

1 APPENDIX A: Sequences of Operation

2 1. Fan Coil Units

3 Run Conditions - Scheduled:

4 The unit shall run according to a user definable time schedule in the following modes:

- 5 • Occupied Mode: The unit shall maintain
 - 6 • A 75°F (adj.) cooling setpoint
 - 7 • A 70°F (adj.) heating setpoint.
- 8 • Unoccupied Mode (night setback): The unit shall maintain
 - 9 • A 85°F (adj.) cooling setpoint.
 - 10 • A 55°F (adj.) heating setpoint.

11 Alarms shall be provided as follows:

- 12 • High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user
- 13 definable amount (adj.).
- 14 • Low Zone Temp: If the zone temperature is less than the heating setpoint by a user
- 15 definable amount (adj.).

16 Zone Setpoint Adjust:

17 The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the

18 zone sensor.

19 Zone Unoccupied Override:

20 A timed local override control shall allow an occupant to override the schedule and place the unit

21 into an occupied mode for an adjustable period of time. At the expiration of this time, control of

22 the unit shall automatically return to the schedule.

23 Freeze Protection:

24 The unit shall shut down and generate an alarm upon receiving a freezestat status.

25 Fan:

26 The fan shall run anytime the unit is commanded to run, unless shutdown on safeties.

27 Primary Cooling/Heating Coil Valve:

28 The controller shall measure the zone temperature, humidity and open the primary coil valve to

29 maintain its cooling/heating setpoint.

30 The cooling shall be enabled whenever:

- 31 • The zone temperature is above cooling setpoint.
- 32 • AND the fan is on.
- 33 • AND the water to water heat pumps are in the cooling mode.

34 The heating shall be enabled whenever:

- 35 • The zone temperature is below heating setpoint.
- 36 • AND the fan is on.
- 37 • AND the water to water heat pumps are in the heating mode.

1 The dehumidification shall be enabled whenever:

- 2 • The zone the zone has high humidity.
- 3 • AND the fan is on.
- 4 • AND the water to water heat pumps are in the cooling mode.

5 The primary coil valve shall open whenever the freezestat (if present) is on.

6 Secondary Cooling/Heating Coil Valve:

7 The controller shall measure the zone temperature, humidity and open the secondary coil valve to
8 maintain its cooling/heating setpoint.

9 The cooling shall be enabled whenever:

- 10 • The zone temperature is above cooling setpoint.
- 11 • AND the fan is on.
- 12 • AND the water to water heat pumps are in heating mode.

13 The heating shall be enabled whenever:

- 14 • The zone temperature is below heating setpoint.
- 15 • AND the fan is on.
- 16 • AND the water to water heat pumps are in cooling mode.

17 The dehumidification shall be enabled whenever:

- 18 • The zone the zone has high humidity.
- 19 • AND zone temperature is at or below one degree of cooling setpoint.
- 20 • AND the fan is on.
- 21 • AND the water to water heat pumps are in the cooling mode.

22 The secondary coil valve shall open whenever the freezestat (if present) is on.

23 Filter Differential Pressure Monitor:

24 The controller shall monitor the differential pressure across the filter.

25 Alarms shall be provided as follows:

- 26 • Filter Change Required: Filter differential pressure exceeds a user definable limit (adj.).

27 Discharge Air Temperature:

28 The controller shall monitor the discharge air temperature.

29 Alarms shall be provided as follows:

- 30 • High Discharge Air Temp: If the discharge air temperature is greater than 120°F (adj.).
- 31 • Low Discharge Air Temp: If the discharge air temperature is less than 40°F (adj.).

32 Fan Status:

33 The controller shall monitor the fan status.

1 Alarms shall be provided as follows:

- 2 • Fan Failure: Commanded on, but the status is off.
- 3 • Fan in Hand: Commanded off, but the status is on.
- 4 • Fan Runtime Exceeded: Fan status runtime exceeds a user definable limit (adj.).

5 Zone Humidity:

6 The controller shall monitor the zone humidity.

7 Alarms shall be provided as follows:

- 8 • High Zone Humidity: If the zone humidity is greater than 60% (adj.).

