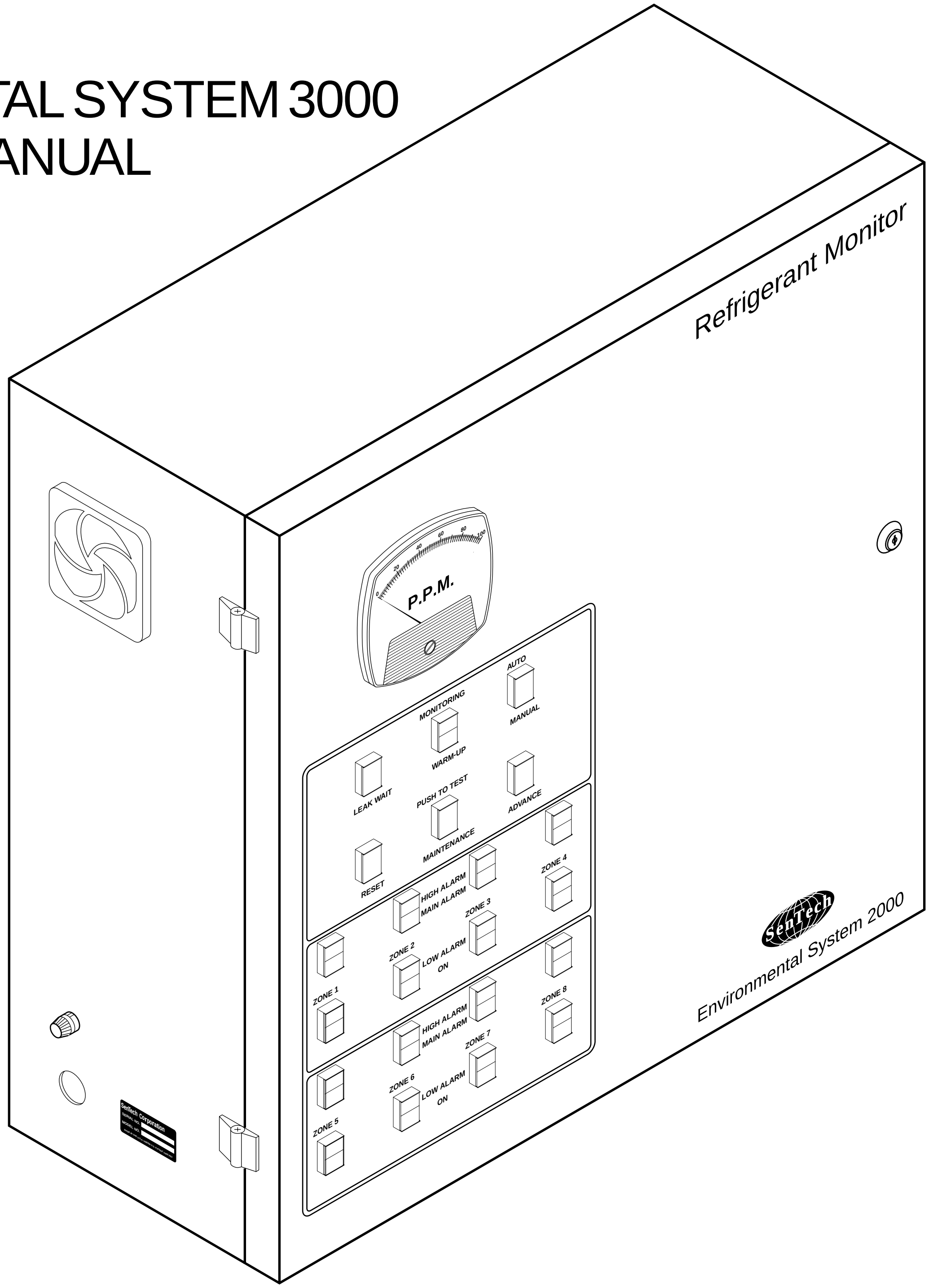
ENVIRONMENTAL SYSTEM 3000
OPERATION MANUAL



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PH: 317/248-1988
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Distributor Name: ____

Address: ____

Phone: ____

Date of Installation: ____

Model Number: ______________ Serial Number: ______________________

Installer/Service Technician: ______________________________

WARRANTY INFORMATION: Remove the Check Test Start (CTS) form from the pocket of this manual and fill it out in its entirety. Return the original (top) copy to SenTech by folding as instructed on the reverse of copy. Dealer/Distributor retain second copy and Owner/Operator retain third copy.

