APPENDIX A
COMMISSIONING (CX) TEST SHEETS

EASTPOINT
ENGINEERING

LIST OF COMMISSIONING FORMS

FT-001 Water Cooled Chillers CH-1, CH-2, CH-3 and Pumps

FT-002 Air Cooled Chillers CH-4, CH-5 and Pumps

FT-003 Sump Pump SP-1

FT-004 Refrigerant Leak Detection and Alarm

Functional Test FT-001

JAG Building – Chiller Replacement

WATER COOLED CHILLERS CH-1, CH-2 and CH-3

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 Chiller have been started up and startup reports submitted and approved

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

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. __Chilled and Condenser water treatment system complete and operational. Testing reports have been submitted by the water treatment specialist.
e. ___Pressure testing of chilled water and condenser water piping is complete.
f. __Test and balance (TAB) complete and approved for the hydronic system.

Notes:

g. __Piping properly insulated, labeled and supported
h. __ Strainers cleaned.
i. __Refrigerant leak detectors have been properly commissioned and tested using test gas. Copy of test results submitted.
j. __Sufficient clearance around equipment for servicing.
k. __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.
l. __**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:

m. __ Record made of All Values for Current Setpoints (SPt), Control Parameters, Limits, Delays, Lockouts, Schedules, Etc. Changed to accommodate Testing: (**CHECK IF OK**)

Parameter	Pre-Test Values	Returned to Pre-Test Values (check if OK)		Parameter	Pre-Test Values	Returned to Pre-Test Values (check if OK)
Space Temp. Set pts.				CHW Pumps P-3 P-4 P-94 P-95 P-96 (hand, off, auto)		
Min. OSA preheat coil DAT setpoint				Condenser Pumps P-97 P-98 P-99 (hand, off, auto)		
Boiler enable, heating water temp. etc.				CT bypass valve (auto, manual)		
CHWS SPt temp				Chiller flow switches CH-1: CH-2: CH-3: (normal, jumped)		
Lead chiller ID: Lag chiller ID:				CHW pumps speed P-94 P-95 P-96 (auto, manual)		
Safety Overrides				Occupied schedule Start Stop		
Chillers CH-1: CH-2: CH-3: (hand, off, auto)				Delays		
				CT fans CT-1 CT-2 CT-3 (hand, off, auto)		

Notes:

Parameter	Pre-Test Values	Returned to Pre-Test Values (check if OK)		Parameter	Pre-Test Values	Returned to Pre-Test Values (check if OK)
CT vibration sensors CT-1 CT-2 CT-3 (normal, jumped)						
CT makeup valve CT-1 CT-2 CT-3 (auto, manual)						

Notes:

3. Sensor Calibration Checks

The sensors listed below checked for calibration and adequate location.

"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. If not, 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	Location OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?
CHWS temp mixed from chillers (T-3)					
CHWR temp mixed to chillers (T-4)					
CDW temp to chiller CH-1 (T-1)					
CDW temp to chiller CH-2 (T-1)					
CDW temp to chiller CH-3 (T-1)					
CDW temp from chiller CH-1 (T-2)					
CDW temp from chiller CH-2 (T-2)					
CDW temp from chiller CH-3 (T-2)					
CH-1 CHWS (on board)					
CH-3 CDWS (on board)					
CH-3 CDWR (on board)					

Sensor & Location	Location OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?
CH-1 CHWR (on board)					
CH-2 CHWS (on board)					
CH-2 CHWR (on board)					
CH-3 CHWS (on board)					
CH-3 CHWR (on board)					
CH-1 CDWS (on board)					
CH-1 CDWR (on board)					
CH-2 CDWS (on board)					
CH-2 CDWR (on board)					

Notes:

Sensor & Location	Location OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?
CHWS temp to building (T-6)					
CHWR temp to building (T-5)					
Pump P-3 status current					
Pump P-4 status current					
Pump P-94 status current					
Pump P-95 status current					
Pump P-96 status current					
Pump P-97 status current					

Sensor & Location	Location OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?
Pump P-98 status current					
Pump P-99 status current					

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

Notes:

4. Device Calibration Checks

The actuators or devices listed below checked for calibration.

"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 before proceeding.

Device or Actuator & Location	**Procedure / State**	**1st** BAS Value	Site Obser-vation	**Final** BAS Reading	Pass Y/N
CT-1 bypass valve V-1 position or command and stroke*	1. Full open				
	2. Full closed				
	3. Full modulation over control signal range -start to open				
	4. Full modulation over control signal range – start to close (from full open position)				
	5. Remove power (fail safe)				
CT-1 bypass valve V-2 position or command and stroke*	1. Full open				
	2. Full closed				
	3. Full modulation over control signal range -start to open				
	4. Full modulation over control signal range – start to close (from full open position)				
	5. Remove power (fail safe)				
CT-2 bypass valve V-1 position or command and stroke*	1. Full open				
	2. Full closed				
	3. Full modulation over control signal range -start to open				
	4. Full modulation over control signal range – start to close (from full open position)				
	5. Remove power (fail safe)				
CT-2 bypass valve V-2 position or command and stroke*	1. Full open				
	2. Full closed				
	3. Full modulation over control signal range -start to open				
	4. Full modulation over control signal range – start to close (from full open position)				
	5. Remove power (fail safe)				
CT-3 bypass valve V-1 position or command and stroke*	1. Full open				
	2. Full closed				
	3. Full modulation over control signal range -start to open				
	4. Full modulation over control signal range – start to close (from full open position)				
	5. Remove power (fail safe)				

Notes:

Device or Actuator & Location	**Procedure / State**	**1st** BAS Value	Site Obser-vation	**Final** BAS Reading	Pass Y/N
CT-3 bypass valve V-2 position or command and stroke*	1. Full open				
	2. Full closed				
	3. Full modulation over control signal range -start to open				
	4. Full modulation over control signal range – start to close (from full open position)				
	5. Remove power (fail safe)				
P-94 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
P-95 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
P-96 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
CT-1, Fan #1 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
CT-1, Fan #2 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
CT-2, Fan #1 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
CT-2, Fan #2 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
CT-3, Fan #1 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
CT-3, Fan #2 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				