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Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Zone Temp	x							x		x
Zone Setpoint Adjust	x									x
Filter Differential Pressure	x							x		x
Discharge Air Temp	x							x		x
Zone Humidity	x							x		x
Zone Override			x					x		x
Freezestat			x					x	x	x
Fan Status			x							x
Fan Start/Stop				x				x		x
Primary Coil Valve				x				x		x
Secondary Coil Valve				x				x		x
Schedule							x			
Heating Setpoint								x		x
Cooling Setpoint								x		x
High Zone Temp									x	
Low Zone Temp									x	
Filter Change Required									x	
High Discharge Air Temp									x	
Low Discharge Air Temp									x	
Fan Failure									x	
Fan in Hand									x	
Fan Runtime Exceeded									x	
High Zone Humidity									x	
Totals	5	0	3	3	0	0	1	11	10	13

Total Hardware (11)

Total Software (22)

1 2. Water to Water Heat Pump Manager

2 Chilled Water Mode – Water to Water Heat Pump Manager - Run Conditions:

3 The controller shall measure the load loop water temperature and stage the water to water heat pumps to
4 maintain its setpoint. To prevent short cycling, there shall be a user definable (adj.) delay between heat
5 pumps stages, and each heat pump stage shall have a user definable (adj.) minimum runtime. The water
6 to water heat pumps shall run subject to its own internal safeties and controls.

7 The heating shall be enabled whenever:

- 8 • Outside air temperature is less than 60°F (adj.).
9 • AND the fan status is on.
10 • AND the reversing valve is in heat mode.

11 The cooling shall be enabled whenever:

- 12 • Outside air temperature is greater than 50°F (adj.).
13 • AND the fan status is on.
14 • AND the reversing valve is in cool mode.

15 Water to Water Heat Pump Staging - Four Equal Sized Heat Pumps Running in Parallel:

16 This section refers to the staging and sequencing of each heat pump "train". The sequence of operation
17 for each individual heat pump and its associated support equipment (such as pumps) are not included in
18 this section.

19 The controller shall determine the cooling and heating load from:

- 20 • CHWS/HWS temperature

21 The following setpoints are recommended values. All setpoints shall be field adjusted during the
22 commissioning period to meet the requirements of actual field conditions.

23 The stage 1 of the lead heat pump shall run anytime the water to water heat pump manager is enabled.
24 Additional heat pump stages shall be on as follows.

Stage ON	Stage 2 HP-1	Stage 1 HP-2	Stage 2 HP-2
Cooling: CHWS temp rises above setpoint of:	44°F	45°F	45°F
Heating: HWS temp drops below setpoint of:	113°F	113°F	113°F
Stage OFF	Stage 2 HP-1	Stage 1 HP-2	Stage 2 HP-2
Cooling: CHWS temp drops below setpoint of:	2°F	2°F	2°F
Heating: HWS temp rises above setpoint of:	3°F	3°F	3°F

Stage ON	Stage 1 HP-3	Stage 2 HP-3	Stage 1 HP-4
Cooling: CHWS temp rises above setpoint of:	45°F	45°F	45°F
Heating: HWS temp drops below setpoint of:	113°F	113°F	113°F

Stage OFF	Stage 1 HP-3	Stage 2 HP-3	Stage 1 HP-4
Cooling: CHWS temp drops below setpoint of:	2°F	2°F	2°F
Heating: HWS temp rises above setpoint of:	3°F	3°F	3°F

Stage ON	Stage 2 HP-4
Cooling: CHWS temp rises above setpoint of:	45°F
Heating: HWS temp drops below setpoint of:	113°F

Stage OFF	Stage 2 HP-4
Cooling: CHWS temp drops below setpoint of:	2°F
Heating: HWS temp rises above setpoint of:	3°F

1 The water to water heat pump staging order shall be user definable. The designated lead heat pump
 2 (user definable) shall rotate upon one of the following conditions (user selectable):

- 3 • manually through a software switch
- 4 • if chiller runtime (adj.) is exceeded
- 5 • daily
- 6 • weekly
- 7 • monthly

8 Each heat pump shall run subject to its own internal safeties and controls. On failure of any heat pump,
 9 the failed heat pump shall be "removed" from operation and the next available piece of equipment as
 10 defined by the user shall be staged on in its place.

