STANDARD COMMISSIONING PROCEDURE FOR WATER LOOP HEAT PUMP SYSTEMS

BUILDING NAME: _____ **APPLICATION #:** _____
BUILDING ADDRESS: _____
_____

NAME & FIRM OF PERSON(S) DOING TEST: _____
DATE(S) OF TEST: _____

General Notes:

1. This is a generic test procedure for water loop heat pump systems. If the complexity, configuration, or other aspects of a specific project require substitute tests or additional tests, explain on the comments sheets, and attach the additional test procedures and field data. Due to the many possible types of system controls, it is likely that this will be necessary. Note also that not all questions or tests apply to all types of systems. Attach all relevant functional performance verification sheets, and always attach the final signed and dated procedure certification page.
2. In all test sections, circle or otherwise highlight any responses that indicate deficiencies (i.e. responses that don't meet the criteria for acceptance). Acceptance requires correction and retest of all deficiencies, as defined in each test section under "Criteria for Acceptance" or "Acceptance". Attach all retest data sheets. Complete the Deficiency Report Form for all deficiencies.
3. This Commissioning Procedure does not address fire and life safety or basic equipment safety controls.
4. To ensure that this Commissioning Procedure will not damage any equipment or affect any equipment warranties, have the equipment manufacturer's representative review all test procedures prior to execution.

OPERATOR INTERVIEW (Existing Buildings Only):

Determine from a discussion with the building operator whether the heat pump system and its component equipment are operating properly to the best of their knowledge. Note any known problems, and possible solutions.

EQUIPMENT TYPE & SYMBOL	PROBLEM DESCRIPTION & EFFECT	PROPOSED SOLUTION
Cooling Towers		
Boilers		
Pumps		
Heat Pumps		
Heat Pumps		
Other		

Building Name: _____

HEAT PUMP SYSTEM, INSTALLED CHARACTERISTICS

Enter answers from field inspection. Note under response if the feature as installed differs in any way from the design documents. If an item does not apply, write "NA" for not applicable.

Installed characteristics must be in accordance with design intent documentation and approved submittals.

	RESPONSE (add sheets as necessary to adequately describe)
1. Number of heat pumps in system. Does this agree with the design?	
2. Total system cooling capacity, tons, of heat pumps. Does this agree with the design?	
Does system include a well water heat/cool source?	
4.	
5. Back-up loop heat source (gas boiler, oil boiler, electric boiler, etc.).	
6. cooling tower, other).	
Does system include a storage tank?	
8.	
9.	
10.	
11.	

COMMENTS ON SYSTEM CHARACTERISTICS:

Building Name: _____

SYSTEM COMPONENT NAMEPLATE DATA (From equipment nameplates, as recorded in field. Attach other sheets as necessary. Use blank lines for non-listed equipment.):

Sampling: It is not necessary to document all installed heat pump units. Select a sample of 5% of the total installed units, or 6 units, whichever is greater. Units should be selected of different capacities, from different areas of each floor, and from different floors, insofar as practical.

Criteria for Acceptance: Nameplate data must be in accordance with submittals as approved by Designer and Commissioning Agent. If submittals are not required by contract, nameplate data must be consistent with Energy FinAnswer Prescriptive Spreadsheet equipment assumptions.

EQUIPMENT TYPE	UNIT #	MANUFACTURER	MODEL #	CAPACITY *	FULL LOAD AMPS	COMMENTS
1. Loop circulation pump						
2. Loop circulation pump						
3. Well pump						
4. Pump motor VFD						
5. Pump motor VFD						
6. Boiler						
7. Boiler						
8. Cooling tower						
9. Heat exchanger						
10. Heat exchanger						
11. Expansion tank						
12. Storage tank						
13.						
14.						
15. Heat pump						
16. Heat pump						
17. Heat pump						
18. Heat pump						
19. Heat pump						
20. Heat pump						
21. Heat pump						
22. Heat pump						
23.						
24.						

* Include all relevant capacity parameters, and units. For example, for heat exchangers include rated GPM and delta P on both sides. For pumps, note GPM and TDH. For heat pumps, note CFM and tons total cooling. For boilers, note Btu/hour.

COMMENTS ON NAMEPLATE DATA:

_____

_____

_____

_____

Building Name: _____

INSTALLATION VERIFICATION:

Instructions: Under each unit write "Y" for yes, "N" for no, "NA" for not applicable, or a number to refer to any needed comments. If other information is requested such as temperature, write the appropriate values.

Criteria for Acceptance: All items in this section require answers of “Y” (or “NA”, where relevant) except where other criteria are noted.

HEAT PUMPS INSPECTION ITEM	UNIT #							
1. Test and balance report reviewed for flows								
2. Test and balance report spot-checked for accuracy								
3. No unusual noise or vibration								
4. Adequate access for service & filter change								
5. Room thermostats/sensors in appropriate locations								
6. Electrical connections tight								
7. Piping configuration correct								
8. Condensate drains unobstructed, properly sloped, & trapped								
9. No visible water leaks								
10. Filter clean and tight-fitting								
11. Ductwork appears tight, with no obvious leaks								
12. Duct insulation appears in good condition where visible								
13. If loop pump equipped with a VFD, are automatic 2-way valves installed at heat pump?								
14. O&M manuals on site								
15.								
16.								
17.								

Installation Verification, Contd.

BOILER	UNIT # ____	UNIT # ____
18. Manufacturer's start-up sheet completed and attached. (For new construction, this sheet must be completed before proceeding with commissioning.)		
19. Adequate access for maintenance and service		
20. No visible water or fuel leaks		
21. No unusual noise or vibration		
22. Insulation in place & undamaged on boiler & piping		
23. Electrical connections are tight		
24. Motor rotations are correct		
25. Pipe fittings, valves, gauges, & accessories complete & properly installed		
26. Check valve & flow switch direction correct		
27. Blowdown valves not leaking		
28. Valve & switch positions correct		
29. Expansion tank installed & pressurized		
30. Make-up water & blowdown systems are operable		
31. Ventilation & combustion air adequate		
32. O&M manual on site		
33.		
34.		

Building Name: _____

Installation Verification, Contd.

COOLING TOWER	UNIT # _____	UNIT # _____
35. Manufacturer's start-up sheet completed and attached. (For new construction, this sheet must be completed before proceeding.)		
36. Adequate access for maintenance and service		
37. No visible leaks		
38. No unusual noise or vibration		
39. Pipe fittings, valves, gauges, & accessories complete		
40. Pan strainer clean		
41. Fan rotation correct		
42. Fan belt tension is correct / belts in good condition	/	/
43. Electrical connections tight		
44. Are fan motor overload heaters sized for nameplate FLA?		
45. Fan motor, measured & rated volts. Acceptance: Avg measured volts must be within ±10% of rated volts.	/ / ; volts	/ / ; volts
46. Voltage Imbalance into motor, $(V_{max,min} - V_{avg}) / V_{avg}$ Acceptance: Voltage imbalance must be <2%		
47. Fan current, measured amps & rated full load amps. Acceptance: Measured amps must be less than FLA.	/ / ; FLA	/ / ; FLA
48. Pony fan motor current, measured & full load amps. Acceptance: Measured amps must be less than FLA.	/ / ; FLA	/ / ; FLA

Building Name: _____

Installation Verification, Contd.

OTHER LOOP EQUIPMENT	UNIT # _____	UNIT # _____
57. Test and balance report reviewed for main loop and well/ground flows		
58. Air separator & air vents installed as specified		
59. No evidence of air in system		
60. Loop pump, no visible leaks		
61. Pump strainer clean & construction strainer replaced		
62. Loop pump, no unusual noise or vibration		
63. Pump rotation correct		
64. Are pump motor overload heaters sized for nameplate FLA?		
65. Loop pump, measured & rated volts. Acceptance: Avg measured volts must be within ±10% of rated volts.	/ / ; volts	/ / ; volts
66. Voltage Imbalance into motor, $(V_{max,min} - V_{avg}) / V_{avg}$ Acceptance: Voltage imbalance must be <2%		
67. Loop pump, measured & rated amps. Acceptance: Measured amps must be less than FLA.	/ / ; FLA	/ / ; FLA
68. Loop pump, measured (TAB report) & rated GPM. Acceptance: Measured GPM must be within ±15% of rated GPM.	/	/
69. Loop pump, measured (TAB report) & rated TDH. Acceptance: Measured TDH must be no more than 10% greater than rated TDH.	/	/
70. Well pump, no unusual noise or vibration		
71. Well pump rotation correct		
72. Are well pump motor overload heaters sized for nameplate FLA?		
73. Well pump, measured & rated volts. Acceptance: Avg measured volts must be within ±10% of rated volts.	/ / ; volts	/ / ; volts
74. Voltage Imbalance into motor, $(V_{max,min} - V_{avg}) / V_{avg}$ Acceptance: Voltage imbalance must be <2%		
75. Well pump, measured & rated amps. Acceptance: Measured amps must be less than FLA.	/ / ; FLA	/ / ; FLA
76. Well pump, measured (TAB report) & rated GPM. Acceptance: Measured GPM must be within ±15% of rated GPM.	/	/
77. Well pump, measured (TAB report) & rated TDH. Acceptance: Measured TDH must be no more than 10% greater than rated TDH.	/	/
78. Loop temperature sensor location (describe). Acceptance: Must be placed according to good instrumentation practice.		
79. Water treatment system is operable.		
80.		
81.		
82.		

Building Name: ______________________

COMMENTS ON INSTALLATION VERIFICATION CHECKLIST ITEMS (add more sheets if needed):

ITEM #	UNIT #	COMMENT

Building Name: _____

Controls calibration tests: Perform the following calibration verifications by slowly adjusting the setpoint of each thermostat, humidistat, etc. until the controlled response begins (i.e. contact make or break). Note the setpoint when that occurs, and note the reading on a calibrated thermometer (or other instrument as required) held in close proximity. For sensors, compare the sensor input to the energy management system (EMS) to the field measurement. Check calibration on a sampling of room temperature sensors or thermostats that correspond to those zones selected below for functional performance testing, and comment if room setpoints are warmer or cooler than necessary. Use the blank lines for other sensors and stats.

Criteria for Acceptance: If sensor or stat is out of calibration by more than ± 3 degrees F or 5% relative humidity, note that as a deficiency and report it for correction. Note additional acceptance criteria for room temperatures.

1. Outdoor air sensor or thermostat, computer input signal or setpoint when controlled action occurs (°F)	
2. Outdoor air temperature, measured (°F)	
3. Loop temperature sensor or stat, computer input signal or setpoint controlled action occurs (°F)	
4. Loop temperature @ sensor, measured (°F)	
5.	
6.	
7.	
8.	

ROOM SENSORS/STATS, ZONE #						
9. Room temperature sensor/stat, make/break setpoint or EMS input						
10. Room temperature, measured						
ROOM SENSORS/STATS, ZONE #						
11. Room temperature sensor/stat, make/break setpoint or EMS input						
12. Room temperature, measured						
ROOM SENSORS/STATS, ZONE #						
13. Room temperature sensor/stat, make/break setpoint or EMS input						
14. Room temperature, measured						

COMMENTS ON CONTROLS CALIBRATION ITEMS (add more sheets if needed):

ITEM # COMMENT

_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____

Building Name: _____

FUNCTIONAL PERFORMANCE VERIFICATION:

The following sections are a series of field tests that are intended to verify that the water loop heat pump system, as installed, operates as it was intended to operate by the manufacturer and designer. For each test, first determine and record the design operation, and then record the actual field observation. If the field observation does not correspond to the intended design operation, also write a comment number that refers to an explanatory comment in the comments section or on attached comments sheets. If a test does not apply, write "NA" for not applicable. If you were not able to complete a test, write "ND" for not done, and explain in a comment.

Sampling: If there are more than 6 heat pump units, you may select a sample for the following performance tests. The sample should be at least 5% of the total number of heat pumps, or 6 units, whichever is greater. Zones should be selected from different areas of each floor, and from different floors. If there is failure of any test for more than 10% of the sampled units, or 2 units, whichever is greater, then the entire heat pump system installation shall be considered to be not in conformance. In that case, the installing contractor is responsible to test all units prior to calling for a retest under this procedure.

Basic performance tests: Put each unit under heating and cooling loads by lowering/raising zone temperature setpoints by 10 F degrees and waiting 5 minutes for heat pump operation to stabilize. (If the system includes an economizer, lock it out for these tests.) Record the following. The design line in each test set refers to the design condition as reflected in catalog data, drawings, design intent document, etc. The measured line refers to your test results.

Criteria for Acceptance: The measured values for all CFM and delta temperature tests must be within ±15% of the design value as noted on each previous line. Measured unit currents must be less than or equal to the design value.

UNIT #								
HEATING LOAD TESTS								
1. Supply air CFM, design								
2. Supply air CFM, from air balance report								
3. Unit current, FLA design								
4. Unit current, measured (amps)	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /
5. Delta water temp (entering - leaving), design								
6. Entering/leaving/delta water temp, measured	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /
7. Delta air temp (leaving - entering), design								
8. Entering/leaving/delta air temp, measured	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /
COOLING LOAD TESTS								
9. Unit current, FLA design								
10. Unit current, measured (amps)	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /
11. Delta water temp (ent - leaving), design								
12. Entering/leaving/delta water temp, measured	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /
13. Delta air temp (leaving - ent), design								
14. Entering/leaving/delta air temp, measured	/ /	/ /	/ /	/ /	/ /	/ /	/ /	/ /

COMMENTS ON BASIC PERFORMANCE TESTS:

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Building Name: _____

SYSTEM CONTROLS VERIFICATION:

Since there are many variations on controls sequences for water loop heat pump systems, it is impossible to write a generic test for system controls. In this section, first describe the controls sequences for start/stop control and loop temperature control, and then describe what tests were done to verify each. Do the same for economizer and thermal storage controls if relevant. Attach to this test sheet all relevant field data, monitored data, graphs, trend logs, etc. Annotate any data and graphs so that it is clear what the data are proving. Energy Management System (EMS) trend logs of EMS outputs, program print-outs, or schedule and setpoint print-outs are not acceptable as proof of operation unless you have first verified and documented that the output signals accurately represent actual operation. Trend logs of sensor inputs to the EMS are acceptable. See the attached example for the level of detail expected. Add sheets as necessary.

Criteria for Acceptance: The actual control sequence must be in accordance with the controls submittal as approved by the Designer. Acceptance is based on thorough documented verification of each control mode.

Start/Stop Control (include pump, tower, boiler, and heat pump interlocks, time-of-day control, well pump control, etc.)**:**

Describe the control sequence:

_____

_____

_____

_____

_____

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_____

Describe the tests that were done to verify the control sequence:

_____

_____

_____

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_____

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_____

Conclusions:

_____

_____

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_____

Loop Temperature Control (include well pump, boiler, and tower, as relevant)**:**

Describe the control sequence:

Describe the tests that were done to verify the control sequence:

Conclusions:

Economizer Control:

Describe the control sequence:

Describe the tests that were done to verify the control sequence:

Conclusions:

Building Name: _____

Thermal Storage / Storage Tank Controls:

Describe the control sequence:

Describe the tests that were done to verify the control sequence:

Conclusions:

ADDITIONAL COMMENTS ON FUNCTIONAL PERFORMANCE VERIFICATION CHECKLIST ITEMS:

I certify that the data and test results as recorded herein are accurate.

Signature, Commissioning Agent _____ Date _____

Firm Name _____ (Area Code) Phone Number _____

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Building Name: _____

SAMPLE CONTROLS VERIFICATION SHEET

Start/Stop Control (include interlocks, time-of-day control, well pump control, etc.)**:**

Describe the control sequence:

The main loop pump is enabled during the occupied mode or when any heat pump zone calls for heat or cooling during the unoccupied mode, as programmed through the EMS. Individual heat pump fans run continuously during occupied mode, or during compressor operation during unoccupied mode. On a call for compressor heating or cooling, the heat pump 2-way valve opens. After proof of flow, the compressor starts. The loop pump VFD modulates the pump speed to maintain the static pressure setpoint.

Describe the tests that were done to verify the control sequence:

We monitored the loop pump current for 2 days. We also observed the 2-way valve and fan operation for 4 units when the compressor cycled on and off. Finally, we observed the fan operation for the same 4 units when the system went into unoccupied mode.

Conclusions:

The loop pump runs continuously. This is a deficiency that needs correction. The VFD did modulate the pump speed (as evidenced by the variation in current - see attached graphs). The unoccupied mode pump current was on average about 20% of the pump current during the occupied mode. The heat pump fans and 2-way valves operated as expected.

Loop Temperature Control (include well pump, boiler, and tower, as relevant)**:**

Describe the control sequence:

The well pump is turned on whenever the loop return temperature falls below 60°F or rises above 95°F (adjustable).

Describe the tests that were done to verify the control sequence:

We monitored the loop temperature and the well pump current for a 2 day period. Since the weather was quite cold, we simulated the high temperature control by changing the upper limit setpoint from 95 to 65°F.

Conclusions:

The data show that the well pump ran only when the loop temperature was below 60°F or above 65°F. (We reset the upper limit to 95°F.) The data also show that, even though outdoor temperatures were generally between 25 and 40°F during the monitoring period, the well pump only operated for about 2 hours. (See attached graphs.)