IMPORTANT

TO VALIDATE WARRANTY, THE CTS FORM MUST BE COMPLETED AND RETURNED TO THE FACTORY WITHIN 30 DAYS OF INSTALLATION.

Note: The Check Test Start function should be performed by a qualified individual.

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Model 3000 Specifications	
Weight:	250 lbs (110 kgs)
Power:	120 Volt, 60 Hz (300 Watt)
Temperature:	32°- 125° Fahrenheit (0°- 50° Centigrade)
Range:	0 - 100 P.P.M. Standard
Trip Point:	0 - 100% of FS
Zones:	Model 3003W - 1 to 3 water (jumper selectable) plus ambient air Model 3004WA - 1 to 4 water (jumper selectable) 1 to 3 air (jumper selectable) plus ambient air
Leak Wait:	Varies from seven (7) seconds to three (3) minutes depending on refrigerant concentration
Alarm Output:	Alarm Relay - Four (4) form C contacts rated 5 Amps maximum

I. PROCESS OVERVIEW

(1-1) Introduction

The SenTech Environmental System 3000 provides an early warning of refrigerant leaks into the condenser water of water-cooled chillers. The System 3000 periodically samples the condenser outlet water. Through a proprietary process, it extracts any refrigerant that may be present in the sample. It measures the concentration of the refrigerant and if it exceeds a preset trip point, the System 3000 reports an alarm condition to the user. By discovering the existence of a leak before the refrigerant loss has become great enough to be evident from a degradation in equipment performance, the potential loss is reduced, saving money and helping protect the environment. When the System 3000 is used in combination with SenTech's air monitoring system, the user is provided with a complete refrigerant loss control regime.

(1-2) Basic Concept

See the block diagram (Fig. 1) of the System 3000. Condenser outlet water from each chiller to be monitored is connected to the zone inlet ports. Water from the zone being checked is passed to the test chamber.

Any refrigerant present is extracted from the water and enters the air above the water in the chamber. The Test Valve is energized, and the sample pump draws the air into the sensor.

The sample air flows across a heating element in the sensor which ionizes any halogen molecules present. The ionized halogens cause a current to flow which is proportional to the amount of ions present. The microprocessor controlled sensor electronics measures the current and provides an output reading of the concentration in PPM (Parts Per Million). More critically, it compares the PPM level to a preset trip point. When the trip point is exceeded, the sensor electronics report an Alarm condition to the PLC (Programmable Logic Controller).

When the PLC receives an alarm signal, it enters Alarm Mode. In Alarm Mode, the alarm light for that zone starts to flash, the alarm relay is energized, and the sensor is deactivated to protect it from damage. The unit proceeds to the next zone and after a warm-up cycle continues to monitor the remaining zones. During the portions of the cycle when the system is not checking the test chamber, it is testing the background air.