11 Alarms shall be provided as follows:

- 12 • Heat Pump 1 Failure: Commanded on, but the status is off.
- 13 • Heat Pump 2 Failure: Commanded on, but the status is off.
- 14 • Heat Pump 3 Failure: Commanded on, but the status is off.
- 15 • Heat Pump 4 Failure: Commanded on, but the status is off.
- 16 • High Load Loop Chilled Water Supply Temp: If the load loop chilled water supply temperature is
 17 greater 56°F (adj.).
- 18 • Low Load Loop Chilled Water Supply Temp: If the load loop chilled water supply temperature is
 19 less than 38°F (adj.).
- 20 • High Load Loop Heating Water Supply Temp: If the load loop heating water supply temperature is
 21 greater 130°F (adj.).
- 22 • Low Load Loop Heating Water Supply Temp: If the load loop heating water supply temperature is
 23 less than 105°F (adj.).
- 24 • High Load Loop Chilled Water Return Temp: If the load loop chilled water return temperature is
 25 greater than 68°F (adj.).
- 26 • Low Load Loop Chilled Water Return Temp: If the load loop chilled water return temperature is
 27 less than 47°F (adj.).

- 1 • High Load Loop Heating Water Return Temp: If the load loop heating water return temperature is
- 2 greater 120°F (adj.).
- 3 • Low Load Loop Heating Water Return Temp: If the load loop heating water return temperature is
- 4 less than 80°F (adj.).

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Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Load Loop Water Supply Temp	x							x		x
Load Loop Water Return Temp	x							x		x
Load loop Water Supply Flow	x							x		x
Heat Pump 1 Failure									x	x
Heat Pump Failure									x	x
Heat Pump 3 Failure									x	x
Heat Pump 4 Failure									x	x
High Load Loop Chilled Water Supply Temp									x	
Low Load Loop Chilled Water Supply Temp									x	
High Load Loop Heating Water Supply Temp									x	
Low Load Loop Heating Water Supply Temp									x	
High Load Loop Chilled Water Return Temp									x	
Low Load Loop Chilled Water Return Temp									x	
High Load Loop Heating Water Return Temp									x	
Low Load Loop Heating Water Return Temp									x	
Totals	3	0	0	0	0	0	0	3	8	7

Total Hardware (3)

Total Software (11)

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3. Energy Recovery Makeup Air Unit

Run Conditions - Scheduled:

- The unit shall run based upon an operator adjustable schedule.
- OR when kitchen hood exhaust fan is on
- OR on high CO2 signal

Freeze Protection:

The unit shall shut down and generate an alarm upon receiving a freezestat status.

Smoke Detection:

The unit shall shut down and generate an alarm upon receiving a smoke detector status.

Outside Air Damper:

The outside air damper shall open anytime the unit runs and shall close anytime the unit stops. The supply fan shall start only after the damper status has proven the damper is open. The outside air damper shall close 4sec (adj.) after the supply fan stops.

Alarms shall be provided as follows:

- Outside Air Damper Failure: Commanded open, but the status is closed.
- Outside Air Damper in Hand: Commanded closed, but the status is open.

Heat Recovery Wheel - Constant Speed:

The controller shall run the heat wheel for energy recovery as follows.

Cooling Recovery Mode:

The heat wheel shall run for cool recovery whenever:

- The units return air temperature is 5°F (adj.) or more below the outside air temperature.
- AND the unit is in a cooling mode.
- AND the supply fan is on.

Heating Recovery Mode:

The heat wheel shall run for heat recovery whenever:

- The units return air temperature is 5°F (adj.) or more above the outside air temperature.
- AND the unit is in a heating mode.
- AND the supply fan is on

Periodic Self-Cleaning:

The heat wheel shall run for 10sec (adj.) every 4hrs (adj.) the unit runs.

Electric Preheating Stages:

The controller shall measure the outside air temperature and stage the preheating to maintain an air temperature before the heat recovery wheel above 15°F (adj.) To prevent short cycling, there shall be a user definable (adj.) delay between stages, and each stage shall have a user definable (adj.) minimum runtime.

1 The preheating shall be enabled whenever:

- 2 • Outside air temperature is less than 25°F (adj.).
- 3 • AND the supply fan status is on.

4 Supply Fan:

5 The supply fan shall run anytime the unit is commanded to run unless shutdown on safeties.

6 Alarms shall be provided as follows:

- 7 • Supply Fan Failure: Commanded on, but the status is off.
- 8 • Supply Fan in Hand: Commanded off, but the status is on.

