Liquid-to-Water High Capacity Commercial Geothermal Heat Pumps

HW-350-HAC

Water Well, Groundloop or Wastewater Operation

Boreal
Energy Efficient Solutions

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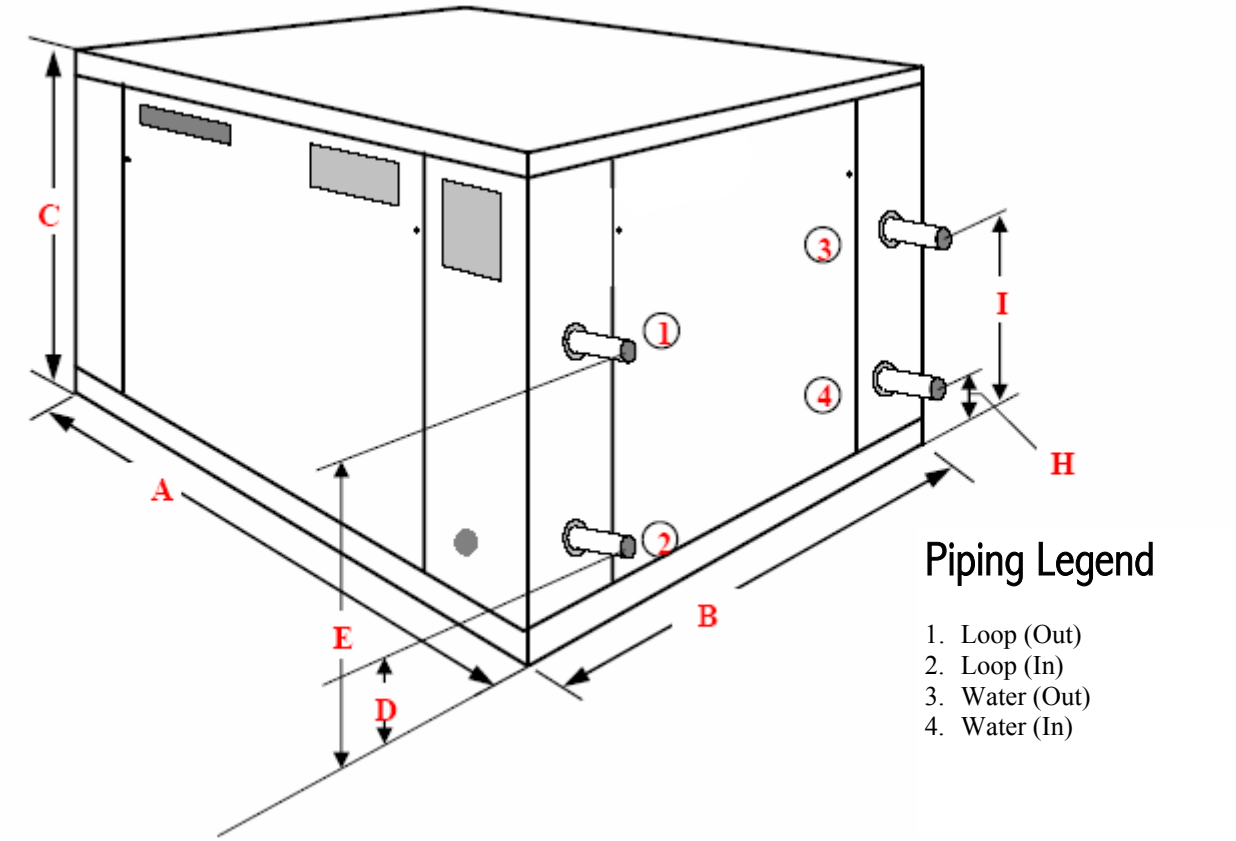
High Capacity Liquid-to-Water Heat Pump



Piping Legend

1. Loop (Out)
2. Loop (In)
3. Water (Out)
4. Water (In)

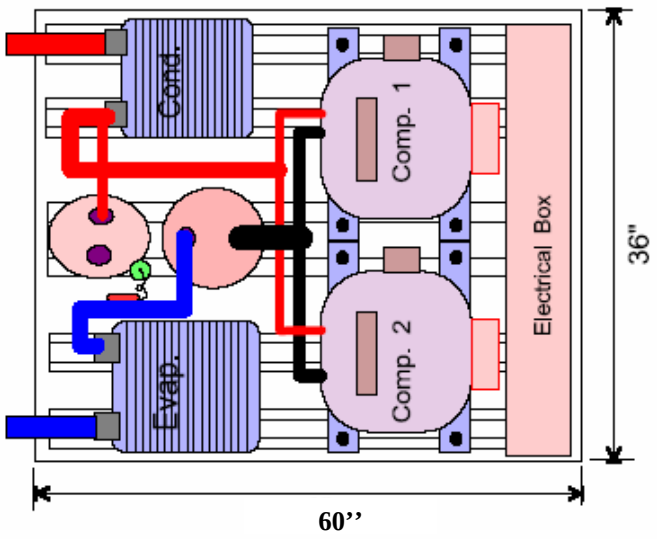
Model	Size	A	B	C	D	E	H	I	1	2	3	4
HW-350	in	60	36	36	2-7/8	21	2-7/8	21	2	2	2	2

All Pipe Dimensions are "ID"

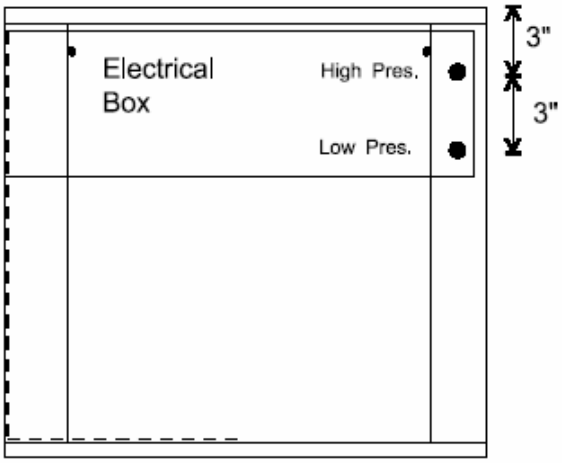
Standard Features

1. Heavy duty case constructed of 20 gauge 1mm satin galvanized panels with welded reinforcing channel stiffeners and corner posts.
2. Finished inside and out with an oven baked epoxy enamel.
3. Cabinet completely insulated with 1/2" acoustic insulation (1" optional).
4. Four removable access doors for easy servicing.
5. Heavy duty heat pumps rated Copeland "Tandem" compressors with sump heater.
6. Oversized commercial duty compressor contactor rated for 2 million cycles.
7. Integrated heavy duty electrical box enclosure with removable cover.
8. Suction line accumulator & liquid line receiver.
9. Liquid line receiver.
10. High efficiency 316 SS brazed plate evaporator and condenser heat exchangers.
11. Flow proving switches standard.
12. Solid State Phase loss protector / anti short cycle timers.
13. Filter drier and sight glass standard equipment.
14. TXV with off cycle equalization port.
15. Compressor can be operated independently allowing two "stages" of capacity with 50% and full output.
16. Operational and lock-out indicator lights.
17. Optional dry contacts for remote alarms.
18. Low water flow cutoff safety (flow switch).
19. Low and high pressure / temperature refrigerant safety controls.
20. Suitable for wastewater, open well or closed loop applications.
21. Optional water valve for water well operation.
22. Optional LONWORKS Connections.
23. Optional Random Start Control.
24. All water lines constructed of copper with optional PVC piping available for harsh environments.
25. CAN/CSA C22.2 NO 236-05 certified for electrical safety.
26. CSA for performance as per CSA 446 M-94 (equivalent to ARI 325 & 330-98).

