STANDARD COMMISSIONING PROCEDURE FOR EXHAUST AIR HEAT RECOVERY SYSTEMS

BUILDING NAME: ____ **APPLICATION #:** ________________
BUILDING ADDRESS: ____
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NAME & FIRM OF PERSON(S) DOING TEST: ____
DATE(S) OF TEST: __________________________________

General Notes:

1. This is a generic test procedure for exhaust air heat recovery 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 heat recovery systems and their 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 recovery system and its component equipment are operating properly to the best of their knowledge. Note any known problems, and possible solutions.

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Building Name: ______________________

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”j for not applicable.

Criteria for Acceptance: Installed characteristics must be in accordance with design intent documentation and/or approved submittals.

DESCRIPTION	RESPONSE (add sheets as necessary to adequately describe)
1. Type of system (run-around, heat pipe, heat wheel, fixed plate heat exchanger, other (specify)	
2. Number of heat exchanger units in system (i.e. # of heat pipes, coils, etc.)	
3. Sensible or total heat recovery?	
4. Heat pump or chiller assisted? (run-around systems in which the fluid is heated/cooled further by heat pumps or chillers) If yes, fill out and attach the chiller commissioning procedure.	
5. Indirect evaporative cooler assisted? If yes, fill out and attach the evaporative cooling system commissioning procedure.	
6. Backup heat source (gas boiler, gas furnace, electric resistance coils, etc.)	
7. Backup cooling source (chiller, DX unit, etc.)	
8. O&M manuals for all system equipment on site? (Acceptance: “Yes”)	
9.	
10.	

COMMENTS ON INSTALLED CHARACTERISTICS ITEMS (item #, unit #, comment). Add more sheets as needed:

Building Name: ______________________

SYSTEM COMPONENT NAMEPLATE DATA (From equipment nameplates, as recorded in field. Attach other sheets as necessary.):

Criteria for Acceptance: Nameplate data must be in accordance with submittals as approved by Designer.

EQUIPMENT TYPE	UNIT #	MANUFACTURER	MODEL #	CAPACITY *	COMMENTS
1. Pump, run-around loop					
2. Pump, run-around loop					
3. Pump, _______________					
4. Pump, _______________					
5. Fan, exhaust					
6. Fan, exhaust					
7. Fan, exhaust					
8. Booster fan, exhaust					
9. Booster fan, exhaust					
10. Booster fan, exhaust					
11. Booster fan, exhaust					
12. Booster fan, exhaust					
13. Fan, supply					
14. Fan, supply					
15. Fan, supply					
16. Booster fan, supply					
17. Expansion tank (run-around systems only)					
18. Water treatment					
19. Heat pump / chiller (assisting, not backup)					
20. Heat exchanger (coil, heat wheel, heat pipe, etc.)					
21. Heat exchanger					
22. Heat exchanger					
23. Heat exchanger					
24. Heat exchanger					
25. Heat exchanger					
26.					
27.					

* Include all relevant capacity parameters, and units. For example, for coils in a run-around system, include air-side CFM and delta P and water-side GPM and delta P. For heat pipes, heat wheels, and plate heat exchangers include both exhaust and supply CFM and delta P. For expansion tanks, note ft^3. For pumps, note GPM , TDH, and FLA. For fans, note CFM, static pressure, and FLA.

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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. If a motor is driven by a VFD, complete also the Standard Commissioning Procedure for VFDs. If the motor is VFD-driven, make all supply fan electrical measurements upstream of the VFD, unless directed otherwise, and use a true RMS multimeter for all supply fan motor and drive electrical measurements.

Current and voltage imbalance is defined as the greatest difference between the measurement for any of the 3 phases and the average of the 3 phases, that quantity divided by the average of the 3 phases. As an example, if the voltage measurements are 451, 461, and 463, then the average is 458.3 volts. The greatest difference between any measurement and the average is 451-458.3, or 7.3 volts. Then, the voltage imbalance is 7.3 volts / 458.3 volts, or 0.016. As a percentage, this is 1.6%, and would be acceptable by the criteria below.

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

COILS / HEAT EXCHANGERS	UNIT #					
INSPECTION ITEM						
1. Test and balance (TAB) report reviewed for flows						
2. TAB report spot-checked for accuracy						
3. Face velocities per design						
4. Adequate access for cleaning						
5. Proper location (upstream of backup coils, in well-mixed air stream, etc.)						
6. Is material selected suitable for the airstream?						
7. Piping & ductwork configuration is correct						
8. Proper valves installed?						
9. 3-way valves ported properly?						
10. Flow direction correct?						
11. Cross-leakage is not excessive (not relevant to run-around systems). Determine by visual inspection of seals, gaskets, brushes, duct, etc.						
12. Condensate drains installed on exhaust side						
13. Condensate drains unobstructed, properly sloped, trapped, and insulated						
14. Filter installed upstream of coil or heat exchanger						
15. Filter clean and tight-fitting						
16. Run-around systems: water treatment in place						
17. Heat wheels: wheel rotation correct						
18. Heat wheels: wheel alignment within mfctr’s specifications						
19.						