9 Supply Air Control:

10 The supply fan VFD shall ramp up supply fan to provide 30% (adj.) of the scheduled supply cfm
11 value. On signal from the controller that the kitchen exhaust fan is on, the supply fan VFD shall
12 ramp up the supply fan to provide 80% (adj.) of the scheduled supply cfm. On signal from the
13 controller that the CO2 is above set point, the supply fan VFD shall ramp up the supply fan to
14 provide 100% (adj.) of the scheduled supply cfm.

15 Alarms shall be provided as follows:

- 16 • Supply Fan VFD Fault.

17 Exhaust Fan:

18 The exhaust fan shall run whenever the supply fan runs, unless shutdown on safeties.

19 Alarms shall be provided as follows:

- 21 • Exhaust Fan Failure: Commanded on, but the status is off.
- 22 • Exhaust Fan in Hand: Commanded off, but the status is on.

23 Exhaust Air Control:

24 The exhaust fan VFD shall ramp up the exhaust fan to provide 30% (adj.) of the scheduled
25 exhaust cfm value. On signal from the controller that the kitchen exhaust fan is on, the exhaust
26 fan VFD shall keep the exhaust fan at 30% (adj.) of the scheduled exhaust cfm. On signal from
27 the controller that the kitchen exhaust fan is on and the CO2 is above set point, the exhaust fan
28 VFD shall ramp up the exhaust fan to provide up to 50% (adj.) of the scheduled exhaust cfm. On
29 signal from the controller that the CO2 is above set point, the exhaust fan VFD shall ramp up the
30 exhaust fan to provide up to 100% (adj.) of the scheduled exhaust cfm.

31 Alarms shall be provided as follows:

- 32 • Exhaust Fan VFD Fault.

33 Supply Air Temperature Setpoint - Fixed:

34 The controller shall monitor the supply air temperature and shall maintain a fixed supply air
35 temperature setpoint of 70°F (adj.).

36 Cooling/ Heating Coil Valve:

37 The controller shall measure the supply air temperature and modulate the cooling/heating coil
38 valve to maintain the supply air setpoint.

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2 The cooling shall be enabled whenever:

- 3 • Outside air temperature is greater than 70°F (adj.).
- 4 • AND the supply air temperature is above setpoint.
- 5 • AND the fan status is on.

6 The heating shall be enabled whenever:

- 7 • Outside air temperature is less than 68°F (adj.).
- 8 • AND the supply air temperature is below setpoint.
- 9 • AND the fan status is on.

10 The cooling/heating coil valve shall open to 100% (adj.) whenever the freezestat is on.

11 Re-Heating Coil Valve:

12 In dehumidification mode the controller shall measure the supply air temperature and modulate
13 the re-heat coil valve to maintain the supply air setpoint.

14 The re-heat coil valve shall open to 100% (adj.) whenever the freezestat is on.

15 Minimum Outside Air Ventilation - Carbon Dioxide (CO2) Control:

16 When in the occupied mode, the controller shall measure the return air CO2 level and the outside
17 air CO2 level. The controller shall modulate the supply and exhaust VFDs as described above,
18 when the return air CO2 concentration is 750 ppm (adj.) over the outside air CO2 concentration.

19 Alarms shall be provided as follows:

- 20 • High Return Air Carbon Dioxide Concentration: If the return air CO2 concentration
21 is greater than 1000 ppm (adj.) above the outside air CO2 concentration.

22 Dehumidification:

23 The controller shall measure the return air humidity and override the cooling sequence and open
24 the cooling coil valve and modulate the re-heat coil valve to maintain the supply air temperature
25 and the return air humidity at or below 60% rh (adj.). Dehumidification shall be enabled whenever
26 the supply fan status is on.

27 Exhaust Air Filter Differential Pressure Monitor:

28 The controller shall monitor the differential pressure across the prefilter.

29 Alarms shall be provided as follows:

- 30 • Exhaust Air Filter Change Required: Prefilter differential pressure exceeds a user
31 definable limit (adj.).

32 Outside Air Filter Differential Pressure Monitor:

33 The controller shall monitor the differential pressure across the final filter.

34 Alarms shall be provided as follows:

- 35 • Outside Air Filter Change Required: Final filter differential pressure exceeds a user
36 definable limit (adj.).