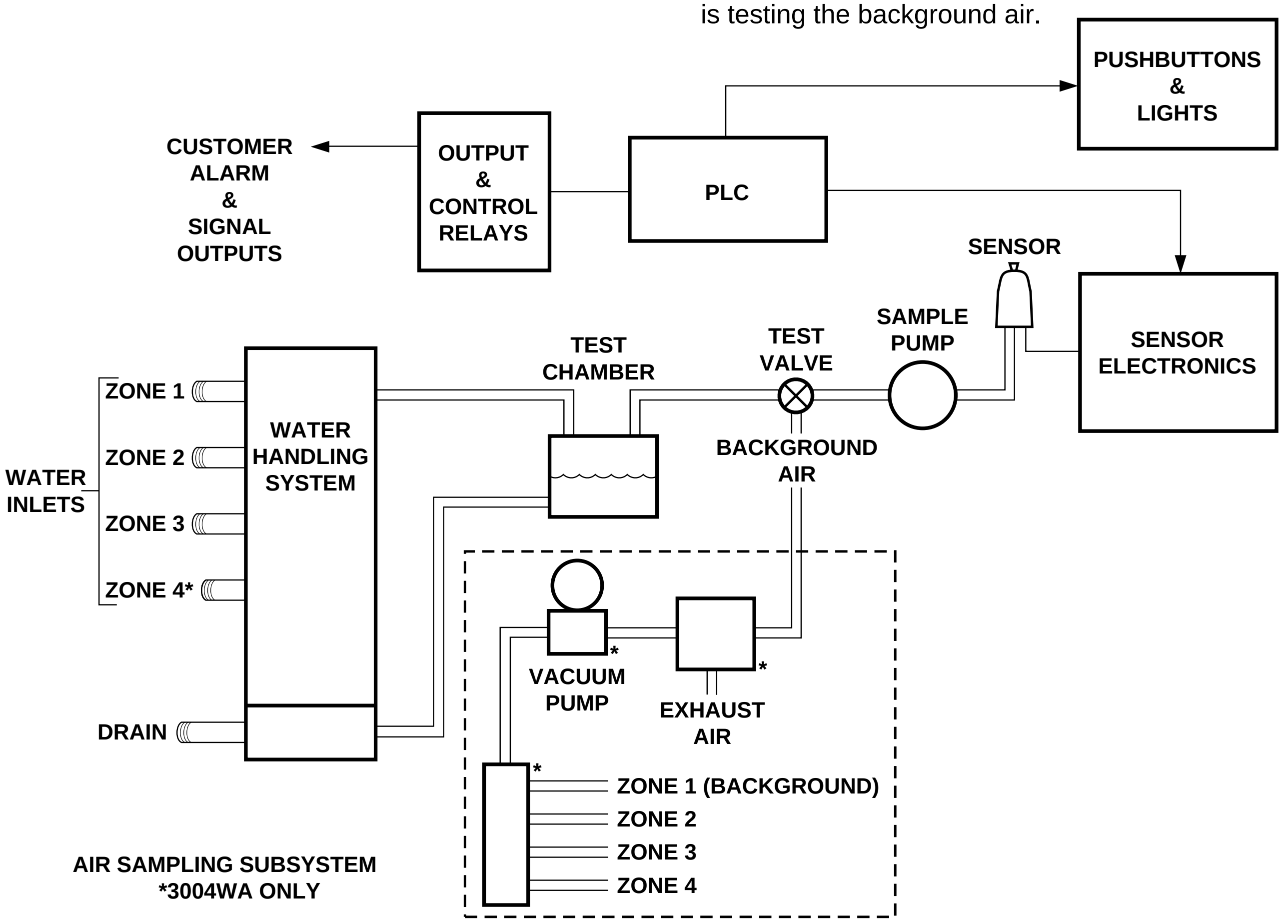


Fig. 1
Block Diagram

(1-3) Available Models

There are two models of the System 3000.

Model 3003W
The model 3003W can monitor 1 to 3 water-cooled condensers and the background air at the System 3000.

Model 3004WA
The model 3004WA can monitor 1 to 4 water-cooled condensers, the background air at the System 3000, and up to 3 additional remote air zones. Note that the asterisked items (Fig. 1) are available on the model 3004WA only.

(1-4) Water Test Cycle

There are 6 basic steps in the water test cycle.

1. **Standby**: The cycle starts in Standby Mode with the Test Chamber empty, the Zone and Fill valves deenergized, and the sensor system testing background air.

2. **Flush**: The flush cycle opens the selected Zone valve and the Fill valve. The Test Chamber is filled with water from the selected zone and then drained. This step flushes out the water in the piping left from the last test. The flush cycle discards approximately two gallons of water.

3. **Fill**: The next step is to fill the chamber to the test level with a fresh one gallon sample of water.

4. **Extraction**: The proprietary extraction process drives the refrigerant out of the water and into the air in the chamber.

5. **Test**: The inlet to the sensor system is switched from testing the background air to testing the air in the chamber, which now contains any refrigerant that was in the water. If the level of refrigerant in the chamber exceeds a preset trip point, it enters Alarm Mode.

6. **Drain**: When the test cycle is complete, the system drains the chamber and switches to Standby. The system then switches to the next selected zone and repeats the measurement. After all selected zones have been tested, the system starts a Cycle Repeat Timer. After the Cycle Repeat Timer has timed out, the system repeats the process of testing each of the selected zones. The Cycle Repeat Timer can be set by the user from continuous operation to multiple hours between tests.

(1-5) Air Test Cycle

The major functional difference between the Model 3003W and 3004WA is in the testing of air.

Model 3003W: As noted above, the system monitors background air whenever it is not checking the chamber. If an alarm condition should occur while testing background air, an alarm is reported to the user, the system stops testing the water zones, and the Maintenance light is lit.

Model 3004WA: The Model 3004WA distinguishes between background air which is air zone 1, and the remaining remote air zones. Clearly, if an alarm occurs in a remote air zone it is not necessary to stop testing the water zones. It is necessary to check background air prior to the Test portion of the water cycle.