Building Name: ______________________

FANS INSPECTION ITEM	UNIT #					
1. Fan belt tension & condition okay?						
2. Fan rotation correct?						
3. Fan blades clean?						
4. Fan full speed RPM						
5. No unusual noise or vibration						
6. Motor contactors in good condition?						
7. Motor overload heaters properly sized?						
8. Fan motor volts, rated						
9. Fan motor volts into motor. Acceptance: ±10% of rating, all phases	/ /	/ /	/ /	/ /	/ /	/ /
10. Voltage Imbalance into motor, $(V_{max,min} - V_{avg}) / V_{avg}$						
11. Voltage Imbalance into motor is < 2%?						
12. Fan motor FLA, rated						
13. Fan motor full speed Amps, measured at motor (downstream of VFD)	/ /	/ /	/ /	/ /	/ /	/ /
14. Fan motor measured Amps < Rated FLA?						
15. Current imbalance at motor is < 2%?						

PUMPS INSPECTION ITEM	UNIT #					
1. Pump rotation correct?						
2. Pump full speed RPM						
3. No unusual noise or vibration						
4. Pump & piping are free of leaks?						
5. Pump strainer proper, clean, & in place?						
6. Motor contactors in good condition?						
7. Motor overload heaters properly sized?						
8. Pump motor volts, rated						
9. Pump motor volts into motor. Acceptance: ±10% of rating, all phases	/ /	/ /	/ /	/ /	/ /	/ /
10. Voltage Imbalance into motor, $(V_{max,min} - V_{avg}) / V_{avg}$						
11. Voltage Imbalance into motor is < 2%?						
12. Pump motor FLA, rated						
13. Pump motor full speed Amps, measured at motor (downstream of VFD)	/ /	/ /	/ /	/ /	/ /	/ /
14. Pump motor measured Amps < Rated FLA?						
15. Current imbalance at motor is < 2%?						

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

ITEM #	UNIT #	COMMENT
______	______	____
______	______	____
______	______	____
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FUNCTIONAL PERFORMANCE VERIFICATION:

The following sections are a series of field tests that are intended to verify that the heat recovery systems, as installed, operate as they were 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 units of a given type of heat exchanger (or coil, heat wheel, heat pipe, etc.), you may select a sample for the following performance tests. The sample should be at least 10% of the total number of heat exchangers, or 4 units, whichever is greater. 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 recovery system installation shall be considered to be not in conformance.

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. Note the setpoint when that occurs, and note the reading on a calibrated thermometer (or other instrument as required) held in close proximity. If the units are controlled by a building energy management system (EMS), compare the sensor input to the EMS to the simultaneous field measurement made on a calibrated thermometer (or other instrument as required) held in close proximity. Use the blank lines for other sensors and stats such as return air thermostats, 2nd stage temperature differentials, etc.

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.

UNIT #						
1. Outdoor air sensor or thermostat, computer input signal or setpoint when control action occurs (°F)						
2. Outdoor air temperature, measured (°F)						
3. Exhaust air sensor or stat, computer input signal or setpoint when control action occurs (°F)						
4. Exhaust air sensor, measured (°F)						
5. Discharge air sensor or stat, computer input signal or setpoint when control action occurs (°F)						
6. Discharge air sensor, measured (°F)						
7.						
8.						
9.						
10.						

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

UNIT # COMMENT

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Basic performance tests: With the system in the full recovery mode, 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 value for tests marked with an "◆" must be within ±15% of the design value as noted on each previous line. Measured fan currents (tests # 85 and 95) must be less than or equal to the design value.