1 Return Air Humidity:
2 The controller shall monitor the return air humidity and use as required for humidity control (if
3 present).

4 Alarms shall be provided as follows:

- 5 • High Return Air Humidity: If the return air humidity is greater than 70% (adj.).
- 6 • Low Return Air Humidity: If the return air humidity is less than 35% (adj.).

7 Supply Air Temperature:
8 The controller shall monitor the supply air temperature.

9 Alarms shall be provided as follows:

- 10 • High Supply Air Temp: If the supply air temperature is greater than 80°F (adj.).
- 11 • Low Supply Air Temp: If the supply air temperature is less than 60°F (adj.).

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Outside Air Temp	x							x		x
Exhaust Air Temp	x							x		x
Heat Wheel Discharge Air Temp	x							x		x
Preheat Mixed Air Temp	x							x		x
Return Air Temp	x							x		x
RA Carbon Dioxide PPM	x							x		x
OA Carbon Dioxide PPM	x							x		x
Exhaust Air Filter Differential Pressure	x							x		
Outside Air Filter Differential Pressure	x							x		
Return Air Humidity	x							x		x
Supply Air Temp	x							x		x
Cooling/Heating Valve		x						x		x
Reheating Valve		x						x		x
Freezestat			x					x	x	x
Smoke Detector			x					x	x	x
Outside Air Damper Status			x					x		x
Supply Fan VFD Speed		x						x		x
Exhaust Fan VFD Speed		x						x		x
Heat Wheel Status			x					x		x
Supply Fan VFD Fault			x						x	x
Supply Fan Status			x					x		x
Exhaust Fan VFD Fault			x						x	
Exhaust Fan Status			x					x		x
Outside Air Damper				x				x		x
Heat Wheel Start/Stop				x				x		x
Preheating Stage 1				x				x		x
Preheating Stage 2				x				x		x
Supply Fan Start/Stop				x				x		x
Exhaust Fan Start/Stop				x				x		x
Supply Air Temp Setpoint					x			x		x
Preheating Mixed Air Temp Setpoint					x			x		x
Dehumidification Setpoint					x			x		x

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Schedule							x			
Outside Air Damper Failure									x	
Outside Air Damper in Hand									x	
Heat Wheel Rotation Failure									x	
Heat Wheel in Hand									x	
Supply Fan Failure									x	
Supply Fan in Hand									x	
Exhaust Fan Failure									x	
Exhaust Fan in Hand									x	
Exhaust Air Filter Change Required									x	x
Outside Air Filter Change Required									x	x
High RA Carbon Dioxide Concentration									x	
High Return Air Humidity									x	
Low Return Air Humidity									x	
High Supply Air Temp									x	
Low Supply Air Temp									x	
Totals	11	4	8	6	4	0	1	30	19	31

Total Hardware (29)

Total Software (54)

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4. Mini energy recovery units

Run Conditions - Scheduled:
The unit shall run based upon an operator adjustable schedule.

Outside Air Damper:
The outside air damper shall open anytime the unit runs and shall close anytime the unit stops.
The supply fan shall start only after the damper status has proven the damper is open. The outside air damper shall close 4sec (adj.) after the supply fan stops.

Alarms shall be provided as follows:

- Outside Air Damper Failure: Commanded open, but the status is closed.
- Outside Air Damper in Hand: Commanded closed, but the status is open.

Exhaust Air Damper:
The exhaust air damper shall open anytime the unit runs and shall close anytime the unit stops.
The exhaust fan shall start only after the damper status has proven the damper is open. The exhaust air damper shall close 4sec (adj.) after the exhaust fan stops.

Alarms shall be provided as follows:

- Exhaust Air Damper Failure: Commanded open, but the status is closed.
- Exhaust Air Damper in Hand: Commanded closed, but the status is open.

Heat Wheel:
The heat wheel shall run anytime the unit is commanded to run unless shutdown on safeties.

Alarms shall be provided as follows:

- Heat Wheel Rotation Failure: Commanded on, but the status is off.

Supply Fan:
The supply fan shall run anytime the unit is commanded to run unless shutdown on safeties.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.

Exhaust Fan:
The exhaust fan shall run whenever the supply fan runs, unless shutdown on safeties.

Alarms shall be provided as follows:

- Exhaust Fan Failure: Commanded on, but the status is off.