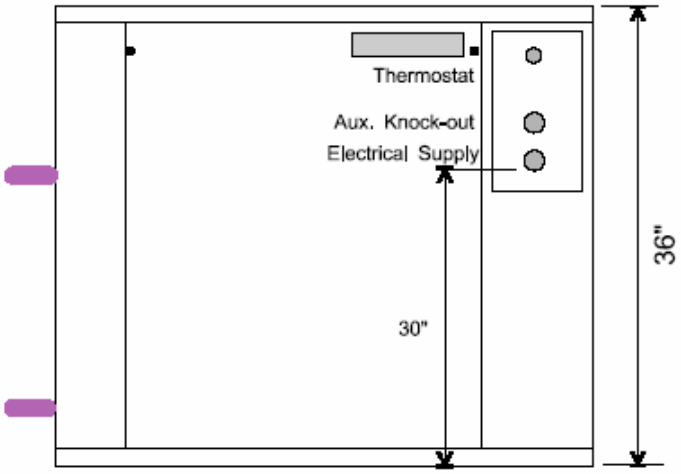
Cabinet & Piping Layout



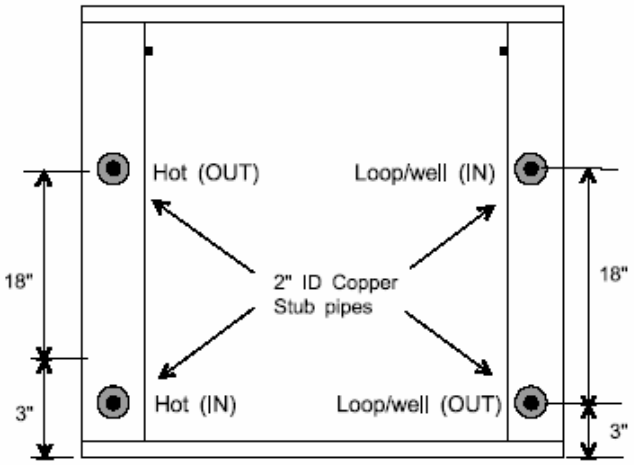
Top View



Back View



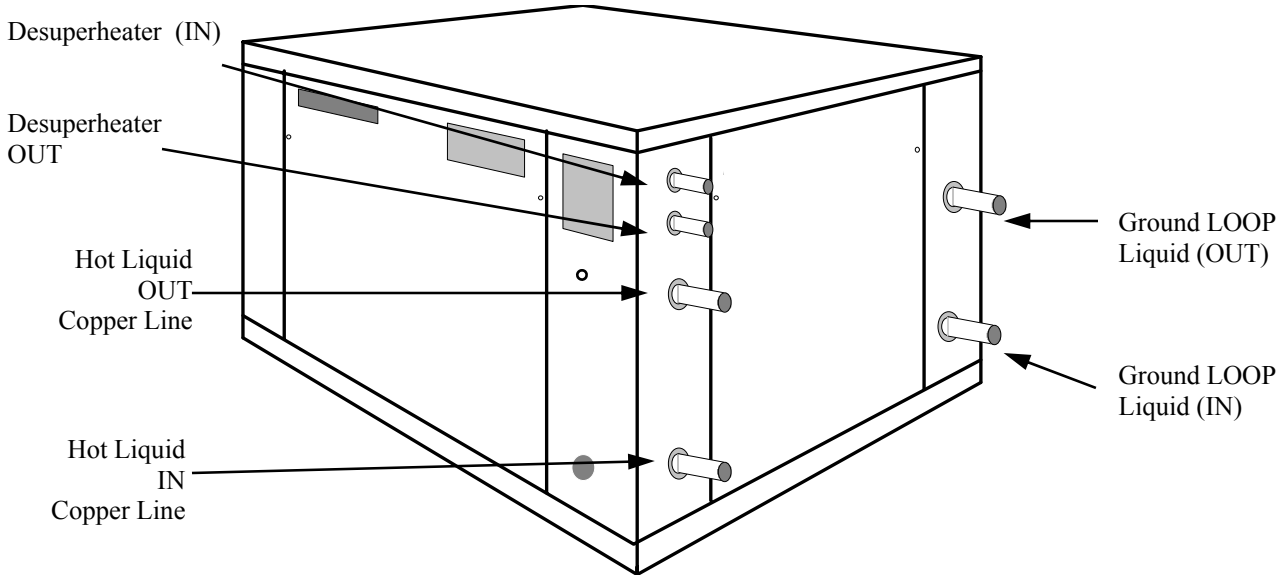
Right Side View



Front View

1. All water lines are type "L" copper with diameters as noted above.
2. Maintain 2 ft. clearance on all sides for service personnel.
3. Weight = 850 lbs.
4. Refrigerant charge = 42 lbs. R-22
5. Install shut off and pressure relief valves as per engineer's spec.
6. Sound level less than 53 db at 4 ft.
7. Vibration low.
8. Surface temperature rise less than 5°C above ambient at any point on the cabinet of the heat pump.
9. Allow suitable insulation to minimize heat loss on all external piping of the heat pump.
10. Hot lines will not exceed 80°C.
11. Cold lines may experience temperatures down to –5°C.

BOREAL® Piping Layout & Electrical Requirements



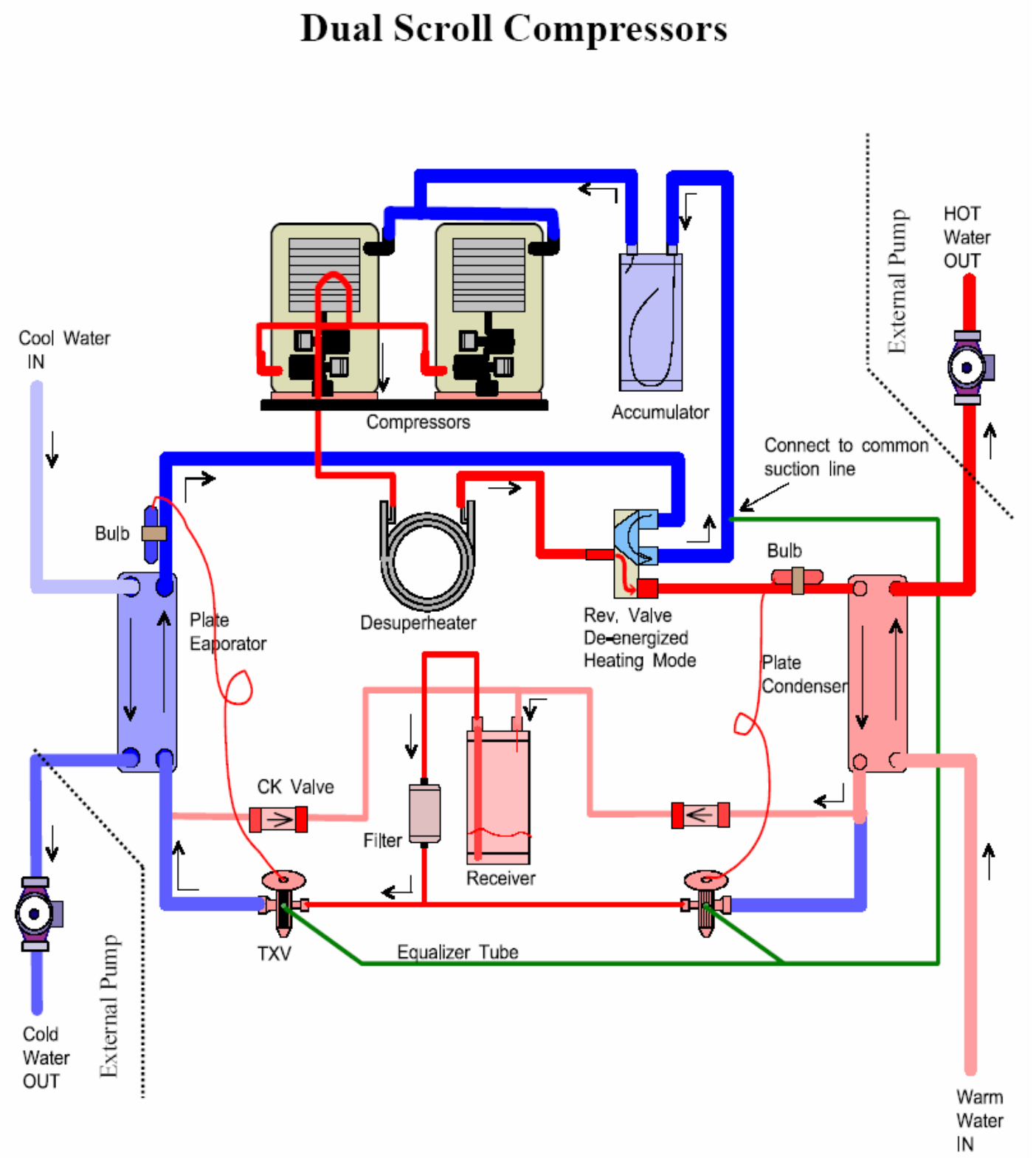
Electrical Supply and Thermostat Wire Sizes

Model	W-350-HAC		
Voltage	208-3-60	460-3-60	575-3-60
Min. circuit ampacity	96	48	38
Minimum wire size	1-3 + Gnd	3-3 + Gnd	6-3 + Gnd
Max. Time Delay Fuse Size	150	80	60
Max. breaker size	150	80	60
Thermostat wire size	18	18	18
Thermostat conductors	4	4	4

(Optional) ….Domestic Hot Water Generator Specifications

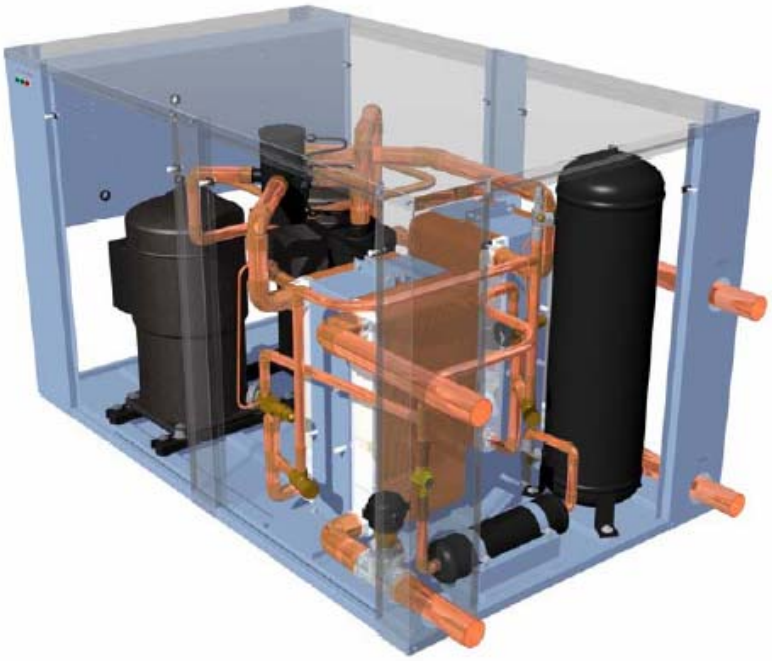
Temperature (IN) °F.	Temp (OUT) °F.	Temperature Rise °F.	% of Total	W-350-HAC (Igal/hr)
40	150	110	20	54.5
45	150	105	18	51.4
50	150	100	15	48.0
60	150	90	12	46.0
75	150	75	10	43.0
90	150	60	8	40.0
110	150	40	5	38.0

Refrigerant Circuit Specification



Features HW-350-HAC Model

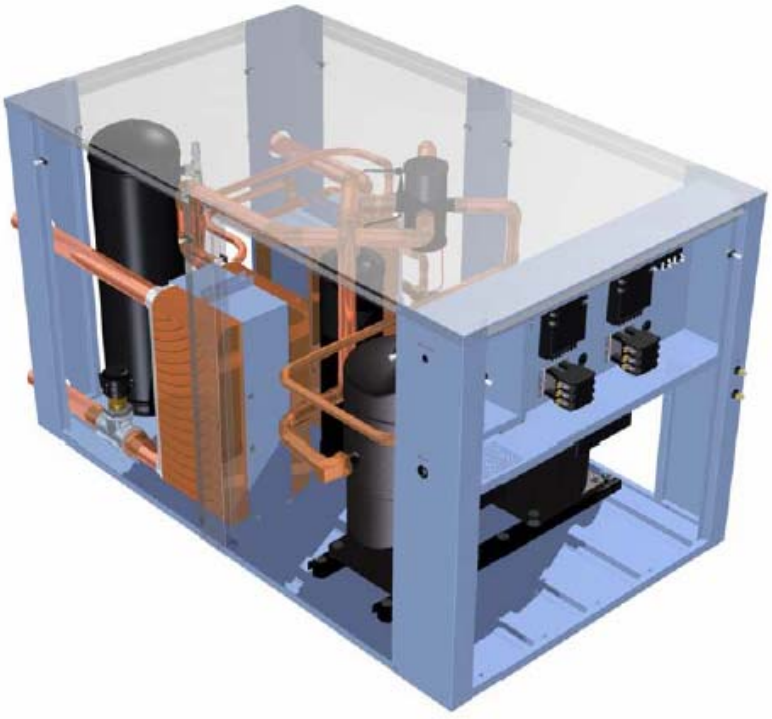
- Galvanized metal with baked enamel or epoxy based finish.
- Thermostatic expansion valves.
- High efficiency scroll compressors.
- High Efficiency brazed plate heat exchangers.



(Front) Plumbing side

- Liquid line filter drier.
- Sight glass.
- Liquid receiver.
- Insulated water coils.
- Suction accumulator.

- Baked enamel cabinet with satin galvanized panels.
- Components accessible from all four sides.
- Heavy duty electrical components.
- High & Low access ports.
- Remote reset lock-out relay system.



(Back) Electrical Box Side

- Acoustically insulated cabinet.
- Cabinet spot welded for superior strength.
- High efficiency scroll compressors.
- 1/2 or full out-put capacity.
- Low water Flow switch protection

Legend

ELT – entering liquid temperature
EWT – entering water temperature
EAT – entering air temperature
LWT – leaving water temperature
LAT – leaving air temperature
LLT – leaving liquid temperature
Evap. – the temperature on evaporator side when Freon is converted from a liquid to a vapor (gas)
Cond. – Freon temperature on condenser side
Flow IGPM – liquid flow in Imperial Gallons Per Minutes
IGPM – Imperial Gallons Per Minutes
Temp. diff. – Temperature difference in-between ELT and a LLT
Delta T. – Temperature difference in-between LWT and EWT
HAB – in heating mode: heat absorption capacity from the ground or water
– in cooling mode: heat absorption capacity from the inside air (total cooling load)
LSM – HAB, Lower Stage compressor Mode
Sensible - The interior heat gain (sensible) due to heat conduction, convection, and radiation from the exterior into the interior, and from occupants and appliances.
Latent – The latent load created by moisture in the air, including from outside air infiltration and that from indoor sources such as occupants, plants, cooking, showering, etc.
Comp. - Watts – compressor electricity consumption
Fan-Watts – blower motor electricity consumption
Watts – heat pumps electricity consumption
Amps – electrical current (back up excluded)
Output – heat pump capacity in Btu's & Ton's
KW OUT – heat pump capacity in kilowatts
COP – coefficient of performance
EER – energy efficiency ratio
CFM – air flow rate in cubic feet per meter

Performance Charts

HW-350-HAC — Nominal 30 tons — Heating

Source Data						Power Consumption				Sink Data					
ELT °F	Evap. ° F	Flow Igpm	LLT °F	Temp. Diff °F	HAB (Btu's)	Watts	Amps	Output (Btu's)	KW OUT	COP	EWT ° F	Igpm	LWT ° F	Delta ° F	Cond. °F
°C	°C	L/min	°C	°C	tons			tons			°C	L/min	°C	°C	°C
27	15	67.0	22.7	4.27	171,498	23,640	34.2	252,183	73.9	3.13	105	67.0	111.3	6.3	120
-2.8	-9.4	303	-5.1	2.4	14.3			21.0			40.6	303	44.0	3.5	48.9
33	20	67.0	28.2	4.80	193,133	23,839	34.4	274,496	80.4	3.37	105	67.0	111.8	6.8	120
0.6	-6.7	303	-2.1	2.7	16.1			22.9			40.6	303	44.3	3.8	48.9
39	25	67.0	33.6	5.37	215,941	23,990	34.5	297,819	87.3	3.64	105	67.0	112.4	7.4	120
3.9	-3.9	303	0.9	3.0	18.0			24.8			40.6	303	44.7	4.1	48.9
45	30	67.0	39.0	5.97	240,163	24,106	34.6	322,435	94.5	3.92	105	67.0	113.0	8.0	120
7.2	-1.1	303	3.9	3.3	20.0			26.9			40.6	303	45.0	4.5	48.9
51	35	67.0	44.4	6.62	266,040	24,199	34.7	348,632	102.1	4.22	105	67.0	113.7	8.7	120
10.6	1.7	303	6.9	3.7	22.2			29.1			40.6	303	45.4	4.8	48.9
57	40	67.0	49.7	7.31	293,813	24,284	34.8	376,693	110.4	4.55	105	67.0	114.4	9.4	120
13.9	4.4	303	9.8	4.1	24.5			31.4			40.6	303	45.8	5.2	48.9
63	45	67.0	54.9	8.05	323,723	24,372	34.9	406,905	119.2	4.89	105	67.0	115.1	10.1	120
17.2	7.2	303	12.7	4.5	27.0			33.9			40.6	303	46.2	5.6	48.9
69	50	67.0	60.1	8.86	356,011	24,478	35.1	439,552	128.8	5.26	105	67.0	115.9	10.9	120
20.6	10.0	303	15.6	4.9	29.7			36.6			40.6	303	46.6	6.1	48.9

In accordance with ARI 325 and 330 standards & CAN/CSA C446-M94

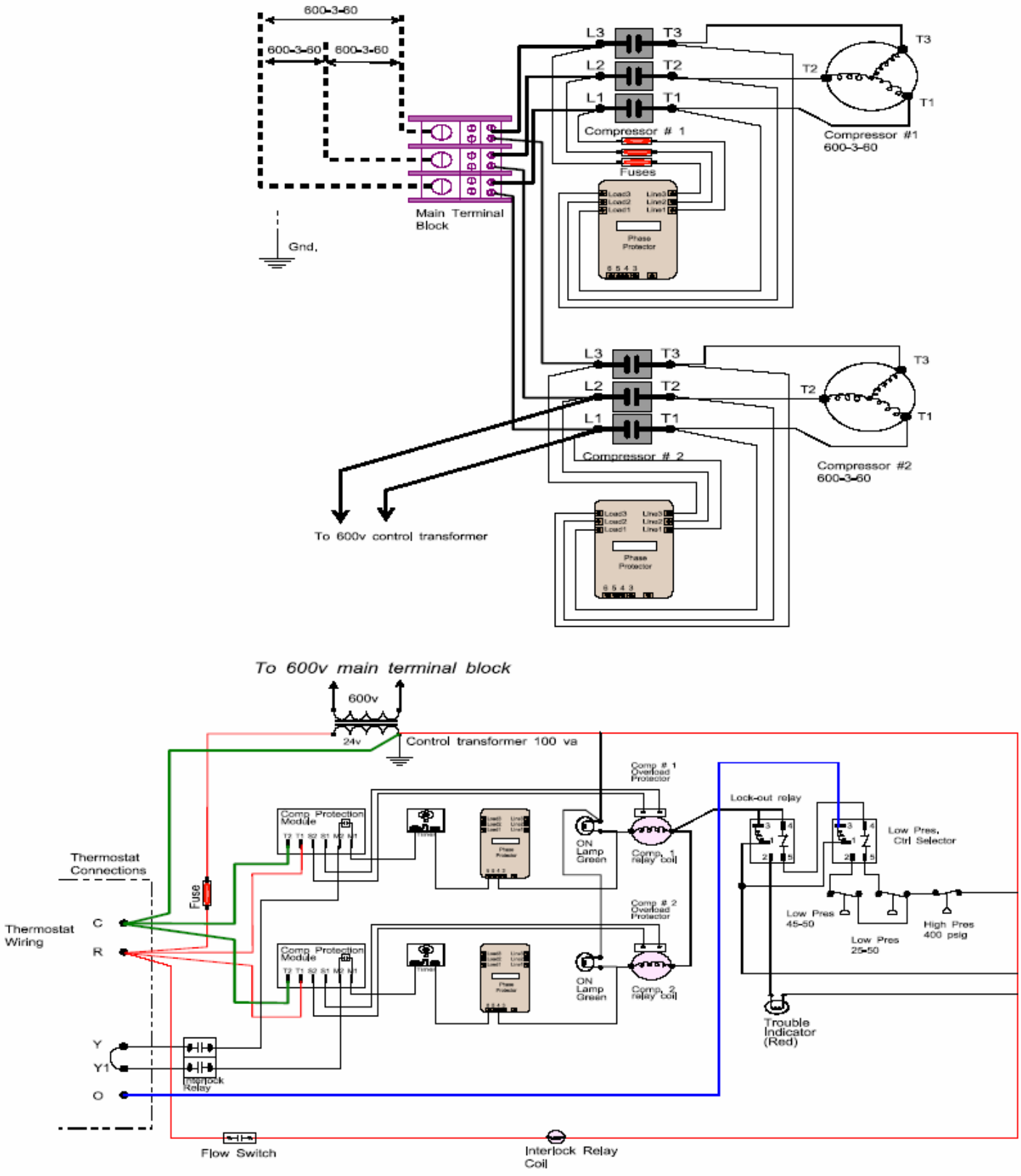
Current in amps @ 460v—Multiply by 2.2 for 208v, by .8 for 575v

HW-350-HAC — Nominal 30 tons — Cooling

Source Data						Power Consumption				Sink Data					
ELT °F	Evap. ° F	Flow Igpm	LLT °F	Temp. Diff °F	HAB (Btu's)	Watts	Amps	Output (Btu's)	KW OUT	EER	EWT ° F	Igpm	LWT ° F	Delta ° F	Cond. °F
°C	°C	L/min	°C	°C	tons			tons			°C	L/min	°C	°C	°C
55	40	67.0	46.4	8.65	347,657	17,136	27.1	406,141	119.0	20.29	70	67.0	80.1	10.1	85
12.8	4.4	303	8.0	4.8	29.0			33.8			21.1	303	26.7	5.6	29.4
55	40	67.0	46.5	8.45	339,798	17,934	27.9	401,006	117.5	18.95	75	67.0	85.0	10.0	90
12.8	4.4	303	8.1	4.7	28.3			33.4			23.9	303	29.4	5.5	32.2
55	40	67.0	46.7	8.26	332,150	18,809	28.8	396,345	116.1	17.66	80	67.0	89.9	9.9	95
12.8	4.4	303	8.2	4.6	27.7			33.0			26.7	303	32.1	5.5	35.0
55	40	67.0	46.9	8.08	324,616	19,762	29.8	392,062	114.9	16.43	85	67.0	94.8	9.8	100
12.8	4.4	303	8.3	4.5	27.1			32.7			29.4	303	34.9	5.4	37.8
55	40	67.0	46.9	8.08	324,616	19,762	29.8	392,062	114.9	16.43	85	67.0	94.8	9.8	100
12.8	4.4	303	8.3	4.5	27.1			32.7			29.4	303	34.9	5.4	37.8
55	40	67.0	47.1	7.89	317,101	20,790	30.9	388,057	113.7	15.25	90	67.0	99.7	9.7	105
12.8	4.4	303	8.4	4.4	26.4			32.3			32.2	303	37.6	5.4	40.6
55	40	67.0	47.3	7.70	309,510	21,893	32.1	384,231	112.6	14.14	95	67.0	104.6	9.6	110
12.8	4.4	303	8.5	4.3	25.8			32.0			35.0	303	40.3	5.3	43.3
55	40	67.0	47.7	7.31	293,715	24,321	34.9	376,723	110.4	12.08	105	67.0	114.4	9.4	120
12.8	4.4	303	8.7	4.1	24.5			31.4			40.6	303	45.8	5.2	48.9

Current in amps @ 460v—Multiply by 2.2 for 208v, by .8 for 575v

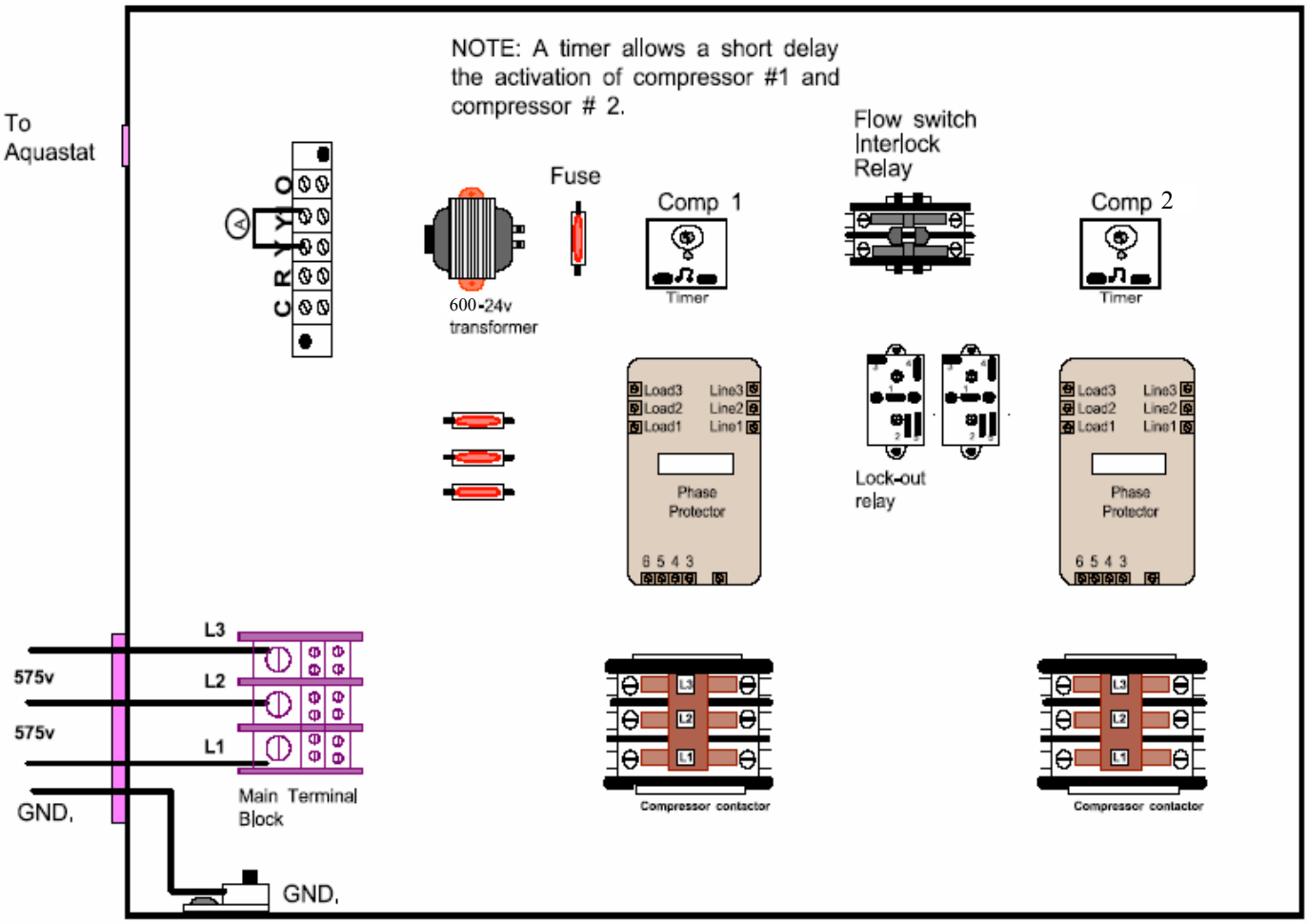
BOREAL® HW-350-HAC (600-3-60) Schematic



Heating Mode
Both compressor operation
Connection between "R" and "Y"
activates compressor # 1 & 2

To stage compressor operation, remove small jumper between
Y and Y1.
Connection between R and Y activates compressor # 1
Connection between R and Y1 activates compressor # 2
Connection between R and O activates cooling mode

BOREAL® HW-350-HAC (600-3-60) Electrical Box



600 V High Voltage Connections

Connect L3, L2, and L1 as shown at left to 600v 3 phase power.

Connect ground wire to GND.

24v Low voltage Connections

(Use 18-2 or 18-3 thermostat wire)

1)To activate the heat pump, connect "R" and "Y" in electrical box to a SPST aquastat or other switch.

NOTE: Compressors 1 and 2 are connected together with jumper "A" shown above.
To operate the compressors separately remove the jumper between Y and Y1. Connection from "R" to "Y" will then start compressor 1 and a connection between "R" and "Y1" will start compressor # 2.

NOTE: A timer allows a short delay the activation of compressor #1 and compressor # 2.

BOREAL® HW-350-HAC Start-up Instructions

IMPORTANT

Before attempting a start-up of any Geothermal heat pump, verify that the proper quantity and quality of liquid is available to flow on both the "source" side (ground loop or water well etc.) and the "sink" side (building loop side, pool, and or hot buffer tank side).

Circulator pumps on both the loop side and building side of the system must be selected according to the loop designer's pressure drop analysis. Verify with the pump supplier or the pump specification manual that the loop pumps are of sufficient capacity to supply adequate flow to the heat pumps as per specifications supplied by Maritime Geothermal Ltd.. Any ground loop system must be flushed of debris, purged of air, filled with a (30% by volume solution) of methanol / water and pressurized to 30 psig. Verify that the pumps have been properly wired to operate whenever a control signal has been sent to the HP unit.

Pressure gauges should be installed on the inlet and outlet of the circulator pump(s) so that the service technician can easily observe that flow is present. Temperature gauges should also be installed on the inlet and outlet lines to the heat pump on both the hot and cold sides so that performance of the heat pump can be readily observed. In lieu of permanent gauges, Pressure/Temperature plugs (PT) plugs can be installed at the above mentioned locations allowing the technician to observe pressures and temperatures with handheld instruments.

NOTE: Make sure your circulator pumps are wired purged and ready to pump whenever the unit is activated.

1.0 Scope: To verify that the heat pump is working correctly upon startup.

2.0 Equipment: Refrigeration Gauges
Phase Protector Manual
Temperature Gun or Thermometers
Electrical Tape

3.0 Procedure:

Step 1: Remove the caps from the service ports and connect the refrigeration gauges to the unit.

Step 2: Turn on the power to the unit. When the phase protectors power up (they come up with a delay, wait for the delay to time out), verify that the green "energized" LED is on. If it is not on and the red "fault" LED is on, press the FAULT button to check the faults. If there are faults, check the phase protector manual for information on how to correct them. Press and hold the FAULT button to clear the faults. When no faults appear again, the green "energized" LED should light up.

Step 3: If controlled by others, verify the water flow to both heat exchangers. If the unit is equipped with flow switches, verify that the 2 pole contactor in the electrical box is energized.

Step 4: Set the controller or Aquastat to the desired settings. A typical setting would be 110F to 115F with a delta of 5F.

Step 5: NOTE: **Dual compressor systems are wired to operate together at the factory. Individual control can be achieved by removing the low voltage jumper as per instructions in the units electrical diagram.**

The first compressor should start after approximately 30 secs. Check the refrigeration gauges to ensure that it is running forward. The unit is equipped with 3-phase compressors which will not pump when running backwards. The suction pressure should come down and the discharge pressure should go up. If the pressures do not change then the compressor is turning backwards. Turn the power off and interchange any two of the 3 phase wires on the main terminal block to reverse rotation. Repeat step 5.

Step 6: The second compressor should start approximately 30secs after the first one starts. Check the gauges. The suction and discharge pressures will depend on the loop temperatures but they would be about 50-65 and 160-210 respectively for a typical start-up on a loop that has not been previously chilled.
On an open loop system these source pressures would remain constant for a given water flow and temperature. As the hot side temperature increases, the discharge pressure will climb. If operating from a ground loop, the suction will drop off as the cold side source temperature decreases.

Step 7: Check the cold side temperature differential after the unit has been running for 10-15min. If using a temperature gun, wrap black electrical tape (1 layer only) around the pipes first since the bare copper does not give accurate readings. Measure as close to the unit as possible. The cold side loop should have a 5-7 °F temperature differential if the flow is correct. If the value is higher, the liquid flow must be increased to meet MGL published standards.

Step 8: Check the hot side temperature differential after the unit has been running for 10-15min. If using a temperature gun, wrap electrical tape around the pipes first as copper does not give accurate readings. Measure as close to the unit as possible. The hot side loop should have an 8-10 °F temperature differential if the flow is correct. If the value is higher, the flow must be increased, if it is lower the flow may be reduced.

Step 9: Let the heat pump run through a complete cycle. Verify the discharge pressure when the Aquastat shuts the unit off. The Aquastat setting must not be above 120°F to keep the discharge pressure within a safe working range and below the high pressure cutout value to avoid nuisance safety lockouts. Under normal operation, the discharge pressure should not exceed 320 psig on an R22 system. If it is too close to the lockout pressure, reduce the Aquastat set point.

Step10: Turn the power off to the unit. Purge all air from the domestic hot water circulator circuit. Connect the domestic hot water circulator wire (brown wire with insulated terminal) to the compressor contactor as indicated in the unit schematic. With the heat pump running, check the temperature differential of the domestic hot water lines at a distance of 6 ft away from the heat pump. The DHW (OUT) line should be a few °F hotter than the DHW (IN) line. If the two lines are approximately the same temperature then the circulator is air locked. Bleed the air from the system and check the temperature differential again to ensure there is flow from the circulator to the DHW storage tank.

Use the attached commissioning certificate to document all measurements for archival purposes.

Installation Start-Up Record Example

Owners Name:			Dealer's Name:	
Address:			Address:	
Telephone:			Telephone:	
Fax:			Fax:	
Contact:			Contact:	

Equipment Identification

Model	Serial No	Refrigerant	Voltage	Ground Loop Fluid	Floor Loop Fluid
HW-XX-HW	1173-03-03	R407c	208-3-60	Ethanol/water	Ethanol/ water

Start-up Data

Hot Water Heating Mode

Building Ambient	70°F	
Suction Pressure (start) psig.	63 psig.	Normal
Suction Pressure @ 1 hr psig.	47 psig.	Normal
Suction Pressure @ 2 hr psig.	44 psig.	Normal
Loop Entering Fluid Temp	46°F	OK
Loop Leaving Fluid Temp	40°F	OK
Loop Delta T (Leaving—Entering)	6°F	Normal
Fluid flow	10 Igpm	Normal
Discharge Pressure (start) psig.	271 psig.	Normal
Discharge Pressure @ 1 hr Bldg. Entering -Leaving Water Temp	282 psig. 100°F / 112°F	OK
Discharge Pressure @ 2 hr Bldg. Entering-Leaving Water Temp	290 psig. 103°F / 115°F	OK
Bldg Loop Delta T	12 °F	OK
Bldg. Loop Fluid flow	10 Igpm.	
Voltage / Amps @ 2 hrs.—60 HZ	208v / 11.5 A	OK
Voltage at Aux. Circulators	120v	OK
Aquastat operation checked	DDC set point by ot	OK
Aquastat set-point	118°F	OK
Sight Glass	Clear	OK
Noise Level	Normal	OK
Vibration Level	Normal	OK

We certify that the above unit has been started and run in both heating mode and that the resulting pressures, temperatures, voltages and current draws are within the standard operating ranges for the equipment described above.

Signature _____ for Dealer/ Manufacturer Date _____

Boreal

Installation Start-Up Record

Owners Name:			Dealer's Name:	
Address:			Address:	
Telephone:			Telephone:	
Fax:			Fax:	
Contact:			Contact:	

Equipment Identification

Model	Serial No	Refrigerant	Voltage	Ground Loop Fluid	Floor Loop Fluid

Start-up Data	Heating Mode	
Building Ambient		
Suction Pressure (start) psig.		
Suction Pressure @ 1 hr psig.		
Suction Pressure @ 2 hr psig.		
Loop Entering Fluid Temp		
Loop Leaving Fluid Temp		
Loop Delta T (Leaving—Entering)		
Fluid flow		
Discharge Pressure (start) psig.		
Discharge Pressure @ 1 hr Bldg. Entering -Leaving Water Temp		
Discharge Pressure @ 2 hr Bldg. Entering-Leaving Water Temp		
Bldg Loop Delta T		
Bldg. Loop Fluid flow		
Voltage / Amps @ 2 hrs.—60 HZ		
Voltage at Aux. Circulators		
Aquastat operation checked		
Aquastat set-point		
Sight Glass		
Noise Level		
Vibration Level		

Start-up Data	Cooling Mode	
Building Ambient		
Suction Pressure (start) psig.		
Suction Pressure @ 1 hr psig.		
Suction Pressure @ 2 hr psig.		
Entering Loop Fluid Temp		
Leaving Loop Fluid Temp		
Loop Delta T (Leaving—Entering)		
Fluid flow		
Discharge Pressure (start) psig.		
Discharge Pressure @ 1 hr Entering / Leaving Water Temp		
Discharge Pressure @ 2 hr Entering / Leaving Water Temp		
Delta T (Leaving—Entering)		
Fluid flow (estimated)		
Voltage / Amps @ 2 hrs.—60 HZ		
Voltage at Aux. Circulators		
Aquastat operation checked		
Aquastat set-point		
Sight Glass		
Noise Level		
Vibration Level		

We certify that the above unit has been started and run in both heating mode and that the resulting pressures, temperatures, voltages and current draws are within the standard operating ranges for the equipment described above.

Signature _____ for Dealer/ Manufacturer Date _____

Maintenance

Routine maintenance of any liquid-to-water heat pump is generally of a very limited nature, since there are no moving parts inside the unit.

Once per year a general inspection of the unit should include the following areas.

ELECTRICAL

- Remove the electrical box cover and inspect all electrical wiring for any signs of degradation from loose connection etc.
- If the unit is located within a high humidity area make sure all terminals are tight and show no signs of overheating possibly caused by a loose or oxidized connection.
- Manually check out the settings of the compressor phase protection modules as per the instructions at the end of this section.
- Check for operation of the compressor status indicator lights and fault lights.
- Check the points of the two main compressor contactors for excessive wear. There will normally be some black soot around these contacts however the silver contacts should be of a consistent uniform nature with no excessive pitting.
-

REFRIGERANT CIRCUIT

- If there are no refrigeration gauges built into the unit then attach a standard manifold gauge set to the access ports on the unit while the unit is cycled OFF.
- Start up the unit and observe the suction and discharge pressures as the unit cycles the first and second compressors.
- Compare the values observed with those recorded at time of original commissioning. Record the new values with date etc.
- Visually inspect any exposed piping, refrigerant controls etc. for any signs of a refrigerant leak.
- Check the refrigerant sight glass for a full glass.
- Make sure access cap "O" rings are in good shape. Apply a drop of oil to the "O" ring before reinstalling the cap. Tighten sufficiently to prevent refrigerant leak.
-

WATER CIRCUIT

- Check both the evaporator and condenser sides of the system for the proper ΔT between inlet and outlet. Reference the original commissioning certificate for values.
- Visually check both outside and inside the unit for any signs of water leaks or corrosion from sweating etc.

SPECIFICATIONS

Input
- **Voltage:** Universal, 190-630 VAC
- **Frequency:** 50/60 Hz
- Load side monitoring optional

Output
- **Type:** Relay, SPDT
- **Voltage Range:** 240VAC @ 10A maximum
- **Frequency:** 50/60 Hz

Control OperatingTemperature
- **Operating Temperature:** -40º to +75ºC (-40º to +167ºF)
- **Storage Temperature:** -40º to +80ºC (-40º to +185ºF)

LCD Operating Temperature
- **Operating Temperature:** -20º to +75ºC (-4º to +167ºF)

Mechanical
- **Mounting:** Surface mount using (2) #8 screws
- **Terminations:** screw terminals
- **Weight:** 12 ounces (341 grams)

Dimensions
- 6 1/2" L, 4 1/4" W, 1 3/8" H
- 16.5 L, 10.8 W, 3.5 H (in cm.)

PARAMETERS

Phase Unbalance Protection
- **Voltage Unbalance:** 2-20% adjustable

Over/Under Voltage Protection
- **Over Voltage:** 2-25% adjustable
- **Under Voltage:** 2-25% adjustable

Phase Loss Protection
- **Phase Loss Condition** = 25% of nominal for any given phase; system will shut down and a fault will be recorded should this occur

Delay on Break Timer
- **Control Voltage:** 18-240 VAC
- **Time Delay:** 0-10 minute adjustable

Fault Interrogation Delay
- **Time Delay:** 0-15 second adjustable
- Provides a delay between fault detection and system shutdown - helps to eliminate nuisance trips or unnecessary shutdowns

CAUTION

Installation of the ICM450 shall be performed by trained technicians only. Adhere to all local and national electric codes.

Disconnect all power to the system before making any connections.

CONTROL INSTALLATION

Instructions

1. Using (2) #8 screws, mount the ICM450 in a cool, dry, easily accessible location in the control panel.
2. Connect voltage as shown in Figure 1 (below). Leave existing line and load side connections on the contactor intact.
3. Load side monitoring is optional (unit may be used to monitor line side only). Wire the contactor and optional control voltage monitoring as in Figures 2 and 3 (below).

   NOTE: Load/line wire must be rated for 3 phase voltage rating, 20ga minimum.
4. Upon application of power, the ICM450 will be on line and will begin to monitor the system.

Figure 1

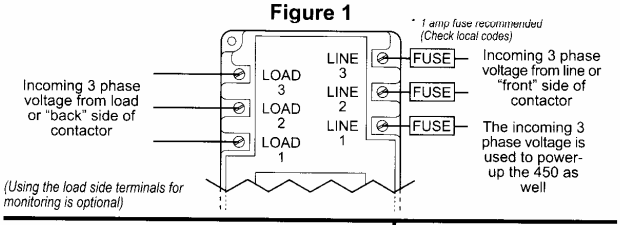


Figure 2

- Terminals 1 and 3 are the command signal input terminals
- With "Control Mode" set to "ON," there must be a voltage present on terminals 1 and 3 for the relay output terminals 4 and 6 to close; this voltage can be supplied from a thermostat, pressure switch, etc.
- "Control Mode" is turned ON or OFF in setup
- When the voltage on these terminals is re-applied, the unit will not re-energize until the delay on break (0-10 minutes) time has elapsed
- Use of terminals 1 and 3 is optional; they will be ignored if the "Control Mode" is set to "OFF"

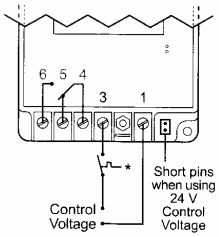
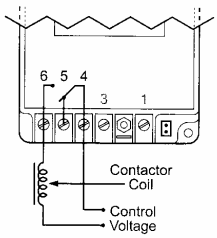
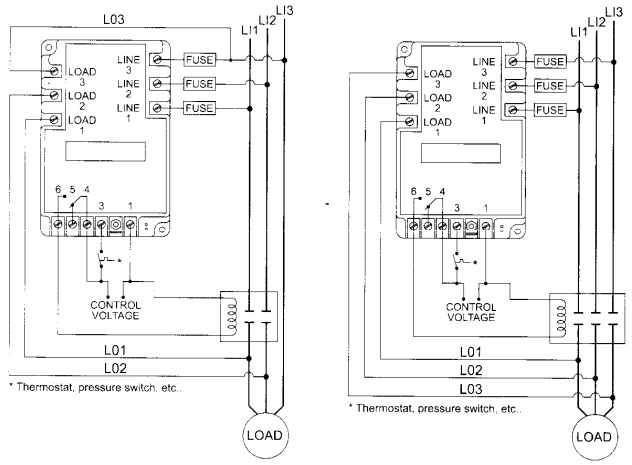


Figure 3

- Terminals 4 and 6 are "dry," normally open contacts
- Terminals 4 and 6 are closed when power is within specification
- Terminals 4 and 6 open when there is a fault condition or loss of control signal



ICM450 Ladder Diagram



Setting the Parameters

1. Press the green SETUP button to enter Setup mode.
2. Use the ⇧ UP and ⇩ DOWN arrows to change user parameters.
3. Scroll through setup by pressing and releasing the SETUP button.
4. When the last parameter has been set, the phase average will be displayed and the Setup LED will automatically turn OFF.

BUTTON FUNCTIONS

▲ ▼	SETUP	READ	FAULT
Press arrows to scroll through and select user parameter settings in Setup mode. HOLD down for fast edit.	Press to enter Setup mode and select user parameters.	Hold for voltage display a→b, b→c, a→c (simultaneously)	Press to read faults. Hold for 5 seconds to clear faults and reset memory.

PARAMETERS

Parameter	Description	Range	Default	Recommended
Line Voltage	Average phase to phase line voltage	190-630	208	Nameplate Voltage
Delay On Break	Amount of time between the load de-energizing and re-energizing	0-10 minutes	.1 minute	4 minutes **
Fault Interrogation	Amount of time before the load de-energizes due to a non-critical fault*	0-15 seconds	15 seconds	7-8 seconds **
% Over/Under Voltage	Maximum/minimum phase to phase average voltage, respectively	2-25%	20%	12-15% **
% Phase Unbalance	Amount of allowable voltage unbalance	2-20%	20%	4-5% **
Reset Mode	AUTO or number of times the load can be reenergized after a load side fault before a manual reset is necessary (**Note:** *When monitoring line side only, the reset mode will always be AUTO*)	AUTO, 0-10	AUTO	AUTO
Control Mode	With control mode set to OFF, the load will energize if no 3 phase fault conditions exist; with control mode ON, the load will energize if no fault conditions exist ***and*** control voltage is present at terminals 1 and 3 of the ICM450	ON or OFF	ON	Based on wiring

* Non-critical faults are faults such as *High/Low Voltage* and *Phase Unbalance*. Critical faults, such as *Phase Loss* and *Phase Reversal*, have a fault interrogation of under 2 seconds and it is ***not*** user adjustable.

** For best recommendations, consult manufacturer of equipment.

FAULT CONDITIONS

Press and release fault button to scroll through all saved faults.

NOTE: ***For initial setup, press and hold [FAULT] for 5 seconds to remove any previously stored faults.***

Fault	Problem	Corrective Action
Back Phase Loss	Not all three of the phases on the load side are present	1. Re-energize the contactor. 2. If the fault reappears after the load energizes: a. Turn all power OFF b. Check all load side connections c. Check the contacts of the contactor for debris or excess carbon
Back Phase Rev	Loads 1, 2, or 3 are not in sequence (not 120° phase shifted)	1. Turn all power OFF. 2. Swap any **2** phases on the load side of the unit only (example: swap load 1 and load 2) * 3. Re-apply power.
Back Phase Unbal	A voltage unbalance between the three load phases exceeds the unbalance setpoint	1. Press the [READ] button to observe the present load voltages. Check system for unbalance cause. 2. Increase the fault interrogation time if necessary. 3. Increase the percent unbalance setting if necessary.
Front Over Volt	Average phase-phase voltage exceeds the maximum percentage	1. Check system for over-voltage cause. 2. Increase the *percent* over-voltage setting if necessary. 3. Increase the fault interrogation time if necessary.
Front Phase Loss	Not all three of the phases on the line side are present.	1. Press and hold the [READ] button on the phase monitor or use an AC voltmeter to carefully measure all three phase-phase line voltages. (example: Line 1→Line 2, Line 2→Line 3, Line 3→Line 1) 2. Repair the missing phase.
Front Phase Rev	Lines 1, 2 or 3 are not in sequence (not 120° phase shifted)	1. Turn all power OFF. 2. Swap any 2 phases on the line side of the unit. For example: swap load 1 and load 2*. 3. Re-apply power.
Front Phase Unbal	A voltage unbalance between the three line phases exceeds the unbalance setpoint	1. Press the [READ] button to observe the present load voltages. Check system for unbalance cause. 2. Increase the fault interrogation time if necessary. 3. Increase the percent unbalance setting if necessary.
Front Under Volt	Average phase-phase voltage is below the minimum percentage	1. Check system for under-voltage cause. 2. Increase the *percent* under-voltage setting if necessary. 3. Increase the fault interrogation time if necessary.

* **Only** swap phases during initial setup, ***not*** after unit has been in operation without errors.

TROUBLESHOOTING

Symptom	LCD Readout	LED Status	Corrective Action
Load will not energize	Phase Avg.	All LEDs Off	Confirm that the control input is properly connected
Load will not energize	Phase Avg.	Load LED Off, Fault LED blinking	Press [FAULT] to observe the current fault; correct the condition of the first fault that appears (see Fault Conditions, Page 6 for a list of corrective actions)
Fault LED blinks repeatedly while load is energized	Phase Avg.	Fault LED Blinking, Load LED On	Indicates there are faults saved in the memory, press [FAULT] rapidly to scroll through saved faults; to clear the faults, press and hold [FAULT] for more than 5 seconds
Load will not de-energize when control voltage is OFF	Phase Avg.	Load LED On, Control LED Off	The control mode setting is OFF; press [SETUP] to get to the control mode. Press [▲] to set the control mode ON
Setup LED is on while load is being energized	*Anything Other Than Phase Avg.*	Setup LED On, Load LED On	To exit the setup mode, press either [READ] or [FAULT]
Load will not energize	Reset	Fault LED Blinking	Unit in lockout; maximum number of retries in manual reset mode has been reached; to reset unit, press [FAULT] and hold for more than 5 seconds
Load turns ON and OFF repeatedly	*Readout is Irrelevant*	Fault LED Blinking	Fix load side fault; press [FAULT] to observe condition; the delay on break period may be too short; press [SETUP] to enter the delay on break mode; press [▲] to lengthen the delay

LIMITED WARRANTY

MANUFACTURER warrants that the heat pumps manufactured by it shall be free from defects in materials and workmanship for a period of (1) ONE YEAR after the date of installation or for a period of (1) ONE YEAR AND (60) SIXTY DAYS after the date of shipment, whichever occurs first. In addition MANUFACTURER warrants that the compressor shall be free of defects in materials and workmanship for an additional period of (48) FORTY-EIGHT MONTHS from said date.

MANUFACTURER shall, at it's option repair or replace any part or parts covered by this warranty which shall be returned to BOREAL GEOTHERMAL INC., transportation charges prepaid, which, upon examination proves to be defective in materials or workmanship. Replacement or repaired parts and components are warranted only for the remaining portion of the original warranty period.

This warranty is subject to the following conditions:

1. The BOREAL® heat pump must be properly installed and maintained in accordance with Boreal Geothermal Inc.'s installation and maintenance instruct ions.

2. The installer must complete the "**Installation Data Sheet**", have it endorsed by the owner and return it to MANUFACTURER within 21 days after the installation of the unit.

3. It is the responsibility of the building or general contractor to supply temporary heat to the structure prior to occupancy. These heat pumps are designed to provide heat only to the completely finished and insulated structure. Start-up of the unit shall not be scheduled prior to completion of construction and final duct installation for validation of this warranty.

If the heat pump, manufactured by MANUFACTURER fails to conform to this warranty, MANUFACTURER 's sole and exclusive liability shall be, at it's option, to repair or replace any part or component which is returned by the customer during the applicable warranty period set forth above, provided that (1) MANUFACTURER is promptly notified in writing upon discovery by the customer that such part or component fails to conform to this warranty. (2) The customer returns such part or component to BOREAL GEOTHERMAL INC., transportation charges prepaid, within (30) thirty days of failure, and (3) Manufacturer's examination of such component shall disclose to it's satisfaction that such part or component fails to meet this warranty and the alleged defects were not caused by accident, misuse, neglect, alteration, improper installation, repair or improper testing.