UNIT #						
1. Exhaust side delta static pressure, design						
2. Exhaust side delta static pressure, measured						
3. Exhaust side delta temperature, design						
4. Exhaust side delta temperature, measured (°Fin/°Fout/Δ°F) ◆	/ /	/ /	/ /	/ /	/ /	/ /
5. Exhaust side wb temp in / out, design (total recovery systems only)	/	/	/	/	/	/
6. Exhaust side wb temp in / out, measured (total recovery systems only)	/	/	/	/	/	/
7. Exhaust side auxiliary fan current, design						
8. Exhaust side auxiliary fan current, measured						

9. Exhaust side SCFM, design						
10. Exhaust side SCFM, measured (enter TAB report if verified by spot-check) ◆						
11. Supply side delta static pressure, design						
12. Supply side delta static pressure, measured						
13. Supply side delta temperature, design						
14. Supply side delta temperature, measured (°Fin/°Fout/Δ°F) ◆	/ /	/ /	/ /	/ /	/ /	/ /
15. Supply side wb temp in / out, design	/	/	/	/	/	/
16. Supply side wb temp in / out, measured	/	/	/	/	/	/
17. Supply side auxiliary fan current, design						
18. Supply side auxiliary fan current, measured						
19. Supply side SCFM, design						
20. Supply side SCFM, measured (enter TAB report if verified by spot-check) ◆						

SYSTEM CONTROLS VERIFICATION:

Since there are many possible controls sequences for heat recovery systems, it is impossible to write a generic test for system controls. In this section, first describe the controls sequences for start/stop control, capacity control, freeze protection, and any other modes of performance, then describe what tests were done to verify each, and finally describe your conclusions--including any deficiencies found. 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 that these data accurately reflect actual operation and you attach detailed documentation of that verification. 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 interlocks, time-of-day control, outside temperature lockout, etc.)**:**
Describe the control sequence:

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

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Conclusions:

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Capacity Control (e.g. heat pipe tilt as a function of discharge air temperature, 3-way valve modulation, heat wheel speed, etc.)**:**
Describe the control sequence:

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

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Conclusions:

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Building Name: ______________________

Freeze Protection Control:

Describe the control sequence:

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

Conclusions:

Other Control:

Describe the control sequence:

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

Conclusions:

COMMENTS ON FUNCTIONAL PERFORMANCE VERIFICATION ITEMS (add more sheets as needed):

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, outside temperature lockout, etc.)**:**

Describe the control sequence:

Exhaust fans are interlocked with respective supply fans. Loop circulation pump starts when any supply fan in heat recovery system starts. Circulation pumps (P1 & P2) are lead/lag with lead pump alternating on each start cycle. Circulation pumps are locked out when the outdoor air temperature (T2) is between 55°F and 80°F (adjustable at EMCS). 3-way valve closed to respective supply coil on start-up. Valve modulates open per capacity control sequence (below) after 5 minute delay. Note that only supply fans 2 and 4 are equipped with heat recovery systems. SF1, 3, 5, and 6 do not have heat recovery.

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

We monitored the outdoor air temperature (OSAT), the circulation pump (P1 & P2) currents, exhaust fan #2 and #4 currents, and supply fan #2 and #4 currents concurrently for two days. *[This could also be recorded field observations.]* During this time the OSAT varied between 45 and 65°F, so we reset the upper lockout limit setpoint to 62°F to test the circ pump lockout. (We reset it again to 80°F after the test.) We also observed the operation of the 3-way valve for systems 2 & 4 during system start-up.

Conclusions:

The monitored data show that one of P1 or P2 cycled on when either SF2 or SF4 started. The respective EF2 or EF4 also cycled on at that time. P1 and P2 alternated as lead pump on every pump start. We observed the circ. pumps to be off when the OSAT was between 57 and 65°F. After resetting the upper lock-out setpoint, the pump cycled on above 63°F. The system #2 & #4 3-way valves modulated open after the 5 minute start-up delay. See attached data graphs. Operation is per the control sequence.

Capacity Control (e.g. heat pipe tilt as a function of discharge air temperature, 3-way valve modulation, heat wheel speed, etc.)**:**

Describe the control sequence:

The 3-way valve for each respective supply coil modulates to maintain the discharge temperature (T2-4 and T4-4) at setpoint. Backup heat (P6 and V2-4 and V4-4) operate as 2nd stage if the discharge temperature falls 2 degrees below setpoint. Backup mechanical cooling (P7, and V2-5 and V4-5) operate as 2nd stage cooling if the discharge temperature rises 2 degrees above setpoint.

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

We monitored the temperatures immediately upstream and downstream of the supply side heat recovery coils as well as the discharge temperature for SF 2 and 4. We also monitored P6 and P7 current to verify proper staging of backup heating and cooling. Since there was no call for backup cooling during the 24 hour monitoring period, we reset the discharge air setpoint to simulate a call for backup cooling.

Conclusions:

The data show that there was no backup heat or cooling except when we reset the discharge air temperature 5 degrees above the actual temperature, at which time P7 started and V2-5 & 4-5 modulated open. The data show delta temperatures across the supply side heat recovery coils of between 4 and 8 degrees F. These were adequate to maintain the discharge air temperatures at setpoint at all times. See attached graphs. Operation is per the control sequence.