Outside Air Filter Differential Pressure Monitor:
The controller shall monitor the differential pressure across the final filter.

1 Alarms shall be provided as follows:

- 2 • Outside Air Filter Change Required: Outside air filter differential pressure exceeds a user
3 definable limit (adj.).

4 Exhaust Air Filter Differential Pressure Monitor:

5 The controller shall monitor the differential pressure across the exhaust air filter.

6 Alarms shall be provided as follows:

- 7 • Exhaust Air Filter Change Required: exhaust air filter differential pressure exceeds a user
8 definable limit (adj.).

9 Supply Air Temperature:

10 The controller shall monitor the supply air temperature.

11 Alarms shall be provided as follows:

- 12 • High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
13 • Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Outside Air Temp (before Heat Wheel)	x							x		x
Exhaust Air Temp (after Heat Wheel)	x							x		x
Exhaust Air Temp (before Heat Wheel)	x							x		x
Outside Air Temp (after Heat Wheel)	x							x		x
Outside Air Filter Differential Pressure	x							x		
Exhaust Air Filter Differential Pressure	x							x		
Outside Air Damper Status			x					x		x
Exhaust Air Damper Status			x					x		x
Heat Wheel Status			x					x		x
Supply Fan Status			x					x		x
Exhaust Fan Status			x					x		x
Outside Air Damper				x				x		x
Exhaust Air Damper				x				x		x
Energy Recovery Unit Start/Stop				x				x		x
Schedule							x			
Outside Air Damper Failure									x	
Exhaust Air Damper Failure									x	
Heat Wheel Rotation Failure									x	
Supply Fan Failure									x	
Exhaust Fan Failure									x	
Outside Air Filter Change Required									x	x
Exhaust Air Filter Change Required									x	x
High Supply Air Temp									x	
Low Supply Air Temp									x	
Totals	6	0	5	3	0	0	1	14	9	14

Total Hardware (14)

Total Software (24)

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2 5. Load Loop Monitoring and Pumps (To the Primary Coils)

3 Water to water Heat Pump load Loop Monitor - Run Conditions:
4 The load loop monitor shall run whenever:

- 5 • Any zone is occupied.
- 6 • OR a definable number of unoccupied zones need heating or cooling.

7 The following load loop water conditions shall be monitored:

- 8 • Flow status.
- 9 • Supply temperature.
- 10 • Return temperature.

11 Alarms and a heat pump shutdown signal shall be generated upon any of the following load loop
12 water conditions:

- 13 • No Load Loop Flow.
- 14 • High Load Loop Water Supply Temp Shutdown: If the load loop water supply temperature
15 is greater than 120°F (adj.).
- 16 • Low Load Loop Water Supply Temp Shutdown: If the load loop water supply temperature
17 is less than 40°F (adj.).

18 Alarms shall be provided as follows:

- 19 • High Load Loop Water Supply Temp: If the load loop water supply temperature is greater
20 than 130°F (adj.).
- 21 • Low Load Loop Water Supply Temp: If the load loop water supply temperature is less
22 than 35°F (adj.).

23 Load Loop Water Pump Lead/Lag Operation:
24 The two loop water pumps shall operate in a lead/lag fashion.

- 25 • The lead pump shall run first.
- 26 • On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.
- 27 • On decreasing loop water differential pressure, the lag pump shall stage on and run in
28 unison with the lead pump to maintain load loop water differential pressure setpoint.

29 The designated lead pump shall rotate upon one of the following conditions (user selectable):

- 30 • manually through a software switch
- 31 • if pump runtime (adj.) is exceeded
- 32 • daily
- 33 • weekly
- 34 • monthly

35 Alarms shall be provided as follows:

- 36 • Load Loop Water Pump 1

- 1 • Failure: Commanded on, but the status is off.
- 2 • Running in Hand: Commanded off, but the status is on.
- 3 • Runtime Exceeded: Status runtime exceeds a user definable limit.
- 4 • VFD Fault.
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- 6 • Load Loop Water Pump 2
- 7 • Failure: Commanded on, but the status is off.
- 8 • Running in Hand: Commanded off, but the status is on.
- 9 • Runtime Exceeded: Status runtime exceeds a user definable limit.
- 10 • VFD Fault.

11 Load Loop Water Differential Pressure Control:
12 The controller shall measure load loop water differential pressure and modulate the loop water
13 pump VFDs in sequence to maintain its load loop water differential pressure setpoint. The
14 following setpoints are recommended values. All setpoints shall be field adjusted during the
15 commissioning period to meet the requirements of actual field conditions.

16 The controller shall modulate load loop water pump speeds to maintain a loop water differential
17 pressure of 12lb_f/in² (adj.). The VFD minimum speed shall not drop below 20% (adj.).

18 On dropping load loop water differential pressure, the VFDs shall stage on and run to maintain
19 setpoint as follows:

- 20 • The controller shall modulate the lead VFD to maintain setpoint.
- 21 • If the lead VFD speed is greater than a setpoint of 90% (adj.), the lag VFD shall stage on.
- 22 • The lag VFD shall ramp up to match the lead VFD speed and then run in unison with the
23 lead VFD to maintain setpoint.

24 On rising load loop water differential pressure, the VFDs shall stage off as follows:

- 25 • If the VFD speeds then drops back to 60% (adj.) below setpoint, the lag VFD shall stage
26 off.
- 27 • The lead VFD shall continue to run to maintain setpoint.

28 Alarms shall be provided as follows:

- 29 • High Load Loop Water Differential Pressure: If the load loop water differential pressure
30 is 25% (adj.) greater than setpoint.
- 31 • Low Load Loop Water Differential Pressure: If the load loop water differential pressure
32 is 25% (adj.) less than setpoint.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Load Loop Water Supply Temp	x							x		x
Load Loop Water Return Temp	x							x		x
Load Loop Water Differential Pressure	x							x		x
Load Loop Water Pump 1 VFD Speed		x						x		x
Load Loop Water Pump 2 VFD Speed		x						x		x
Load Loop Water Flow Status			x							x
Load Loop Water Pump 1 VFD Fault			x						x	x
Load Loop Water Pump 2 VFD Fault			x						x	x
Load Loop Water Pump 1 Status			x					x		x
Load Loop Water Pump 2 Status			x					x		x
Load Loop Water Pump 1 Start/Stop				x						x
Load Loop Water Pump 2 Start/Stop				x						x
Load Loop Water Differential Pressure Setpoint					x					x
No Load Loop Flow									x	
High Load Loop Water Supply Temp Shutdown									x	
Low Load Loop Water Supply Temp Shutdown									x	
High Load Loop Water Supply Temp									x	
Low Load Loop Water Supply Temp									x	
High Load Loop Water Differential Pressure									x	
Low Load Loop Water Differential Pressure									x	
Load Loop Water Pump 1 Failure									x	
Load Loop Water Pump 1									x	

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Running in Hand										
Load Loop Water Pump 1 Runtime Exceeded									x	
Load Loop Water Pump 2 Failure									x	
Load Loop Water Pump 2 Running in Hand									x	
Load Loop Water Pump 2 Runtime Exceeded									x	
Totals	3	2	5	2	1	0	0	7	15	13

Total Hardware (12)

Total Software (23)

1 6. Source Loop Monitoring and Pumps (To the Secondary Coils and the Loop Field)

2 Water Source Heat Pump Source Loop Monitor - Run Conditions:
3 The source loop monitor shall run whenever:

- 4 • Any zone is occupied.
- 5 • OR a definable number of unoccupied zones need heating or cooling.

6 The following source loop water conditions shall be monitored:

- 7 • Flow status.
- 8 • Supply temperature.
- 9 • Return temperature.

10 Alarms and a heat pump shutdown signal shall be generated upon any of the following source
11 loop water conditions:

- 12 • No Source Loop Flow.
- 13 • High Source Loop Water Supply Temp Shutdown: If the loop water supply temperature is
14 greater than 90°F (adj.).
- 15 • Low Source Loop Water Supply Temp Shutdown: If the loop water supply temperature is
16 less than 35°F (adj.).

17 Alarms shall be provided as follows:

- 18 • High Source Loop Water Supply Temp: If the source loop water supply temperature is
19 greater than 100°F (adj.).
- 20 • Low Source Loop Water Supply Temp: If the source loop water supply temperature is
21 less than 30°F (adj.).

22 Source Loop Water Pump Lead/Lag Operation:

23 The two source loop water pumps shall operate in a lead/lag fashion.

- 24 • The lead pump shall run first.
- 25 • On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.
- 26 • On decreasing loop water differential pressure, the lag pump shall stage on and run in
27 unison with the lead pump to maintain loop water differential pressure setpoint.

28 The designated lead pump shall rotate upon one of the following conditions (user selectable):

- 29 • manually through a software switch
- 30 • if pump runtime (adj.) is exceeded
- 31 • daily
- 32 • weekly
- 33 • monthly

34 Alarms shall be provided as follows:

- 35 • Source Loop Water Pump 1
36 • Failure: Commanded on, but the status is off.

- 1 • Running in Hand: Commanded off, but the status is on.
- 2 • Runtime Exceeded: Status runtime exceeds a user definable limit.
- 3 • VFD Fault.
- 4
- 5 • Source Loop Water Pump 2
- 6 • Failure: Commanded on, but the status is off.
- 7 • Running in Hand: Commanded off, but the status is on.
- 8 • Runtime Exceeded: Status runtime exceeds a user definable limit.
- 9 • VFD Fault.

10 Source Loop Water Differential Pressure Control:
11 The controller shall measure loop water differential pressure and modulate the source loop water
12 pump VFDs in sequence to maintain its source loop water differential pressure setpoint. The
13 following setpoints are recommended values. All setpoints shall be field adjusted during the
14 commissioning period to meet the requirements of actual field conditions.

15 The controller shall modulate source loop water pump speeds to maintain a loop water differential
16 pressure of 12lb_f/in² (adj.). The VFD minimum speed shall not drop below 20% (adj.).

17 On dropping source loop water differential pressure, the VFDs shall stage on and run to maintain
18 setpoint as follows:

- 19 • The controller shall modulate the lead VFD to maintain setpoint.
- 20 • If the lead VFD speed is greater than a setpoint of 90% (adj.), the lag VFD shall stage on.
- 21 • The lag VFD shall ramp up to match the lead VFD speed and then run in unison with the
22 lead VFD to maintain setpoint.

23 On rising source loop water differential pressure, the VFDs shall stage off as follows:

- 24 • If the VFD speeds then drops back to 60% (adj.) below setpoint, the lag VFD shall stage
25 off.
- 26 • The lead VFD shall continue to run to maintain setpoint.

27 Alarms shall be provided as follows:

- 28 • High Source Loop Water Differential Pressure: If the loop water differential pressure
29 is 25% (adj.) greater than setpoint.
- 30 • Low Source Loop Water Differential Pressure: If the loop water differential pressure
31 is 25% (adj.) less than setpoint.

Point Name	Hardware Points				Software Points					Show On Graphic
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	
Source Loop Water Supply Temp	x							x		x
Source Loop Water Return Temp	x							x		x
Source Loop Water Differential Pressure	x							x		x
Source Loop Water Pump 1 VFD Speed		x						x		x
Source Loop Water Pump 2 VFD Speed		x						x		x
Source Loop Water Flow Status			x							x
Source Loop Water Pump 1 VFD Fault			x						x	x
Source Loop Water Pump 2 VFD Fault			x						x	x
Source Loop Water Pump 1 Status			x					x		x
Source Loop Water Pump 2 Status			x					x		x
Source Loop Water Pump 1 Start/Stop				x						x
Source Loop Water Pump 2 Start/Stop				x						x
Source Loop Water Differential Pressure Setpoint					x					x
No Source Loop Flow									x	
High Source Loop Water Supply Temp Shutdown									x	
Low Source Loop Water Supply Temp Shutdown									x	
High Source Loop Water Supply Temp									x	
Low Source Loop Water Supply Temp									x	
High Source Loop Water Differential Pressure									x	
Low Source Loop Water Differential Pressure									x	
Loop Source Water Pump 1									x	

Point Name	Hardware Points				Software Points					Show On Graphic	
	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm		
Failure											
Loop Source Water Pump 1 Running in Hand										x	
Loop Source Water Pump 1 Runtime Exceeded										x	
Loop Source Water Pump 2 Failure										x	
Loop Source Water Pump 2 Running in Hand										x	
Loop Source Water Pump 2 Runtime Exceeded										x	
Totals	3	2	5	2	1	0	0	7	15		13

Total Hardware (12)

Total Software (23)

1