In the model 3004WA the system continuously scans the selected air zones, spending one minute in each zone. When the water cycle has completed the first half of flush, the air system switches to air zone 1 which is allocated to background air. it remains in air zone 1 until the water cycle switches to Test. At that point, the air system goes back to scanning all the selected air zones.

If an alarm occurs in a remote air zone, the Alarm relay is energized and the zone in alarm is taken out of the sequence. Testing continues on the remaining selected air and water zones.

(1-6) System Sensitivity and Correlation to Actual Leak Rate

The Sensor System measures the concentration of refrigerant in Parts Per Million (PPM) volume of refrigerant to volume of air. There is not a direct relationship between the PPM reading and the actual leak rate in either the water zones or the air zone(s). For a detailed discussion of these relationships refer to the appendices. The case of refrigerant leaking into water is discussed in the appendix titled System 3000 Technical Process Considerations. For leaks into air, refer to the Appendix C, Room Size Considerations (pages 28 and 29 of this manual).

II. INSTALLATION

(2-1) Unpacking

Remove the remainder of the packing material.

Packed within the System 3000 console are the following items:

1. Instruction Manual
2. Schematic Wiring Diagram
3. The sensor container which is packed with desiccant to keep it moisture free during storage and shipment.
4. Four sets of nuts and bolts for mounting the control console to the frame.
5. The CTS/Warranty card which is to be completed and returned after start-up.
6. Model 3004WA only, coarse tube end filters.

(2-2) Initial Assembly

1. Remove this material and set aside.

2. Remove the top, left side (the side with the water inlet connection points) and front covers of the base unit.

3. Position the control console on the base unit and secure with the four sets of hardware.

4. Connect the two electrical sockets from the control console to the two plugs from the base unit. Note one set has 14 pins and the other set has 16 pins.

5. Feed the unattached plastic tube through a hole in the bottom of the control console, and connect it to the input filter.

6. Unpack the sensor and carefully insert the pin end of the sensor into the tubing that comes from the flowmeter. Insert the sensor into its socket. Make certain that the sensor is well seated and that the tubing is not kinked or restricted in any way.

(2-3) Location

The system should be in a central location relative to the chillers being tested and near a floor drain.

(2-4) Piping Between the Chiller(s) and the System 3000

The length and ID of the pipe between the condenser outlet and the system will determine how current the sample is. The Flush step of the water cycle discards 2 gallons (8 ltr) of water. Two gallons is approximately equal to the capacity of:

200 ft. (60 m) of 1/2 in. (12 mm) I.D. pipe

350 ft. (110 m) of 3/8 in. (10 mm) I.D. pipe

If the piping run has a capacity greater than two gallons, it will take more than one complete zone test cycle to detect a leak after it has started.

(2-5) Pressure

The pressure of the cooling water at the inlet to the System 3000 must be:

greater than 5 psi. (3 kpa)

less than 150 psi. (105 kpa)

If any of the pressures are outside this range, the user will have to install a pressure regulator for each chiller that has a condenser cooling water outlet pressure greater than 150 psi. (105 kpa), or a booster pump for any unit with an outlet pressure less than 5 psi. (3 kpa).

(2-6) Remote Air Zones (Model 3004WA only)

Each remote air zone inlet tube should be mounted where it is most likely to sense leaking refrigerant. The criteria to consider in selecting locations include:

As close to the area of potential leaks as possible. On the "downstream" side of the air flow pattern in the room.

Since refrigerants are typically heavier than air, lower is generally better than higher.

No tube run should be longer than 500 (150 m) feet.

(2-7) Piping Installation

Run piping from the condenser water outlet of each chiller to be tested to the System 3000. It may be convenient to terminate the piping at a column near the system 3000 and to use hose for the final connection to the water inlet fittings. If the water pressure at the inlet to the System 3000 is greater than 150 psi. (105 kpa), a regulator will have to be installed to reduce the pressure. Conversely, if the pressure is less than 5 psi. (3 kpa), a booster pump will have to be installed. If either a regulator or pump is required, it should have a capacity of at least two gallons (8 ltr) per minute. To simplify maintenance, it is recommended that shutoff valves be installed at the outlet of each condenser.

Before checking the piping for leaks, close the inlet flow control valves at the System 3000. Make certain that caps are installed on the inlets to any unused water zones.

Install a drain hose from the drain outlet of the System 3000 to a floor drain.

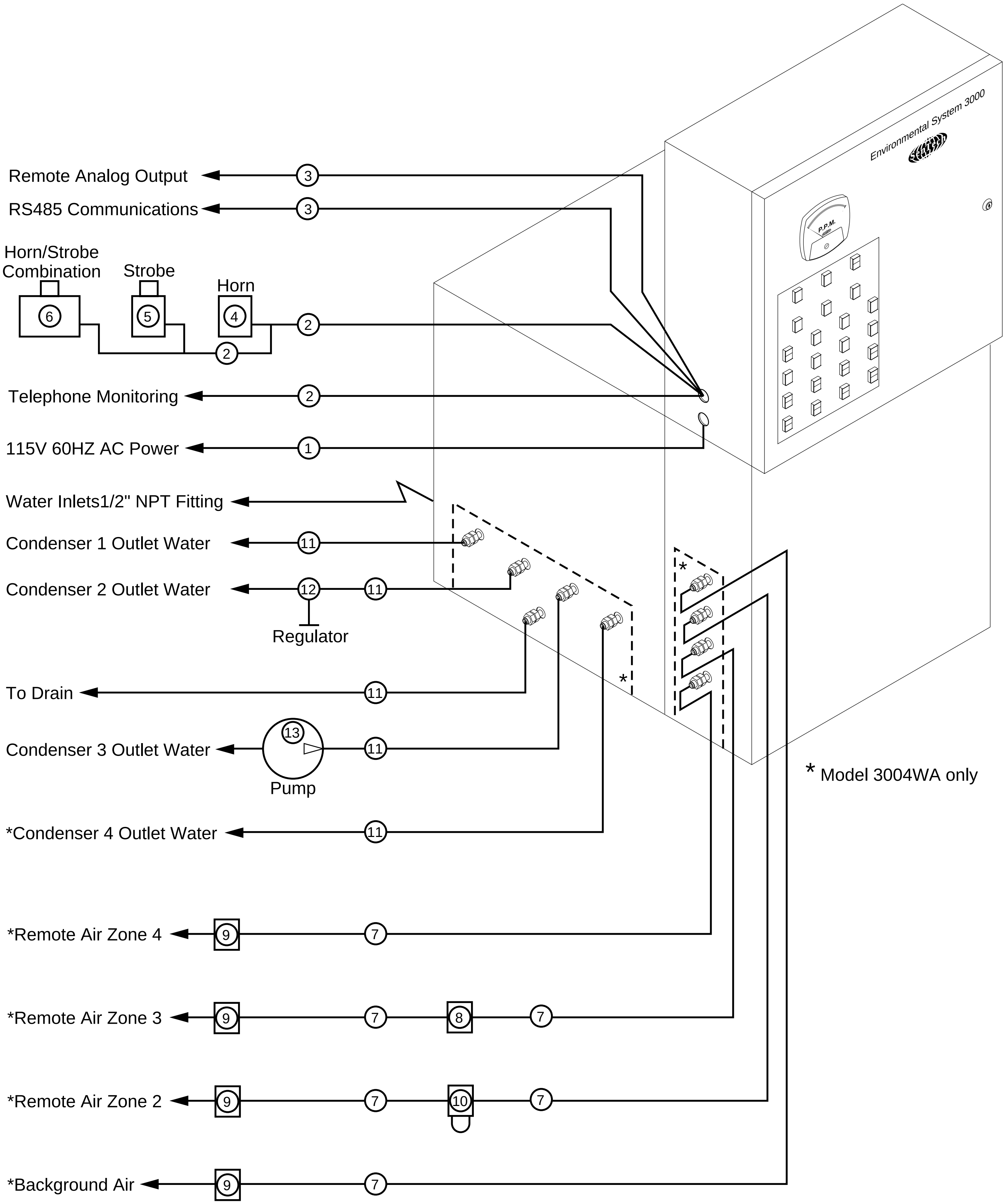
(2-8) Tubing Installation (Model 3004WA only)

CAUTION

MOISTURE CAN DAMAGE THE SENSOR. PICKUP POINTS MUST BE LOCATED AND PROTECTED WHERE NECESSARY TO PREVENT WATER FROM ENTERING THE SYSTEM.

Install 3/8 inch (10 mm) plastic tubing from each zone pickup point to the zone inlet fittings on the right hand side of the control unit. Start with zone 1 the top inlet fitting. