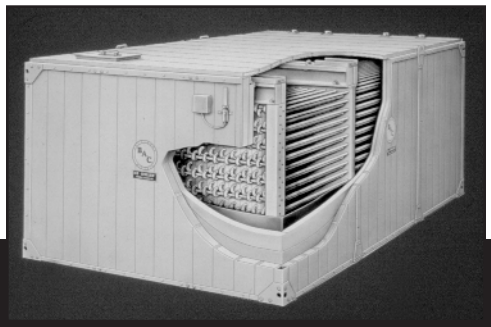
ICE CHILLER®
Thermal Storage Unit



Ice Inventory Sensor Operation, & Maintenance Instructions

INTRODUCTION

Baltimore Aircoil Company's ICE CHILLER® Thermal Storage Units can be furnished with an optional, factory installed ice inventory sensor designed to produce either a 4-20 ma or 1-5Vdc output signal that is directly proportional to the amount of ice in storage. The output signal may be used to provide information to an Energy Management System or to an analog input card. This bulletin presents the procedures, precautions, and safeguards for connecting, calibrating, operating and maintaining these ice inventory sensors. ***Please read this manual carefully before attempting to operate this control.*** All work should follow sound engineering practices and comply with federal, state, and local codes regarding mechanical, electrical, and electronic equipment. If additional information is needed about installing, operating or maintaining this equipment, please contact the local BAC Representative whose name and telephone number are on a label at the connection end of the unit.

TABLE OF CONTENTS:

CAUTION

- This controller is an extremely sensitive pressure transducer. Do not apply pressure to the sensing port(s) as this will cause extensive damage.
- Input voltage greater than 32 Vdc will damage the transducer necessitating replacement.
- Reversal of input and output will damage the transducer necessitating replacement.

NOTICE - Operation, maintenance and repair of this equipment should be undertaken only by qualified personnel. Proper care, procedures and tools must be used in handling, lifting, installing, operating, maintaining, and repairing this equipment to prevent personal injury and/or property damage.

SAFETY - Adequate precautions, appropriate for the installation and location of this product, should be taken to safeguard the public from possible injury and the premises from damage.

WARRANTIES - Please refer to the Limitation of Warranties applicable to and in effect at the time of sale/purchase of this product.

Baltimore Aircoil
Bulletin # M156/1-OAA

GENERAL:

The optional ice inventory sensor supplied with BAC Thermal Storage Units is a differential pressure transducer that senses the difference in water level in the tank, which varies directly with the amount of ice contained in the Thermal Storage Unit, and converts it to an analog signal. The sensor may be ordered to provide either a 4 - 20 ma output signal or a 1 - 5 Vdc output.

THEORY:

The basis of the ice inventory sensor operation is the fact that ice has a lower density (higher specific volume) than water. As the water in the storage tank turns to ice, the resultant increase in volume forces the water level in the tank to rise.

The ice inventory sensor is a very sensitive differential pressure transducer that senses the change in pressure as the water depth in the tank increases. The change in depth is only on the order of 4 to 5 inches.

The principle of operation is simple. When there is no ice in the tank, the water level is set to the "0% Percent Ice Build Level" as indicated in the Sight Tube *(see Figure 5)*. As the water level rises during the ice build cycle, the transducer senses the increase in pressure and converts that to either a 4 - 20 ma or 1 -5 Vdc output signal which is directly proportional to the amount of ice stored.

As the Thermal Storage Unit cycles through build and discharge modes, the water level varies in direct proportion to the amount of ice in the tank. The ice inventory sensor output signal changes accordingly.

ELECTRICAL:

The electronics of the ice inventory sensor are housed in a NEMA 4 enclosure (*See Figure 1)*. Diagrams of the sensor, power supply, and field wiring connections are shown in Figure 2 for the 4 - 20 ma output model and Figure 3 for the 1 -5 Vdc output model.

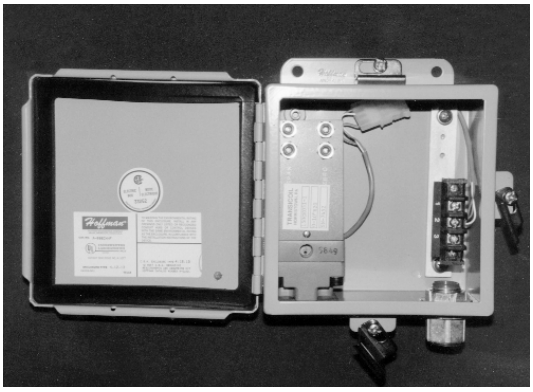


Figure 1.
Ice Inventory Sensor in NEMA 4 Enclosure

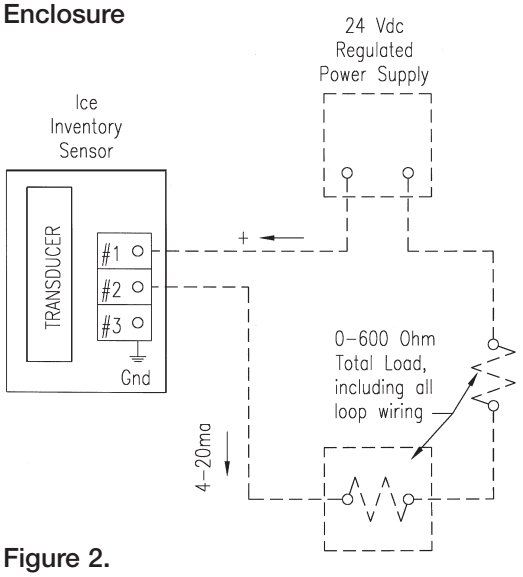


Figure 2.
Wiring for Two-Wire 4 - 20 ma Option

The Two-Wire, 4 - 20 ma Option:

The Two-Wire, 4 - 20 ma sensor is designed to operate on a **REGULATED** supply of 24 Vdc into a total loop resistance, external to the sensor, not to exceed 600 ohms. BAC recommends a shielded, two-wire cable be used with the ground connected to the junction box (Terminal #3). Refer to the wiring diagram in *Figure 2*

Table 1 provides the resistances of commonly used wire sizes:

Wire Size	Resistance/1000 ft
# 14 AWG	2.53 Ohms
# 16 AWG	4.02 Ohms
# 18 AWG	6.39 Ohms
# 20 AWG	10.15 Ohms

The 5 - Wire, 1 - 5 Vdc Option:

The Five-Wire, 1 - 5 Vdc sensor is designed to operate on a **REGULATED** supply of 24 Vdc (5 ma max). BAC recommends a shielded five-wire cable be used with the ground connected to the NEMA 4 enclosure (Terminal GND). The five wires are a positive and a negative input, a positive and a negative output, and the ground. To insure a clean output signal, **DO NOT CONNECT THE GROUND OF THE INPUT TO THE GROUND OF THE OUTPUT.** Refer to the wiring diagram in *Figure 3*.

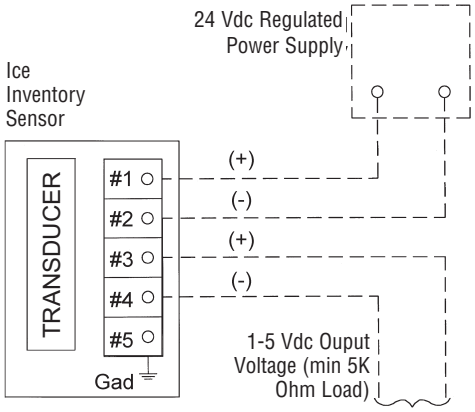


Figure 3. Wiring for 5 - Wire, 1 - 5 Vdc Option

SET-UP:

The sensor has been factory adjusted to provide a base signal of about 7.2 ma (1.8 Vdc) at 0% ice build and 15.2 ma (3.8 Vdc) at 100% ice build. Before placing the Thermal Storage System in operation, verify the building Energy Management System or inventory read-out device is properly correlated to these outputs, using the following procedure:

1. Open the bleed port (Figure 6) by turning the screw counterclockwise until a substantial flow is established. **Note: Do not remove the screw completely.** Allow the flow of water to continue until all the air is purged from the interconnecting tubing.

2. After the lines have been purged, close the bleed port screw and disconnect the tubing from the Sight Tube using the Quick Disconnect provided (See Figure 4). Also remove the Dust Cap from the Operating Control Assembly.

3. Add or remove water from the Control Assembly until the level is **exactly** at the 0% Ice Build Level. Open the bleed port to remove water if necessary *(Figure 6).*

4. Verify that the controller/read-out device (by others) displays 0% ice build, 7.2 ma (1.8 Vdc). Adjust the controller as necessary to obtain this reading.

5. Add water to the Sight Tube until the level is **exactly** at the 100% Ice Build Level.

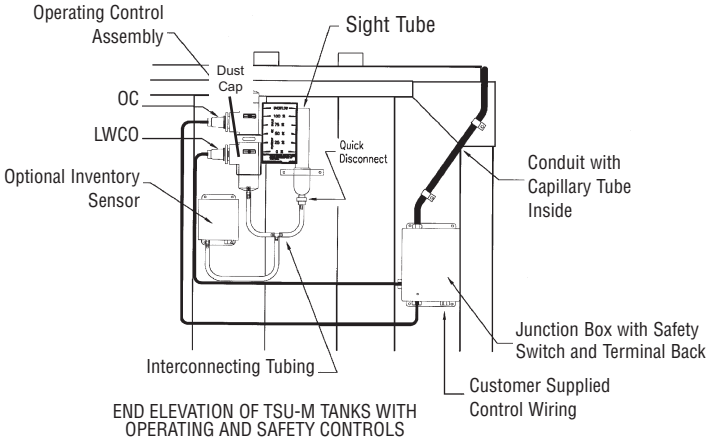


Figure 4. Detail of Operating Control Assembly and Sight Tube

6. Verify that the controller/read-out device displays 100% ice build, 15.2 ma (3.8 Vdc). Adjust the controller as necessary to obtain this reading.

7. Reconnect the tubing.

8. Open the bleed port to purge air that entered the tubing and sensor during the check-out procedure.

Note, if desired, the actual output signals can be read using a multi-meter installed between the power source and Terminal #1 of the Sensor Terminal Strip to measure milli-amp output or across Terminals #3 and #4 of the Sensor Terminal Strip to measure output dc voltage.

RE-CALIBRATION:

The ice inventory sensor furnished with the Thermal Storage Unit has been calibrated at the factory, prior to shipment. To check the calibration, the following procedure should be followed.

When checking the calibration of the ice inventory sensor, the following tools should be on hand:

* small flat blade screwdriver (eyeglass size)
* regular size flat blade screwdriver
* multi-meter (including DC ma and DC voltage scales)
* alligator clips with wires
* a container with a pouring spout.

The ice inventory sensor is set to produce the full signal range (4- 20 ma or 1 - 5 Vdc) over a 10" change in water level, even though the actual control range from 0% to 100% ice build spans only about 5". This is to provide some additional, readable scale above and below the normal operating range that can be used to signal a low or high water level in the tank. **Note: Contact the local BAC Representative to verify the actual water displacement**. To re-calibrate the sensor:

1. Locate the Sight Tube *(See Figure 4)* and the 0% Ice Build Level on the gauge *(See Figure 5).*

2. From the 0% Ice Build Level, measure down exactly two inches (2.0"). This is the "Base" and will provide a 4 ma (1 Vdc) output signal.

3. From the "Base", measure upward exactly ten inches (10.0"). The ouput signal at this level will be 20 ma (5 Vdc).

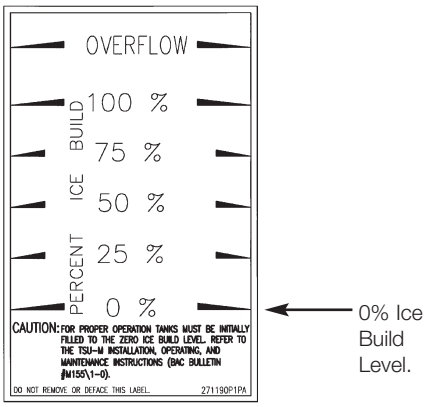


Figure 5. Ice Build Gauge

4. Turn off the 24 Vdc regulated power supply to the sensor and install the multi-meter.

   a. For sensors with a milli-amp output signal, disconnect the positive power lead from Terminal #1 and connect it to the positive lead of the meter. Then connect the negative lead of the milli-amp meter to Terminal #1 on the sensor terminal strip.

   b. For sensors with a Vdc output signal, connect the leads of the voltmeter across Terminals #3 and #4 of the terminal strip.

Restore the 24 Vdc regulated power supply.

5. Purge the sensor to remove any air by turning the bleed port screw on the underside of the sensor counterclockwise (Figure 6) until water begins to flow from the sensor. **Caution Do not remove the screw.**

Purge the sensor until all the air is removed and retighten the bleed port screw.

6. Isolate the Operating Control Assembly and ice inventory sensor from the tank by disconnecting the tubing from the Sight Tube using the Quick Disconnect on the bottom of the Sight Tube (Figure 4).

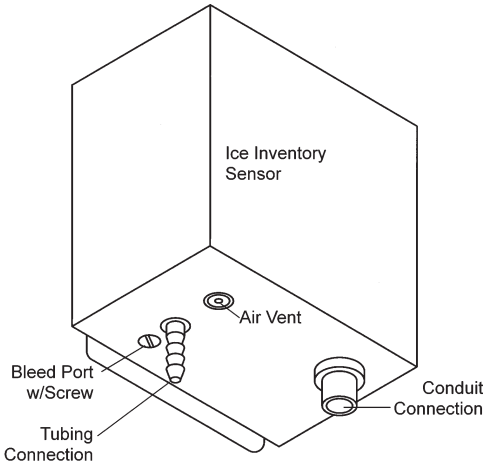


Figure 6. Underside of Sensor

7. Remove the hold down strap on the Operating Control Assembly and lower the assembly until the water level in the tube exactly matches the "Base" level located in Step 2. The meter should read 4 ma, ±0.2 ma (1 Vdc, ±0.05). If not, adjust the Coarse **ZERO** screw (not the **SPAN**) until the desired reading is obtained *(See Figure 7).*

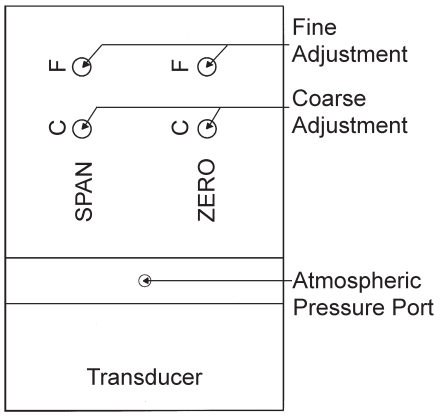


Figure 7. Points of Adjustment

8. Move the Operating Control Assembly upward until the water level exactly matches the 10.0" level located in Step 3. The meter should read 20 ma ±0.4 ma (5 Vdc ±0.1). If not, adjust the Coarse **SPAN** screw until the desired reading is obtained.

9. To verify the calibration, lower the Operating Control Assembly back to the "Base" level as in Step 7. The meter should read 4.0 ma ±0.2 ma (1 Vdc ±0.05). If not, adjust the Fine **ZERO** screw (not the **SPAN**) until the meter reads 4.0 ma (1 Vdc).

10. Raise the Operating Control Assembly until the water level **exactly** matches the 0% Ice Build Level. The meter should read 7.2 ma, ±0.2 ma (1.8 Vdc, ±0.05). If not, return to Step 7 and repeat the calibration procedure.

11. Raise the Control Assembly until the water level exactly matches the 100% Ice Build Level. The meter should read 15.2 ma ±0.2 ma (3.8 Vdc ±0.05). If not, return to Step 7 and repeat the calibration procedure.

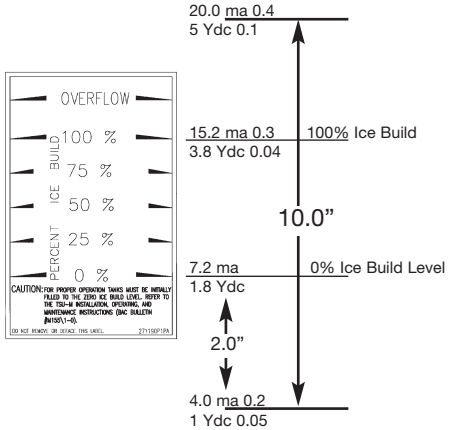


Figure 8. Calibration Markings

12. Reposition the Operating Control Assembly and replace the hold down strap.

13. Reconnect the tubing to the Sight Tube and replace the Dust Cap on the Operating Control Assembly.

14. Open the bleed port screw and purge the tubing and sensor of any air that entered during the calibration procedure.

15. Turn off the power supply and disconnect the multi-meter. Then, restore the power.

MAINTENANCE:

The ice inventory sensors are virtually maintenance-free. To ensure long service life, accuracy, and reliability, the following preventive maintenance procedures should be performed every three months during the operating season or if the output readings appear to be erratic.

1. Visually inspect the interconnecting tubing for any signs of air, blockages or restrictions due to biological growth or sediment accumulation. Clean or replace as necessary.

2. With the interconnecting tubing clear of biologicals and sediment, purge the ice inventory sensor(s) by turning the bleed port screw on the underside of the ice inventory sensor *(Figure 6)* counterclockwise until water begins to flow from the port. Bleed the water until all air is purged and then retighten the screw to stop the flow. It may help to tap the tubing to help remove air bubbles.

3. Visually inspect the ice inventory sensor(s) for damage, corrosion, or other problems. Refinish or replace any corroded parts. Identify and correct the cause of corrosion by checking nearby piping and pipe joints for leakage.

4. Compare the % ice build indicated by the ice inventory sensor with the level in the Sight Tube. If the two do not agree --

   a. Repeat the Set-Up procedure described on page 3, using a multi-meter to read the actual output signals. If the readings do not agree with the values in Figure 8, recalibrate the ice inventory sensor.

   b. If the output of the ice inventory sensor agrees with the values in Figure 8, the Energy Management System or read-out device needs to be adjusted.

5. If the Thermal Storage Unit will be exposed to sub-freezing ambient temperatures, the ice inventory sensor, Operating Control Assembly and Sight Tube must be protected from freezing. If this is not the case, contact your BAC Representative to order an enclosure and 100W heater to protect these controls from freezing. When the enclosure is in place, check the thermostat and heater assembly (*See Figure 9* in the Operation and Maintenance Manual for the Thermal Storage Unit) to ensure they are operative and maintaining an above freezing temperature within the controls enclosure.

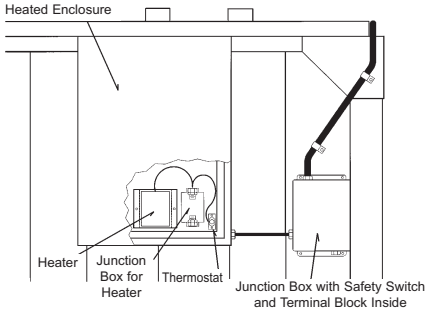


Figure 9. Heated Enclosure

FACTORY AUTHORIZED PARTS:

Baltimore Aircoil maintains a stock of replacement parts at each of its manufacturing facilities. To order factory authorized parts, contact your local Baltimore Aircoil Company representative. Be sure to include the unit serial number when ordering any parts.

TROUBLESHOOTING CHART

PROBLEM	POSSIBLE CAUSE	SUGGESTED SOLUTION
Output Signal exceeds 20 ma (5 Vdc).	Air trapped inside sensor or sensor tubing	Open the bleed port screw (Figure 6) and purge air from the sensor and sensor tubing. It may help to tap the sensor tubing during this process to help remove any air bubbles. ALWAYS DO THIS STEP FIRST BEFORE PROCEEDING WITH THE OTHER POSSIBILITIES.
	Sensor tubing clogged.	Disconnect the tubing from the ice inventory sensor and purge the tubing only with clean water until clear. Reconnect the tubing and open bleed port screw (Figure 6) and purge air from both the sensor and sensor tubing. Caution -- DO NOT apply pressure to the ice inventory sensor as this can cause extensive transducer damage.
	Water level too high	Check the Sight Tube and confirm the water level indicated by the sensor. If confirmed, disconnect the tubing from the Sight Tube using the Quick Disconnect fitting. Open the bleed port screw and drain water from the Operating Control Assembly to a level appreciably below the 100% Ice Build Level. If the sensor still reads above 20 ma (5 Vdc), close the bleed port and adjust the **ZERO** (NOT SPAN) down until a value less than 20 ma (5 Vdc) is read. Then re-calibrate the sensor. Also, determine the cause for the excess water level in the Thermal Storage Unit and remedy. If the output signal of the ice inventory sensor does not agree with the level in the Sight Tube, recalibrate the sensor.
	Faulty Wiring.	***Isolate wiring, check resistance and continuity. Repair or replace if required and reconnect, ensuring all connections are tight.***
	Zero/Span incorrect.	Recalibrate the sensor (see page 4). If it does not hold calibration, replace the sensor.

TROUBLESHOOTING CHART CONTINUED

PROBLEM	POSSIBLE CAUSE	SUGGESTED SOLUTION
Output Signal remains below 3.8 ma (1 Vdc)	Air trapped inside sensor or sensor tubing.	Open the bleed port screw (Figure 6) and purge air from the sensor and sensor tubing. It may help to tap the sensor tubing during this process to help remove any air bubbles. ALWAYS DO THIS STEP FIRST BEFORE PROCEEDING WITH THE OTHER POSSIBILITIES.
	Water level too low	Disconnect the tubing from the Sight Tube using the Quick Disconnect fitting. Remove the Dust Cap from the Operating Control Assembly and add water to raise the level above the 0% Ice Build Level. If sensor still reads less than 3.8 ma (1 Vdc), adjust ZERO set point (NOT SPAN) until a value greater than 4 ma is read, then re-calibrate. Also, determine the cause for the low water level in the Thermal Storage Unit and remedy.
	Leak in sensor tubing	Correct the leak as even a small leak can affect the sensor reading.
	Sensor tubing clogged	Disconnect the tubing from the ice inventory sensor and purge ***the tubing only*** with clean water until clear. Reconnect the tubing and open the bleed port screw (Figure 6) and purge air from both the sensor and sensor tubing. Caution -- **DO NOT** apply pressure to the ice inventory sensor as this can cause extensive transducer damage.
No Output Signal	Blown fuse or bad power supply	Replace fuse or power supply. Use only a REGULATED 24 Vdc power supply.
	Faulty wiring.	Isolate the signal loop wiring and check resistance and continuity. Repair or replace wiring if required and reconnect, ensuring all connections are tight.
	Excessive resistance	Check the total resistance of the signal loop to ensure it does not exceed 600 ohms. Adjust as necessary.
	Defective sensor.	If input voltage and signal loop resistance are correct, replace sensor.

TROUBLESHOOTING CHART CONTINUED

PROBLEM	POSSIBLE CAUSE	SUGGESTED SOLUTION
Current output will not reach 20 ma (5 Vdc)	Power supply is NON-REGULATED, defective, or too small,	Ensure the power supply is REGULATED 24 Vdc and working properly. Ensure there is a minimum of 12 Vdc **AT THE SENSOR TERMINALS** at all times. If unsure that the power supply is REGULATED, connect three, 9-volt batteries in series and substitute them for the existing power supply. Then, complete the Set-Up procedure on page 3. If the sensor operates properly, reinstall the power supply and check out the system. If the system does not function properly, replace the power supply.
	Excessive resistance	Check total loop resistance to ensure it does not exceed 600 ohms. Adjust if necessary.
	Faulty wiring	Isolate the signal loop wiring and check resistance and continuity. Repair or replace wiring if required and reconnect, ensuring all connections are
Slow or no response to level change	Plugged pressure snubber	Usually, the ice inventory sensor does not require any type of dampening or snubber control. If a snubber has been installed, remove it and re-check the ice inventory sensor response. If the response is satisfactory, do not reinstall the snubber.
	Sensor tubing clogged	Disconnect the tubing from the ice inventory sensor and purge ***the tubing only*** with clean water until clear. Reconnect the tubing and open the bleed port screw (Figure 6) and purge air from both the sensor and sensor tubing. Caution -- **DO NOT** apply pressure to the ice inventory sensor as this can cause extensive transducer damage.
	Control system not properly vented.	Check the Dust Cap on the Operating Control Assembly to ensure the vent holes are open and venting properly.
Output signal "bounces"	Water level bouncing	When the Thermal Storage Unit is installed outdoors, the water level may be affected by turbulent or gusty winds. In such cases, install a snubber (R-H part # P7002-3 for brass or part # P7003-3 for stainless steel). Note: Installing a snubber will slow the air bleed rate from the sensor line.

TROUBLESHOOTING CHART CONTINUED

PROBLEM	POSSIBLE CAUSE	SUGGESTED SOLUTION
	Wind affecting low pressure side	High winds may cause the low-pressure side (atmospheric pressure) to pulsate. Install a minimum of 12" tubing and one elbow to the low pressure port.
	Defective power supply	Check the power supply and replace as necessary. Always use a REGULATED 24 Vdc, supply.
	Faulty wiring	Isolate the signal loop wiring and check for shorts to ground and the total resistance. Use a MegOhm meter, as directed by the manufacturer, to determine if the wiring may be breaking down.
Water level reading is too high	Air trapped in sensor tubing	Open the bleed port screw (Figure 6) and purge air from the sensor and sensor tubing. It may help to tap the sensor tubing during this process to help remove any air bubbles. Then recheck the output reading. Also, verify the water level in the sight tube assembly matches the expected output reading. Re-calibrate if required.
	Too much water in tank	Melt out all of the ice and ENSURE THERE IS NO ICE left in the tank. Then, check the water level in the Sight Tube to confirm it corresponds to the 0% Ice Build Level". Drain water from the tank if required. If water was drained, determine the source of the excess water. If the water level is correct, too much ice had been built and the system controls need to be checked and adjusted to ensure the ice build cycle stops at the 100% Ice Build Level.
	Ice system is "over-built"	Melt out all of the ice and ENSURE THERE IS NO ICE in the tank. Check the level in the Sight Tube to see if it corresponds to the 0% Ice Build Level". Add or remove water from the Thermal Storage Unit as necessary to bring the level to the 0% Ice Build Level". Disconnect the tubing from the Sight Tube at the Quick Disconnect fitting and remove the Dust Cap from the Operating Control Assembly. Temporarily, place the system into the ice build mode and add water to the Operating Control Assembly until the level is slightly above 100% Ice Build Level. If the chiller does not stop running, check the control system operation.

TROUBLESHOOTING CHART CONTINUED

PROBLEM	POSSIBLE CAUSE	SUGGESTED SOLUTION
Drifting sensor	Air trapped in sensor or sensor tubing	Open the bleed port screw (Figure 6) and purge air from the sensor and sensor tubing. It may help to tap the sensor tubing during this process to help remove any air bubbles. Then recheck output reading. Also verify the water level in the Sight Tube matches the expected output reading. Re-calibrate if required.
	Zero or span drifting	Isolate the ice inventory sensor by disconnecting the tubing from the Sight Tube using the Quick Disconnect fitting. Repeat the Set-Up procedure described on page 3, using a multi-meter to check the output signal. Wait several days and repeat the procedure. If the sensor output signal has drifted, then replace the sensor.
	Low pressure side not open to atmosphere	Remove the plug from low pressure port.
No water comes out of bleed port	Water level too low	Check to ensure the water level in the Operating Control Assembly is at or above the 0% Ice Build Level. If not, there is insufficient head pressure to force water out of the bleed port.
	Clogged tubing	Clean or replace the interconnecting tubing and/or the Quick Disconnect Fitting, as required.
Current (voltage) output reaches some constant maximum level	Water level at overflow.	In this case, either the ice system is over-built or the initial water level was too high and the tank is overflowing. Follow the instructions above for "Ice System is over-built"
	Zero or span not correctly adjusted	Re-calibrate sensor