* Set pumps to normal mode. Verify normally open and normally closed positions (fail safe) with drawings. *Procedure 1.* Command valve to full open by providing either 100% of control signal or 0% of control signal (0-10V or 4-20mA signal). Verify BAS reading says valve is full open. Visually verify valve is full open. *Procedure 2.* Command valve to full closed by providing either 100% of control signal or 0% of control signal (0-10V or 4-20mA signal). Verify BAS reading says valve is full closed. Visually verify valve is full closed. *Procedure 3.* From closed position, command valve to start opening by providing either 99% of control signal or 1% of control signal. Verify BAS reading indicates valve has adjusted position. Visually verify valve has adjusted position. *Procedure 4.* From full open position, command valve to start closing by providing either 99% of control signal or 1% of control signal. Verify BAS reading indicates valve has adjusted position. Visually verify valve has adjusted position. *Procedure 5.* Provide a control signal of 100% and then remove electricity from valve. Verify that valve stem and actuator move to the fail safe position

Notes:

*** VFD: *Procedure 1*. Override control signal to minimum value. Verify that pump speed is at minimum for VFD *and* packaged controller reads the same. Return signal to normal. *Procedure 2.* Override control signal to maximum value.. Verify that pump speed is at its max. and verify that the packaged controller reads the same. Return all control signals to normal.

Notes:

5. 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.

At the beginning of the cooling season, the chiller will be started and operated, without further testing, unless problems arise. Then, when conditions are warm (approximately 22C-25C), 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.

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

Notes:

6. Testing Procedures and Record

Proced. No.[1]		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					
1a		Startup Sequence. Lead = CH-1. (This is not the initial startup by factory reps). With chiller system off, with schedule allowing chillers ON and OSAT >10°C, 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. Chiller shall not start until AHU CCV have started to open and remain open for set period of time).	Observe that the secondary lead CHW pump (P-3 or P-4) turns ON (by demand or as per existing schedule in place). Observe that primary CH-1 pump does not turn on until a AHU CCV has started to open and has been on for set time delay. After time delay, observe the primary CH-1 pump turn on and slowly ramp up to programmed speed (in order to meet design flow). Starting RPM = _____. Final RPM = _____. Observe the CH-1 CD pump turn on. Observe the lead chiller starting.		
		Lead Cooling Tower: Poll ECDWT every 4 min.	OSAT = [_____F]. OSAWB = [_____F]. Observe that when the lead chiller started the CT specified sequences followed, with delays between stages. Observe that the Entering CDWT SPt is maintained. Observe that the bypass valve is closed when the setpoint is exceeded [_____]. Observe that the cooling tower successively ramps up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT fan stage/RPM		
		Maintain chiller load between 10-15% for 30 minutes.	Observe that there is no surging or abnormal vibration.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
2a		Lag Chiller Staging ON. With chillers in auto, and loaded such that only lead chiller is running, lower space setpoints so AHU CCVs open. Wait ~20 minutes.	Once lead chiller is 40% loaded (by % kW load), and 20 minute have passed, observe lag chiller system start as follows. Time: [_____]. Lag Chiller ID: CH-2 or CH-3(circle). Observe the primary lag chiller pump turn on and slowly ramp up to maximum programmed speed (in order to meet design flow). Starting RPM = [_____]. Final RPM = [_____]. Time to ramp up = [_____]. Observe the lag chiller CD pump turn on. Observe the lag chiller starting. Observe that the amps on both chillers are within 5% of each other as building load continues to rise.		
		Lag Cooling Tower: Specified Sequences: Poll ECDWT every 4 min.	Observe that when the lag chiller started the CT specified sequences followed, with delays between stages. Observe that the Entering CDWT SPt is maintained. Observe that the bypass valve is closed when the setpoint is exceeded [_____]. Observe that the cooling tower successively ramps up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT fan stage/RPM		
		Maintain chiller load between 10-15% for 30 minutes.	Observe that there is no surging or abnormal vibration.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
3a		Chillers Staging OFF. Raise space setpoints so CCVs close, or shut off some or all AHU's. Wait ~5 minutes.	Chiller Capacity ramp down Observe that both chillers ramp down in capacity simultaneously When capacity of each chiller drops to approx. 15% load (by kW) observe that lag chiller shuts off. Time when lag chiller stops: [_____]. Observe lag cooling tower ramp down and shut off. Time stage down/ramp down: [_____]. After chiller has stopped, observe lag CHW primary pump slowly ramp down and stop. Starting RPM = [_____]. Final RPM = [_____]. Time to ramp down = [_____]. After chiller has stopped, observe the CD water pump stop.		
		Repeat to see lead chiller stage off.	Lead Chiller Staging OFF* When all AHU CCVs almost closed and after a time delay, lead chiller and primary CHW pump should shut down. Building secondary pump to shut down automatically as well (or as per user entered time of schedule). *No no-flow alarms should be generated during normal staging down.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
1b		**Repeat Above With CH-2 as Lead** Startup Sequence. Lead = CH-2. (This is not the initial startup by factory reps). With chiller system off, with schedule allowing chillers ON and OSAT >10°C, 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. Chiller shall not start until AHU CCV have started to open and remain open for set period of time).	Observe that the secondary lead CHW pump (P-3 or P-4) turns ON (by demand or as per existing schedule in place). Observe that primary CH-2 pump does not turn on until a AHU CCV has started to open and has been on for set time delay. After time delay, observe the primary CH-2 pump turn on and slowly ramp up to programmed speed (in order to meet design flow). Starting RPM = _____. Final RPM = _____. Observe the CH-1 CD pump turn on. Observe the lead chiller starting.		
		Lead Cooling Tower: Poll ECDWT every 4 min.	OSAT = [_____F]. OSAWB = [_____F]. Observe that when the lead chiller started the CT specified sequences followed, with delays between stages. Observe that the Entering CDWT SPt is maintained. Observe that the bypass valve is closed when the setpoint is exceeded [_____]. Observe that the cooling tower successively ramps up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT fan stage/RPM		
		Maintain chiller load between 10-15% for 30 minutes.	Observe that there is no surging or abnormal vibration.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
2b		Lag Chiller Staging ON. With chillers in auto, and loaded such that only lead chiller is running, lower space setpoints so AHU CCVs open. Wait ~20 minutes.	Once lead chiller is 40% loaded (by % kW load), and 20 minute have passed, observe lag chiller system start as follows. Time: [_____]. Lag Chiller ID: CH-1 or CH-3(circle). Observe the primary lag chiller pump turn on and slowly ramp up to maximum programmed speed (in order to meet design flow). Starting RPM = [_____]. Final RPM = [_____]. Time to ramp up = [_____]. Observe the lag chiller CD pump turn on. Observe the lag chiller starting. Observe that the amps on both chillers are within 5% of each other as building load continues to rise.		
		Lag Cooling Tower: Specified Sequences: Poll ECDWT every 4 min.	Observe that when the lag chiller started the CT specified sequences followed, with delays between stages. Observe that the Entering CDWT SPt is maintained. Observe that the bypass valve is closed when the setpoint is exceeded [_____]. Observe that the cooling tower successively ramps up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT fan stage/RPM		
		Maintain chiller load between 10-15% for 30 minutes.	Observe that there is no surging or abnormal vibration.		
Notes:					

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
3b		Chillers Staging OFF. Raise space setpoints so CCVs close, or shut off some or all AHU's. Wait ~5 minutes.	Chiller Capacity ramp down Observe that both chillers ramp down in capacity simultaneously When capacity of each chiller drops to approx. 15% load (by kW), observe that lag chiller shuts off. Time when lag chiller stops: [_____]. Observe lag cooling tower ramp down and shut off. Time stage down/ramp down: [_____]. After chiller has stopped, observe lag CHW primary pump slowly ramp down and stop. Starting RPM = [_____]. Final RPM = [_____]. Time to ramp down = [_____]. After chiller has stopped, observe the CD water pump stop.		
		Repeat to see lead chiller stage off.	Lead Chiller Staging OFF* When all AHU CCVs almost closed and after a time delay, lead chiller and primary CHW pump should shut down. Building secondary pump to shut down automatically as well (or as per user entered time of schedule). *No no-flow alarms should be generated during normal staging down.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
1c		**Repeat Above With CH-3 as Lead** Startup Sequence. Lead = CH-3. (This is not the initial startup by factory reps). With chiller system off, with schedule allowing chillers ON and OSAT >10°C, 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. Chiller shall not start until AHU CCV have started to open and remain open for set period of time).	Observe that the secondary lead CHW pump (P-3 or P-4) turns ON (by demand or as per existing schedule in place). Observe that primary CH-3 pump does not turn on until a AHU CCV has started to open and has been on for set time delay. After time delay, observe the primary CH-3 pump turn on and slowly ramp up to programmed speed (in order to meet design flow). Starting RPM = _____. Final RPM = _____. Observe the CH-3 CD pump turn on. Observe the lead chiller starting.		
		Lead Cooling Tower: Poll ECDWT every 4 min.	OSAT = [_____F]. OSAWB = [_____F]. Observe that when the lead chiller started the CT specified sequences followed, with delays between stages. Observe that the Entering CDWT SPt is maintained. Observe that the bypass valve is closed when the setpoint is exceeded [_____]. Observe that the cooling tower successively ramps up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT fan stage/RPM		
		Maintain chiller load between 10-15% for 30 minutes.	Observe that there is no surging or abnormal vibration.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
2c		Lag Chiller Staging ON. With chillers in auto, and loaded such that only lead chiller is running, lower space setpoints so AHU CCVs open. Wait ~20 minutes.	Once lead chiller is 40% loaded (by % kW load), and 20 minute have passed, observe lag chiller system start as follows. Time: [_____]. Lag Chiller ID: CH-1 or CH-2(circle). Observe the primary lag chiller pump turn on and slowly ramp up to maximum programmed speed (in order to meet design flow). Starting RPM = [_____]. Final RPM = [_____]. Time to ramp up = [_____]. Observe the lag chiller CD pump turn on. Observe the lag chiller starting. Observe that the amps on both chillers are within 5% of each other as building load continues to rise.		
		Lag Cooling Tower: Specified Sequences: Poll ECDWT every 4 min.	Observe that when the lag chiller started the CT specified sequences followed, with delays between stages. Observe that the Entering CDWT SPt is maintained. Observe that the bypass valve is closed when the setpoint is exceeded [_____]. Observe that the cooling tower successively ramps up as the setpoint remains unsatisfied. Record results. Time Setpoint ECDWT CT fan stage/RPM		
		Maintain chiller load between 10-15% for 30 minutes.	Observe that there is no surging or abnormal vibration.		
Notes:					

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
3c		Chillers Staging OFF. Raise space setpoints so CCVs close, or shut off some or all AHU's. Wait ~5 minutes.	Chiller Capacity ramp down Observe that both chillers ramp down in capacity simultaneously When capacity of each chiller drops to approx. 15% load (by kW), observe that lag chiller shuts off. Time when lag chiller stops: [_____]. Observe lag cooling tower ramp down and shut off. Time stage down/ramp down: [_____]. After chiller has stopped, observe lag CHW primary pump slowly ramp down and stop. Starting RPM = [_____]. Final RPM = [_____]. Time to ramp down = [_____]. After chiller has stopped, observe the CD water pump stop.		
		Repeat to see lead chiller stage off.	Lead Chiller Staging OFF* When all AHU CCVs almost closed and after a time delay, lead chiller and primary CHW pump should shut down. Building secondary pump to shut down automatically as well (or as per user entered time of schedule). *No no-flow alarms should be generated during normal staging down.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
DATA TRENDING					
4		Trend all chiller and cooling tower setpoints and operating values including chiller status, % load, entering CHWT, leaving CHWT, building supply CHWT, building return CHWT, cooling tower status, condenser water entering and leaving temperatures, bypass valve positions. (Start all points simultaneously, 5-10 min. time step for 5 days, including partial weekend, during a period of significant cooling.	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. Observe that the CDW SPt changes as expected and CDW meets setpoint w/o excessive hunting. Attach representative graphs and columnar data and explanatory analysis to this test report.		
MISC. CHILLER SYSTEM FUNCTIONS					
5		<u>Cooling tower fan VFD's</u> With the lead system cooling tower operating, override ECDWT setpoint to cause start up and shut down of the tower. Override fan speed and cycle slowly from min speed to max speed.	Ensure minimum fan speed does not drop below 25% or other minimum value provided by fan manufacturer. Min fan speed = [_____]. Manufacturer minimum fan speed = [_____]. Observe tower structure/framework for vibrations or shaking. Ensure no excessive vibrations or shaking. Fine tune programming as required avoiding any resonating frequencies.		
6		<u>OSAT Lockout.</u> With chiller(s) running in auto, overwrite OSAT sensor to be 12°C (or temperature equal to the existing lock out temp in the programming). *Note: Review existing control programming to ensure that OSAT lockout is in place. This may be used to lock out the chillers when the airside economizers on the AHU's are adequate to meet building cooling load.*	Observe a shutdown of the chillers, including pumps.		

<u>Notes:</u>

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
7		Bypass Valve. With CH-1 condenser water pump operating and chiller off, overwrite CDW SPt, to a higher value.	Observe bypass valves modulate to full bypass position, to try and achieve SPt but unable to achieve SPt.		
		Start up chiller on a demand for chilled water. And poll CDW temp to ensure CDW SPt is maintained.	Observe condenser water temp rise and SPt achieved. Then observe bypass valves modulate to closed position so as to maintain CDW SPt. Time CDW SPt CDWT Bypass V-1% Bypass V-2%		
		Repeat above for CH-2: With CH-2 condenser water pump operating and chiller off, overwrite CDW SPt, to a higher value.	Observe bypass valves modulate to full bypass position, to try and achieve SPt but unable to achieve SPt.		
		Start up chiller on a demand for chilled water. And poll CDW temp to ensure CDW SPt is maintained.	Observe condenser water temp rise and SPt achieved. Then observe bypass valves modulate to closed position so as to maintain CDW SPt. Time CDW SPt CDWT Bypass V-1% Bypass V-2%		
		Repeat above for CH-3: With CH-3 condenser water pump operating and chiller off, overwrite CDW SPt, to a higher value.	Observe bypass valves modulate to full bypass position, to try and achieve SPt but unable to achieve SPt.		
		Start up chiller on a demand for chilled water. And poll CDW temp to ensure CDW SPt is maintained	Observe condenser water temp rise and SPt achieved. Then observe bypass valves modulate to closed position so as to maintain CDW SPt. Time CDW SPt CDWT Bypass V-1% Bypass V-2%		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
8		Secondary CHW Pump Failure, P-3, P-4. During a demand for chilled water and at least one chiller operating in auto mode, manually shut off the lead CHW pump.	The lag pump should become the lead pump and should start. A pump failure alarm should be generated.		
9		Chiller Standby . With lead chiller manually OFF, turn lag chiller to Auto and cause a call for the chilled water.	Lead chiller pump (P-94, P-95 or P-96) should start. Lead chiller CDW pump (P-97, P-98 or P-99) should start. Lead chiller should try and start, but fail. Observe that a chiller failure alarm is generated. The lead chiller pumps shall shut off before the Lag chiller and pumps take over. After [_____] minutes DDC should initiate lag chiller system (pumps, chiller and cooling tower) to function as lead. CDW (shorten delays for test, if desired)		
10		3rd Chiller Standby . Repeat above to test the third backup chiller to operate as lead	First two chillers remain off. 3rd chiller system starts.		
11		Chiller Pump Failure (P-94, P-95 or P-96). With lead chiller pump manually OFF and other two pumps on AUTO, cause a call for chilled water.	A chiller pump failure alarm should be generated. The lag chiller system then acts as lead chiller system and goes through the proper startup sequence.		
12		3rd Chiller Pump Failure. Repeat above to test the third backup chiller system to operate as lead	First two chillers systems remain off. 3rd chiller system starts.		
13		Condenser Pump Failure (P-97, P-98 or P-99). With lead condenser pump manually OFF and other two pumps on AUTO, cause a call for chilled water.	A condenser pump failure alarm should be generated. The lead chilled water pump shall shut down before the lag chiller system can take over. The lag chiller system then acts as the lead chiller system and goes through the proper startup sequence.		
14		3rd Condenser Pump Failure. Repeat above to test the third backup chiller system to operate as lead	First two chillers systems remain off. 3rd chiller system starts.		
15		Low temperature shutdown. With chiller operating, override 3-way valve position or ECDWT SPt below 13°C. Repeat above for the remaining 2 chillers	Observe chiller and condenser pump shutdown and alarm initiated. Observe chiller and condenser pumps shutdown and alarms initiated.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
16		Low Cooling Tower sump water level shutdown. With chiller operating, slowly drain water from sump until water level reaches low level sensor. Repeat above for the remaining 2 chillers	Observe condenser pump and chiller shutdown and alarm initiated. Observe condenser pumps and chillers shutdown and alarms initiated.		
17		High Cooling Tower sump water level alarm: Slowly raise water in sump until water level reaches high level sensor. Repeat above for the remaining 2 chillers	Ensure that water is not flowing out of sump through overflow pipe. Ensure that high level alarm is initiated. Observe similar conditions.		
18		Auto cycle of standby cooling tower. Review data logs from Procedure 4, or override time lapse values of a standby cooling tower system.	Ensure that redundant condenser water pump automatically cycles on for a one (1) hour time period over each 24 hour time period when no call for operation of that system. Observe the same for the other two redundant systems.		
19		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 and ALARM					
20		CHW Flow Switch CH-1. If CHW 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 CHW pump. Turn Chiller 1 to auto.	Observe that chiller won't start because of no CHW flow and that an alarm is generated.		
21		CHW Flow Switch CH-2. If CHW 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 CHW pump. Turn Chiller 2 to auto.	Observe that chiller won't start because of no CHW flow and that an alarm is generated.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
22		CHW Flow Switch CH-3. If CHW 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 CHW pump. Turn Chiller 3 to auto.	Observe that chiller won't start because of no CHW flow and that an alarm is generated.		
23		CDW Flow Switch CH-1. If CDW 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 CDW pump. Turn Chiller 1 to auto.	Observe that chiller won't start because of no CDW flow and that an alarm is generated.		
24		CDW Flow Switch CH-2. If CDW 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 CDW pump. Turn Chiller 2 to auto.	Observe that chiller won't start because of no CDW flow and that an alarm is generated.		
25		CDW Flow Switch CH-3. If CDW 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 CDW pump. Turn Chiller 3 to auto.	Observe that chiller won't start because of no CDW flow and that an alarm is generated.		
26		Bypass valve failure. Disconnect power feed from bypass valve and initiate valve to open or close though the BAS. Repeat above for remaining 5 valves.	Observe that valve does not move and valve failure alarm is generated. Observe that valve does not move and valve failure alarm is generated.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
FULL LOAD PERFORMANICE VERIFICATION					
27		Summer time Test . Develop a plan to test full load performance of the chilled water plant when operating in **mechanical cooling mode**. False loading of the chiller will be required to achieve design load conditions. Reference Section 5 of this document and project specification Section 23 08 01 for more details. Submit written test procedure to owner for approval before any test takes place. Testing should last a minimum of 2 hours or longer as required to ensure all systems are stabilized under full load conditions. Trend all operating conditions at 5 minute intervals throughout test period including supply and return chilled water temperatures, building supply and return chilled water temperatures, chiller load, condenser water temperatures, cooling tower status, outdoor air temperatures, etc.	Results of test have been analyzed and compared with manufacturer performance data for **all three** chillers. Documented results of testing have been submitted to owner.		

Return all changed control parameters and conditions to their pre-test values

Notes:

MONITORING AND TREND LOGGING

Monitoring via BAS trend logs are required per test procedures indicated. Attach representative graphs or columnar data and explanatory analysis to this test report.

**Abbreviations: CHW = chilled water, dP = diff. pressure, SPt = setpoint, CHWS = chilled water supply, CHWR = chilled water return, CT = cooling tower, BAS = building automation system, CDW = Condenser water, CDWT = condenser water temperature, CHWT = chilled water temperature, ECDWT = entering condenser water temperature, OSAT = outside air temperature.

[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, controls 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) Lower the space temperature setpoint.
2) Prior to the chiller test, manually preheat the building space temperature to 25F - 27F.
3) 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:

Functional Test FT-002

JAG Building – Chiller Replacement

AIR COOLED CHILLERS CH-4 and CH-5

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 Chillers have been started up and startup reports submitted and approved

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

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. __Chilled water treatment system complete and operational.
e. ___Pressure testing of chilled water piping is complete.
f. __Test and balance (TAB) complete and approved for the hydronic system.

Notes:

g. __Piping properly insulated, labeled and supported
h. __ Strainers cleaned.
i. __ Refrigerant leak detection system in room has been properly commissioned and tested using test gas. Copy of test results submitted.
j. __Schedules and setpoints attached.
k. __False loading equipment, system and procedures ready (cross-over piping, preheat or reheat coils, control loops, over-ride on OSA dampers, etc.)
l. __Sufficient clearance around equipment for servicing.
m. __Refrigerant system installation and commissioning complete and reports submitted.
n. __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.
o. __**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:

p. __ Record made of All Values for Current Setpoints (SPt), Control Parameters, Limits, Delays, Lockouts, Schedules, Etc. Changed to accommodate Testing: (**CHECK OF OK**)

Parameter	Pre-Test Values	Returned to Pre-Test Values (check if OK)
Space Temp. Setpts		
CH-4 CHWS SPt temp		
CH-5 CHWS SPt temp		
Lead chiller ID: Lag chiller ID:		
Safety Overrides		
Chillers CH-4: CH-5: (hand, off, auto)		

Parameter	Pre-Test Values	Returned to Pre-Test Values (check if OK)
CHW Pumps P-62A P-62B P-82 P-83 (hand, off, auto)		
Chiller flow switches CH-1: CH-2: Chiller pump flow switches P-62A P-62B P-82 P-83 (normal, jumped)		
CHW pumps speed P-94 P-95 (auto, manual)		
Free cooling switchover outdoor air temperature SPt		
Time Delays		

Notes:

3. Sensor Calibration Checks

The sensors listed below checked for calibration and adequate location.

"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 tolerance. If not, 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	Location OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?	Sensor & Location	Location OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?
CHWS temp mixed (T-8)						Outdoor Temp					
CHWR temp mixed (T-7)						CHW Flow Switch on board CH-4					
CHWS building (T-10)						CHW Flow Switch on board CH-5					
CHWR building (T-9)						P-82 flow switch					
CH-5 supply temp (T-11)						P-83 flow switch					
CH-4 supply temp (T-12)						P-62A flow switch					
CH-5 supply temp (on board)						P-62B flow switch					
CH-5 return temp (on board)											
CH-4 supply temp (on board)											
CH-4 return temp (on board)											

[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.

Notes:

4. Device Calibration Checks

The actuators or devices listed below checked for calibration.

"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 before proceeding.

Device or Actuator & Location	**Procedure / State**	**1st** BAS Value	Site Obser-vation	**Final** BAS Reading	Pass Y/N
P-62A variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
P-62B variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
P-82 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				
P-83 variable frequency drive speed (VFD)***	1. Min.: _____%				
	2. Max.: _____%				

*** VFD: *Procedure 1.* Override control signal to minimum value. Verify that pump speed is at minimum for VFD *and* packaged controller reads the same. Return signal to normal. *Procedure 2.* Override control signal to maximum value.. Verify that pump speed is at its max. and verify that the packaged controller reads the same. Return all control signals to normal.

Notes:

5. Seasonal Testing / General Conditions of Tests

A chilled water supply to the data centre and other critical spaces is to be maintained by the chillers CH-4 and CH-5 at all times during testing. Careful attention must be provided during testing procedures to ensure that any chilled water disruptions does not cause concern to the proper operation of IT equipment and other critical equipment. Disruption time lengths of chilled water supply must be minimized and notice must be given to Building Operating Staff 14 days in advance. Space temperatures in these rooms, as well as chilled water supply temperatures must be closely monitored during all commissioning tests. Testing must be coordinated with building operating staff and contractor must accommodate after hours testing and other special conditions as required.

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 assurance that the chillers will function properly and can maintain chilled water load. This will include testing in free cooling operating mode and mechanical cooling operating mode. This will also include load testing to ensure operation of chillers near design loads in free cooling mode through the use of the methods of false loading noted in specifications and in Note 6 at the end of the test. Seasonal testing will ensure chillers operate at summertime outdoor design temperatures in mechanical cooling mode. When outdoor conditions are warm (approximately 22F-25F), the seasonal testing will be performed. This will likely require some false loading to create close to full load conditions. Methods of false loading will likely require introducing a heat source in the data centre and/or other critical rooms. Proper functionality of equipment in these rooms is of critical importance to PWGSC and any disruption to their operation is of upmost importance. Contractor is required to coordinate false loading activities closely with building operating staff and accommodate after hours testing procedures as required.

The data centre chillers are designed to operate on the emergency power system. One of the tests to be completed includes simulation of power outage and monitoring of chillers operation and refrigerant detection and purge system under emergency power. Again this activity must be closely coordinated with building operating staff and is expected to take place after hours or on a weekend as indicated by PWGSC.

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

Notes:

6. Testing Procedures and Record

Proced. No.[1]		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					
I		Startup Sequence. Lead = CH-4, Mechanical Cooling Mode. (This is not the initial startup by factory reps). With chiller system off and outside temperature above switchover SPt (-2°C), turn chillers and pumps to auto. A call for the chillers will be made when any building pump is operating.	Observe that the lead CHW pump does not turn unless at least one of the building pumps (P-80, P-81, P-90, P-91, P-92 or P-93) are running. Observe lead CHW pump ramp up slowly to programmed speed. Starting RPM = _____, final RPM = _____. Observe the lead chiller starting in mechanical mode (i.e. compressors). After a few minutes of operation observe the CHW supply temperature and ensure it meets CHW supply SPt. CHW supply temperature = _____, CHW supply SPt = _____. Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
2		Standby Chiller Startup Test A - Mechanical Cooling Mode. During automatic operation of lead chiller system, manually turn lead chiller switch to off.	Observe that a chiller failure alarm is generated. Observe the lead chiller CHW pump slowly ramp down and stop and simultaneously observe the Standby chiller system CHW pump ramp up slowly to programmed speed. Starting RPM = _____, final RPM = _____. Observe the Standby chiller start in mechanical mode (i.e. compressors). After a few minutes of operation observe the CHW supply temperature and ensure it meets CHW supply SPt.: CHW supply temperature = _____, CHW supply SPt = _____. Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		
3		Standby Chiller Startup Test B - Mechanical Cooling Mode. With lead and lag chiller pumps manually OFF and standby lead/lag chiller pumps on AUTO, cause a call for chilled water.	Observe that chiller pumps failure alarms are generated. Observe the Standby chiller system CHW pump ramp up slowly to programmed speed. Starting RPM = _____, final RPM = _____. Observe the Standby chiller start in mechanical mode (i.e. compressors). After a few minutes of operation observe the CHW supply temperature and ensure it meets CHW supply SPt.: CHW supply temperature = _____, CHW supply SPt = _____. Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
4		***Repeat above 3 tests with other chiller operating as lead.*** <u>Startup Sequence, Lead = CH-5, Mechanical Cooling Mode.</u> With chiller system off and outside temperature above switchover SPt (-2°C), turn chillers and pumps to auto. A call for the chillers will be made when any building pump is operating.	Observe that the lead CHW pump does not turn unless at least one of the building pumps (P-80, P-81, P-90, P-91, P-92 or P-93) are running. Observe lead CHW pump ramp up slowly to programmed speed. Starting RPM = _____, final RPM = _____. Observe the lead chiller starting in mechanical mode (i.e. compressors). After a few minutes of operation observe the CHW supply temperature and ensure it meets CHW supply SPt. CHW supply temperature = _____, CHW supply SPt = _____. Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		
5		<u>Standby Chiller Startup Test A - Mechanical Cooling Mode.</u> During automatic operation of lead chiller system, manually turn lead chiller switch to off.	Observe that a chiller failure alarm is generated. Observe the lead chiller CHW pump slowly ramp down and stop and simultaneously observe the Standby chiller system CHW pump ramp up slowly to programmed speed. Starting RPM = _____, final RPM = _____. Observe the Standby chiller start in mechanical mode (i.e. compressors). After a few minutes of operation observe the CHW supply temperature and ensure it meets CHW supply SPt. CHW supply temperature = _____, CHW supply SPt = _____. Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		

<u>Notes:</u>

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
6		Standby Chiller Startup Test B - Mechanical Cooling Mode. With lead and lag chiller pumps manually OFF and standby lead/lag chiller pumps on AUTO, cause a call for chilled water.	Observe that chiller pumps failure alarms are generated. Observe the Standby chiller system CHW pump ramp up slowly to programmed speed. Starting RPM = _____, final RPM = _____. Observe the Standby chiller start in mechanical mode (i.e. compressors). After a few minutes of operation observe the CHW supply temperature and ensure it meets CHW supply SPt. : CHW supply temperature = _____, CHW supply SPt = _____. Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		
7		Startup Sequence Free Cooling Mode. With chiller system off and outside temperatures in between -7°C and switchover SPt (-2°C), turn chillers and pumps to auto. A call for the chillers will be made when any building pump is operating.	Observe that the lead CHW pumps do not turn unless at least one of the building pumps (P-80, P-81, P-90, P-91, P-92 or P-93) are running. Observe lead CHW pumps for both chillers CH-4 and CH-5 ramp up slowly to programmed speed. CH-4 Starting RPM = _____, final RPM = _____. CH-5 Starting RPM = _____, final RPM = _____. Observe both chillers start in free cooling mode. After a few minutes of operation observe the CHW supply temperature and ensure it meets CHW supply SPt. : CH-4 CHW supply temperature = _____, CH-4 CHW supply SPt = _____. CH-5 CHW supply temperature = _____, CH-5 CHW supply SPt = _____. Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		
8		Chiller Failure - Free Cooling Mode Test A. When outside temperature is still between -7°C and switchover SPt (-2°C), manually turn chiller CH-4 switch to off.	Observe lead CHW pump serving CH-4 stop and chiller CH-5 and associated lead pump start up in mechanical cooling mode.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
9		Chiller Failure - Free Cooling Mode Test B. Continuing from previous test: return systems to normal. Manually turn CH-5 off.	Observe CHW lead pump serving CH-5 stop, and chiller CH-4 and associated lead pump start up in mechanical cooling mode.		
10		Chiller Failure - Free Cooling Mode Test C. Continuing from previous test, return system to normal. Simulate condition that chiller water supply is satisfied. Wait until chillers stop. Manually turn both pumps serving CH-4 to OFF. Cause call for cooling.	Observe pump failure alarm is generated. Observe CH-5 and associated lead pump start up in mechanical cooling mode.		
11		Chiller Failure - Free Cooling Mode Test D. Continuing from previous test, return system to normal. Simulate condition that chiller water supply is satisfied. Wait until chillers stop. Manually turn both pumps serving CH-5 to OFF. Cause call for cooling.	Observe pump failure alarm is generated. Observe CH-4 and associated lead pump start up in mechanical cooling mode.		
12		Switch from Free Cooling to Mechanical Mode. Wait for an opportunity when outdoor air temperatures have dropped to a value close to, but warmer than, -7°C. With chiller automatically operating in Free Cooling mode, override the outdoor air temperature measurement to -1°C . Wait 10 minutes for systems to stabilize, and then return outdoor temperature override to normal.	Observe the system automatically switch to Mechanical Cooling Mode, i.e. lead chiller and associated pump operate in mechanical cooling mode and the stand by chiller and pump are off. Lead chiller CH-4 or CH-5 (circle) CHW supply temperature = _____, Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____. Observe the system automatically switch back to Free Cooling Mode, i.e. both chillers and lead pumps operate. CHW CH-4 supply temperature = _____, CHW CH-5 supply temperature = _____, Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
13		Chiller Failure - Free Cooling Mode Test E. Wait until at time when outside temperatures are below -7°C. With the chillers operating, manually turn off chiller CH-4.	Observe that a chiller failure alarm is generated. Observe chilled water pump serving CH-4 has slowed down and stopped. Observe chiller CH-5 ramp up as required to maintain cooling load. CHW CH-5 supply temperature = _____, Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		
14		Chiller Failure - Free Cooling Mode Test F. Continuing from last test, return system to normal. Manually turn off chiller CH-5.	Observe that a chiller failure alarm is generated. Observe chilled water pump serving CH-5 has slowed down and stopped. Observe chiller CH-4 ramp up as required to maintain cooling load. CHW CH-4 supply temperature = _____, Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		
15		Chiller Pump Failure – CH-4. Return system to normal. Simulate condition that chiller water supply is satisfied. Wait for chillers to stop. Manually turn lead chiller pump serving CH-4 to OFF. Cause call for cooling.	Observe chiller CH-5 pump start and ramp up to full speed. Observe CH-5 start-up and maintain cooling load. Observe that a pump failure alarm is generated. CHW CH-5 supply temperature = _____, Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		
16		Chiller Pump Failure – CH-5. Return system to normal. Simulate condition that chiller water supply is satisfied. Wait for chillers to stop. Manually turn lead chiller pump serving CH-5 to OFF. Cause call for cooling.	Observe chiller CH-4 pump start and ramp up to full speed. Observe CH-4 start-up and maintain cooling load. Ensure that a pump failure alarm is generated. CHW CH-4 supply temperature = _____, Main CHW temperature (T-8) = _____. Bldg CHW temperature (T-10) = _____.		
17		High Chilled Water Temp Warning Alarm. Return system to normal. Overwrite chilled water supply temp from sensor T-8 to 7°C.	After a time delay of 5 minutes, observe that a High Chilled Water Temp Warning Alarm is generated.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
18		High Chilled Water Temp Emergency Alarm. Continuing from last test. Overwrite chilled water supply temp from sensor T-8 to 10°C.	After a time delay of 2 minutes, observe that a High Chilled Water Temp Emergency Alarm is generated.		
19		High Building Water Temp Alarm. Return system to normal. Overwrite chilled water building supply temp from sensor T-10 to 9°C.	Observe that a High Building Chilled Water Temp Alarm is generated.		
20		Chilled Water Sensor Calibration Alert. Return system to normal. Overwrite chilled water supply temp from sensor T-11 by +/- 2°C. Return system to normal. Overwrite chilled water supply temp from sensor T-12 by +/- 2°C. Return systems to normal.	Observe that a calibration alert is generated. Observe that a calibration alert is generated.		
21		Outdoor Temp Sensor Calibration Alert. Overwrite outdoor temperature sensor by +/- 2°C. Return system to normal.	Observe that a calibration alert is generated.		
22		General Staging. **By Monitoring:** For each chiller, trend the status of chillers, CHWS, CHWR, OSAT, all pipe main supply and return temperatures (T-7, T-8, T-9, T-10) (Start all points simultaneously, 5-10 min. time step for 5 days, including weekend over a time when outdoor air temperatures are expected to rise above and drop below switchover SPt of minus 2°C.	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.		
23		For all chiller and associated 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.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
CHILLER SAFETY CONTROLS					
24		CHW Flow Switch CH-4. If CHW pumps are wired in series with proof of flow switch, jumper pump out of this loop. With chiller manually off, but under conditions that will call for cooling, manually turn off CHW pumps. Turn Chiller 4 to auto.	Observe that chiller won't start because of no CHW flow and that an alarm is generated.		
25		CHW Flow Switch CH-5. If CHW pumps are wired in series with proof of flow switch, jumper pump out of this loop. With chiller manually off, but under conditions that will call for cooling, manually turn off CHW pumps. Turn Chiller 5 to auto.	Observe that chiller won't start because of no CHW flow and that an alarm is generated.		
START UP ON EMERGENCY POWER					
26		Develop a plan to test the operation of chiller systems on emergency power. This to include switching over building power supply to operate on the emergency generator. Submit written test procedure to owner for approval before any test takes place. Testing should last a minimum of 1 hour or longer as required to ensure all systems are operational on emergency power.	Date and time of test: _____. Duration of test: _____. Results of test ensure the following: CH-4 system start through BAS (Y/N) _____. Time for CH-4 to start up after normal power is switched off _____. CH-4 system maintain CHW SPt (Y/N) _____. CH-5 system start through BAS (Y/N) _____. Time for CH-5 to start up after normal power is switched off _____. CH-5 system maintain CHW SPt (Y/N) _____. Refrigerant detection system in room up and running (Y/N) _____. Refrig purge fan EF-20 start through the monitoring panel upon initiation (Y/N): _____. Refrig purge fan exhaust damper and make-up air dampers open through the monitoring panel upon initiation (Y/N): _____.		

Notes:

Proced. No.[1]		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N	Note #
FULL LOAD PERFORMANICE VERIFICATION					
27		Winter time Test . Develop a plan to test full load performance of the chilled water plant when operating in **free cooling mode**. Perform test when outdoor temperatures are in the minus 2°C to minus 7°C range. False loading of the chiller will be required to achieve design load conditions. Reference Section 5 of this document and project specifications for more details. Submit written test procedure to owner for approval before any test takes place. Testing should last a minimum of 2 hours or longer as required to ensure all systems are stabilized under full load conditions. Trend all operating conditions at 5 minute intervals throughout test period including supply and return chilled water temperatures, building supply and return chilled water temperatures, chiller load, condenser load, outdoor air temperatures, etc.	Results of test have been analyzed and compared with manufacturer performance data for **both** chillers. Documented results of testing have been submitted to owner.		
28		Summer time Test . Develop a plan to test full load performance of the chilled water plant when operating in **mechanical cooling mode**. Perform test when outdoor temperatures are in the 22°C to minus 25°C range. False loading of the chiller will be required to achieve design load conditions. Reference Section 5 of this document and project specifications for more details. Submit written test procedure to owner for approval before any test takes place. Testing should last a minimum of 2 hours or longer as required to ensure all systems are stabilized under full load conditions. Trend all operating conditions at 5 minute intervals throughout test period including supply and return chilled water temperatures, building supply and return chilled water temperatures, chiller load, condenser load, outdoor air temperatures, etc.	Results of test have been analyzed and compared with manufacturer performance data for **both** chillers. Documented results of testing have been submitted to owner.		

7. Return all changed control parameters and conditions to their pre-test values[5]

Notes:

MONITORING AND TREND LOGGING

Monitoring via BAS trend logs are required per test procedures indicated. Attach representative graphs or columnar data and explanatory analysis to this test report.

**Abbreviations: CHW = chilled water, dP = diff. pressure, SPt = setpoint CHWS = chilled water supply, CHWR = chilled water return, 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, controls 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) Lower the space temperature setpoint.
2) Prior to the chiller test, manually preheat the building space temperature
3) Lower the chilled water supply temperature setpoint.

A SUMMARY OF DEFICIENCIES IDENTIFIED DURING TESTING IS ATTACHED

-- END OF TEST --

Notes:

Functional Test FT-003

JAG Building – Chiller Replacement

SUMP PUMP, SP-1

1. Participants

Party	Participation

Party filling out this form and witnessing testing _____

Date of test _____

2. Physical Installation Checks

Check if Okay. Enter comment or note number if deficient.

	Sump Pump SP-1			Notes
General Installation				
Label permanently affixed				
Piping				
Pipe fittings complete and pipes properly supported				
Pipes properly labeled				
Valves installed provided as per dwgs				
Union installed as per dwgs				
Check valve on discharge side of pump matches reviewed shop drawings				
Control float installed				
Electrical and Controls				
Power disconnects in place and labeled				
All electric connections tight				

Notes:

	Sump Pump SP-1			Notes
Proper grounding installed for components and unit				
Motor safeties in place and operable				
All control devices and wiring complete				
TAB				
Installation of globe valve matches reviewed shop drawings				

3. Functional Testing Record

Proced. No.		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N & Note #
1		Manufacturer start up procedures have been performed.		
2		Manually fill sump pit with water, ensure pump operates when float rises. Make adjustments in order to maintain minimum amount of water left over in pit when pump stops.		
3		Ensure that floor drain does not overflow during pump operation. Make adjustments to globe valve on pump discharge as required. Set stop on globe valve or provide visible permanent marking at maximum position.		
4		Ensure that pump runs for a minimum time of 45 seconds. Make adjustments to float as required.		
5		Verify that check valve does not pass water when in closed position.		

Record Foot Notes

[3]Step-by-step procedures for manual testing, trend logging or data-logger monitoring.

[4]Include tolerances for a passing condition.

-- END OF TEST --

Notes:

Functional Test FT-004

JAG Building – Chiller Replacement

Refrigerant Leak Detection and Alarm

1. Participants

Party	Participation

Party filling out this form and witnessing testing _____

Date of test _____

2. Physical Installation Checks

Check if Okay. Enter comment or note number if deficient.

	check			Notes
General Installation				
Label permanently affixed				
Manufacturer verification procedures have been performed for room refrig detection monitor and sensors.				
Manufacturer verification procedures have been performed for duct refrig detection monitor and sensors.				
Electrical and Controls				
Power disconnects in place and labeled				
All electric connections tight				
Proper grounding installed for components and unit				
All control devices and wiring complete				

Notes:

3. Sensor Calibration Checks

The sensors listed below checked for calibration and adequate location.

"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. 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: _____ ___ Certified calibration within last 12 mo's.

Sensor & Location	Location OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?
R134a room sensor 1					
R134a room sensor 2					
R134a duct sensor AHU#2					
R134a duct sensor AHU#3					
R134a duct sensor Boiler Supply Fan					

Sensor & Location	Location OK[1]	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?

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

4. Functional Testing Record

Notes:

Proced. No.		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N & Note #
1		Room Monitor: Simulate a refrigerant leak alarm situation.	Observe all alarm strobe lights and audible alarms come on. Ensure that the BAS receives alarm signal from monitor and BAS initiates alarm. Observe the purge fan EF-20 damper open, make-up air damper open, and fan start up. Fan to be shut off (and dampers closed) by manually clearing the alarm signal on the refrigerant monitor.	
2		Fan Push button: Return system to normal. Manually depress the push button located on wall outside of the Mechanical room. Repeat the above for the other two push buttons.	Observe the purge fan EF-20 damper open, make-up air damper open, and fan start up. Ensure fan and damper operation as per above.	
3		Oxygen Low Level detection: Return system to normal. Simulate a low oxygen level situation.	Observe fan EF-20 damper open, make-up air damper open, and fan start up.	
4		Duct Monitor AHU#2: Simulate a refrigerant leak alarm situation on the AHU#2 intake duct.	Observe shutdown of AHU#3, AHU#2, and Boiler Room make up Fan through the BAS. Observe alarm condition is initiated by the BAS.	
5		Duct Monitor AHU#3: Return system to normal. Simulate a refrigerant leak alarm situation on the AHU#3 intake duct.	Observe shutdown of AHU#3, AHU#2, and Boiler Room make up Fan through the BAS. Observe alarm condition is imitated by the BAS.	
6		Duct Monitor Boiler Makeup air intake duct: Return system to normal. Simulate a refrigerant leak alarm situation on the Boiler make-up air duct.	Observe shutdown of AHU#3, AHU#2, and Boiler Room make up Fan through the BAS. Observe alarm condition is initiated by the BAS.	

Notes:

Proced. No.		Test Procedure[3] (including special conditions)	Expected and Actual Response[4] [Write ACTUAL response in brackets or circle]	Pass Y/N & Note #

Return all systems to normal.

Record Foot Notes

[3]Step-by-step procedures for manual testing, trend logging or data-logger monitoring.

[4]Include tolerances for a passing condition.

-- END OF TEST --

Notes: