Air-Cooled Chiller System Including Pumps

Project: _____

Dates of tests _____

Commissioning Agent _____

Related Tests: _____

1. Participants

Party	Participation
Owner	
Commissioning Authority	
Commissioning Agent	
Mechanical Engineer	
Control Contractor	
Electrical Contractor	

2. Test Prerequisites

Item	Task Description	Response	
1.	The following have been started up and startup reports and pre-functional checklists submitted and approved ready for functional testing:		
a.	Chiller:		
	• Pre-functional,	Yes	No
	• Startup report	Yes	No
b.	Chilled water pumps:		
	• Pre-functional	Yes	No
	• Startup report	Yes	No
c.	Chilled water piping and valves:		
	• Pre-functional	Yes	No
d.	Air handler units:		
	• Pre-functional	Yes	No
	• Startup report	Yes	No

2.	All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final set-points and schedules and with debugging, loop tuning and sensor and device calibrations completed.	Yes	No
3.	Piping system flushing complete and required report approved.	Yes	No
4.	Water treatment system complete and operational.	Yes	No
5.	Vibration control report approved (if required).	Yes	No
6.	Test and balance (TAB) complete and approved for the hydronic system.	Yes	No
7.	All A/E punchlist items to date for this equipment corrected.	Yes	No
8.	These functional test procedures reviewed and approved by installing contractor.	Yes	No
9.	Safeties and operating ranges reviewed.	Yes	No
10.	Test requirements and sequences of operation attached.	Yes	No
11.	Schedules and setpoints attached.	Yes	No
12.	False loading equipment, system and procedures ready (cross-over piping, preheat or reheat coils, control loops, over-ride on OSA dampers, etc.)	Yes	No
13.	Sufficient clearance around equipment for servicing.	Yes	No
14.	Sump or crankcase heaters have been on long enough to allow immediate starting of chillers.	Yes	No
15.	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.	Yes	No
16.	Misc. tools needed:		
	• two-way radios	Yes	No
	• original calibration temperature probe	Yes	No
	• pressure gages for evaporator dP	Yes	No
	• temperature probe with 6 ft wire or data logger	Yes	No
	• amp meter for pump amps	Yes	No
17.	**Control Program Review** Review the software control program(s) for this equipment. Parameters, setpoints and logic sequences appear to follow the specified written sequences.	Yes	No
18.	Record made of All Values for Current Setpoints (SPt), Control Parameters, Limits, Delays, Lockouts, Schedules, Etc. Changed to Accommodate Testing:	Yes	No

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 pre-functional 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.

[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.

Sensor & Location	Location OK	1st Gage or BAS Value	Instr. Meas'd Value	Final Gage or BAS Value	Pass Y/N?	Chiller Panel Value
CHWST						
CHWRT						
Pump current (CWP1-CUR)						
OSAT						

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 pre-functional check listing and startup.

"In calibration" means observing 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 Observation	Final BAS Reading	Pass Y/N

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

5. Verification of Misc. Pre-functional Checks.

1.	Misc. site checks of the pre-functional checklist and startup reports completed successfully.	Yes	No
2.	Verify that in the chiller control panel, that input is enabling a remote chilled water set point.	Yes	No
3.	All hydronic isolation valves fully open.	Yes	No
4.	Hydronic balancing valves adjusted per the balance report and permanently marked	Yes	No

5.	Pull strainers in strategic locations where debris collection is likely, to verify flush (list):	Yes	No

6. General Conditions of Test

The chiller will be tested with the building in as normal mode as possible. Temperatures are expected to be in the 70's creating sufficient load for most of the tests.
False loading, lowering space set points and/or turning on the preheat will be employed if necessary.

7. Testing Procedures and Record

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
1.	1	**Start-up Sequence** (This is not the initial startup by factory reps). a. With chiller system off, with schedule allowing chillers ON and OSAT >56F, overwrite the OSAT to be 50F. b. Return the OSAT to normal (assuming > 56F), turn chillers and pumps to auto. Turn ON only one AHU and command the cooling coil valve (CCV) to 18% open. A call for the chillers will be made when any AHU fan is ON and its CCV is => 15% open for ____minutes and OSAT is > 55F.	a. Observe that the CHW pump does not come ON b. Observe the lead CHW pump coming ON after [_____]. min. Observe in the BAS that the proof of flow has been made (or see it at the chiller panel). Once there is proof of flow, observe that the chiller starts. Observe that the initial CHWST StPt is [_____] in chiller panel.		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
2.	2	**Min. Chiller Flow.** While only 1 CCV is < 20% open and the other CCV is closed:	Record pump amps [_____] and dP across pump [_____] and dP across CHW evaporator [_____]. Make sure amps aren't over the RLA (_____) of the pump. Plot the operating point of the pump on the pump curve and chiller O&M evap. Dp/gpm chart to estimate gpm: [curve_____ gpm], [chart_gpm]. Make sure the gpm is greater than the minimum req'd chiller flow of _____ gpm.		
3.	3	**Minimum On-Time** With chiller on and running for less than 10 minutes [_____], command all cooling coil valves closed. Return CCVs to normal after procedure.	Observe that the chiller and pump does NOT stop until the 10 min. min ON-time is expired.		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
4.		**Lead Pump Start Failure.** Turn chiller OFF. Turn lead pump (CWP ___) to OFF; turn lag pump [CWP ____) and chiller to auto. Initiate a call for cooling per procedure 1.	Observe that after a call for the chiller is made to the lead pump for 45 seconds [_____] an alarm is generated in the BAS [_____]; and that the lag pump starts and chiller starts.		
5.		**Lead-1 Pump Failure.** With chiller having been running in auto for less than 10 minutes, and all pumps in auto, turn the operating pump (CWP_____) to OFF.	Observe that the chiller stops [_____] and 2 BAS alarms are generated (one for pump failure and one for chiller low flow), that the lag pump (CWP_____) starts [_____] and the chiller restarts after a timeout period of _____ minutes, having been manually reset.		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
6.		**Lag Pump Start Failure.** Turn chiller OFF. Assign other pump to be lead. Turn lead pump (CWP ___) to OFF; turn lag pump [CWP ____) and chiller to auto. Initiate a call for cooling per procedure 1.	Observe that after a call for the chiller is made to the lead pump for 45 seconds [_____] an alarm is generated in the BAS [_____]; and that the lag pump starts and chiller starts.		
7.		**OSAT Lockout.** With chiller and pumps in auto and running, overwrite the OSAT to be 50F or change the lockout to be 2F above current OSAT.	Observe the chiller and pumps shut down.		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
8.		**Lead-2 Pump Failure.** Change other pump to be the lead pump. With chiller running in auto and all pumps in auto, turn the operating (lead) pump (CWP_____) to OFF.	Observe that the chiller stops [_____] and 2 BAS alarms are generated (one for pump failure and one for chiller low flow), that the lag pump (CWP_____) starts [_____] and the chiller restarts after a timeout period of _____ minutes, having been manually reset.		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
9.		**General Chilled Water Temperature Control.** Have the chiller and pumps in auto for less than 10 minutes. Wait for the 10 min. timer to expire.	Record the CHWRT [_____] and CHWRT set point [_____]. Observe that the [_____] CHWST set point in the chiller is released and a new set point [_____] is sent to the chiller from the BAS that will result in bringing the CHWRT closer to set point. (If initial CHWRT is < set point (supposed to be 52F), then the new CHWST set point sent to the chiller should be > 49 or increasing.		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
10.		**TREND LOG 1. General Chilled Water Temperature Control** Trend the OSAT, CHWST, CHWRT, CHWST set point being sent to the chiller, CHWRT set point and both ASU's cooling coil valve positions at 2 minute intervals for a 3 day period. During the trended period, globally lower the space temperature set points 10F for 3 hours to see the chiller go to full load.	Graph and observe that the chiller maintains the CHWST set point being sent to it and that the CHWRT is maintained at set point Observe the CHWST set point and make sure that it is not lower than 45F until both CCVs are > 75% open, otherwise the CHWRT set point may need to be raised from 52F, Within +/- 1F during stable periods without hunting or overshoot (less than +/-3F during staging, etc.).		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
11.	3	**CHWST Hi/Low Alarm** With the chiller and pumps in auto, overwrite the CHWST to be 39F. Overwrite the CHWST to be 56F. Return to normal.	Observe a BAS alarm [_____]. Observe a BAS alarm [_____].		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
12.		**Chilled Water Pump Staging.** a. With the chillers and pumps in auto, command the CCV on both ASUs to be _____% open, just under where lag pump will stage ON (orig. seq. was sum > 100%, but recommend 180%). b. Command CCVs sum to be just over pump staging up point. Within 5 minutes, command both CCVs to be less than ½ of the above setting % [_____].	a. Record pump amps [_____] and dP across pump [_____]. Make sure amps aren't over the RLA (_____) of the pump. Plot the operating point of the pump on the pump curve to estimate gpm: [_____ gpm]. b. Observe that the lag CWP does not start until a 5 min. timer expires. Record both pump amps [CWP-1_____], [CWP-2_____] and dP across pumps [CWP-1 _____, CWP-2 _____] and dP across evap [_____]. Make sure amps aren't over the RLA (_____) of the pumps. Plot the operating points of the pumps on the pump curve and evap dp vs gpm chart to estimate gpm: [curve_____ gpm, chart _____gpm]. Observe that the lag pump remains ON until the 10 min. pump ON timer expires plus the 5 min. condition timer expires. Then the lag pump shuts OFF.		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
13.		**TREND LOG 2. Chilled Water Pump Staging** Trend each CWP status, each CWP current, chiller status, both ASU's CCV position, OSAT, CHWST, CHWRT at 2 minute intervals for 3 days. Also data log or trend an indicator or chiller load (current, kW, etc.). During the trended period, globally lower the space temperature set points 10F for 3 hours to see the chiller go to full load.	Observe that the staging of the pumps is reasonable and evaluate whether the pumps stage ON too soon or too late relative to needs in the building, as shown by the CCV positions. Note that the chiller or pump is not ON when OSAT is less than 55F.		
14.		**Chiller Staging OFF.** With the chiller and pumps in auto, command the CCVs on both ASUs to less than 5% open.	Observe that the chiller remains ON until a 5 minute timer expires and the chiller shuts OFF [_____]. The pump remains ON for another 2 minutes; then it shuts OFF [_____].		

Procedures. No.	Sequence. ID No.	Test Procedure (including special conditions)	Expected and Actual Response [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
15.		**Low ASU Coil Temp. Alarm.** a. Overwrite the OSAT to be 50F. With the chiller in auto, overwrite ASU-1 discharge temperature to be 34F. b. Repeat with ASU-2.	a. Observe the lead CWP start, but not the chiller. b. Observe the lead CWP start, but not the chiller.		
16.	--	**Return all changed control parameters and conditions to their pre-test values[5]**	**Check off in table of Section 2 above when completed**		

A SUMMARY OF DEFICIENCIES IDENTIFIED DURING TESTING IS ATTACHED

1	
2	
3	
4	
5	
6	
7	
8	

Abbreviations:

CWP	chilled water pump,
Pt	set point,
CHWS	chilled water supply,
BAS	building automation system,

END OF FUNCTIONAL TEST