lag chiller started = [__________]. Observe that the amps on all running chillers are within 5% of each other.		
6b Seq 8; 32-34		<u>2nd Lag Secondary CHWP Staging ON Cont.</u> Continue increasing cooling load, if necessary, to cause CCVs to open further.	Observe that after total SCHW flow [_______gpm, CHWP- _______rpm, CHWP- _______rpm] is greater than total design flow of ON SCHW pumps (1530 gpm), and the SCHW pump dP drops 2 psi [______] below SPt [______] for 10 minutes, the 2nd lag SCHWP turns ON. Observe that the 3 pumps' rpm are aprox. equal and at aprox. 67% (1170 rpm), [CHWP- ______ rpm, CHWP- _______ rpm, CHWP- _______ rpm] and that total flow is just over previous gpm (1530) [_______gpm], and that after ~ 2 minutes, pump dP is maintained at SPt _____ [______] and remote dP is maintained at SPt _____ [_____].		
7b Seq 8; 21-24		<u>2nd Lag Cooling Tower Staging ON.</u> During the preceding sequences:	OSAT = [_______F]. Observe that when the 2nd lag chiller started the CT specified sequences followed, with delays between stages. Observe that the ECDWT SPt of 65F is maintained, unless OSA conditions prohibit. Record various ECDW temps when all three chillers are operating: [______], [______], [______], [______], [______]. Record of Observed Sequences: ECDWT Delay <u>Fan Spd</u> <u>ON (F)</u> <u>OFF (F)</u> <u>(min)</u> OFF [_____] --- (bypass valve modulating) Low [_____] [_____] [_____] High [_____] [_____] [_____]		

<u>Notes:</u>

8b Seq 9; 10; 35		Chillers Staging OFF. Raise space setpoints so CCVs close, or shut off some or all AHU's. Wait ~10 minutes. Record time that primary flow exceeds secondary flow by capacity of last selected pump. Wait thru 20 min. delay. (CHWP 1-3 = 675 gpm ea., CHWP 4; 5 = 180gpm ea.) Repeat to see 1st lag chiller stage off. Repeat to see lead chiller stage off.	2nd Lag Chiller Staging OFF* Observe that when the total SCHW gpm has reduced to be <= the sum of the first two selected SCHW pumps for 10 minutes, that the second lag SCHW pump shuts OFF. Primary CHW flow > secondary flow by ________ [______] gpm. Time: [___________]. After 20 minutes, 2nd lag chiller and pumps should stop. Time when 2nd lag chiller stops = [_______________]. Cooling tower fans shut down as expected: Main fan--pony motor--all OFF. First Lag Chiller Staging OFF* Observe that when the total SCHW gpm has reduced to be <= the lead SCHW pump for 10 minutes, that the first lag SCHW pump shuts OFF. Primary CHW flow > secondary flow by ________ gpm. Time: [___________]. After 20 minutes, 1st lag chiller and pumps should stop. Time when 1st lag chiller stops = [_______________]. Cooling tower fans shut down as expected: Main fan--pony motor--all OFF. Lead Chiller Staging OFF* When all CCVs are < 15% open for 10 min. and after an additional 20 min. delay, lead chiller and all pumps should shut down. *No no-flow alarms should be generated during normal staging down.		

Notes:

57	15682 3.3.C; D	**<u>Chiller Efficiency Testing and Benchmarking.</u>** The efficiency and capacity testing specified shall be substituted with the following efficiency benchmarking. In summary this will consist of: A. Obtain calculated kw/ton values from the mf'r for each chiller model for all possible combinations of 4 ECDW temps, 4 LCHW temps and 100, 75, 50 and 25% loads, totalling 60 points. Plot kw/ton vs % Load. Perform a regression based on DOE-2 chiller curve equation forms through the data, using the PG&E Chiller Performance Evaluation Tool. Use the same equation form for each chiller model. B. During a near design day and a moderate cooling day, trend the LCHWT, ECDWT, kw, RCHWT, CHW gpm at 15 min. intervals over the occupied period. Calculate % load and tons at each point. Trend each chiller as needed to establish a good variety of load, ECDWT and reset CHWT. Plot kw/ton vs % Load. Perform a regression based on the same curve forms as for the mf't data. C. Compare the chiller plots in B. to mfr's plots in A. Significant difference between mf'r data in A and actual data plots in B may indicate problems. If the ARI APLV (Application Part Load Value) kw/ton efficiency calculated in the PG&E tool, for the actual chiller is more than 15% greater than the calculated APLV from the mf'r data, then full site verification and testing of full and part load efficiencies at ARI conditions, as per the original specs, will be necessary, unless the reason for inefficiency can be traced to site installation problems and remedied. D. Compare the chiller plots in B for the identical chillers. Significant differences between CH-1 and CH-2 actual plots in B may indicate problems with one of the chillers. E. The plots in B provide the efficiency benchmark for these chillers. Similar tests can be completed annually to verify and ensure continued efficient chiller operation by comparing curve fit regressions of current operation with that of the original benchmarks. The commissioning consultant (PECI) shall perform all data analysis for the benchmarking and submit a full report of the process and results.			
58	--	**Return all changed control parameters and conditions to their pre-test values[5]**	**Check off in table of Section 2 above when completed**		

SEQUENCES AND COMPONENTS NOT TESTED					
59		<u>Vibration Isolators.</u> Not tested.			
60		<u>Capacity Testing</u> Not tested.			
61		<u>SCHW Pump End of Curve Safety.</u> Not tested (from examining the pump curves and operating points, pumps are sufficiently oversized to make an end of curve event highly unlikely)			

<u>Notes:</u>

MONITORING AND TREND LOGGING

Monitoring via BAS trend logs are required per test procedures 10, 14, 17, 29, 31, 34; 57. Attach representative graphs or columnar data and explanatory analysis to this test report.

**Abbreviations: SCHW = secondary chilled water, PCHW = primary chilled water. dP = diff. pressure, SPt = setpoint
CHWS = chilled water supply, CT = cooling tower, BAS = building automation system.

[1]Sequences of operation attached to this test.
[2]Mode or function ID being tested from testing requirements section of the project Specifications.
[3]Step-by-step procedures for manual testing, trend logging or data-logger monitoring.
[4]Include tolerances for a passing condition. Fill-in spaces or lines not in brackets denote sequence parameters still to be specified by the A/E, conrols contractor or vendor. Write “Via BAS” for verifications of device position from BAS readout or “Via obs” for actual observation or from test instrument reading.
[5]Record any permanently changed parameter values and submit changes to Owner.
[6] Methods to False Load Chillers

1) If OSAT is less than 75F, prevent economizer cool OSA from entering the building.
    a) Manually close the economizer OSA dampers, OR
    b) Lower the changeover economizer setpoint below the OSAT (if DB type), OR lastly
    c) Overwrite the OSAT value to be 80F or more so dampers won’t open.
2) Use OSA preheat coils to heat incoming OSA.
   Enable the boiler by removing any lockouts, etc. Manually open the min. OSA preheat coil valve to preheat the OSA. Increase the min. OSA discharge temperature setpoint and the heating water supply temperature, as necessary.
3) Lower the space temperature setpoint.
4) Prior to the chiller test, manually preheat the building space temperature to 78F - 80F.
5) Lower the chilled water supply temperature setpoint.

False Loading Cooling Towers

1) False load the chiller (see above)

A SUMMARY OF DEFICIENCIES IDENTIFIED DURING TESTING IS ATTACHED

-- END OF TEST --

Notes: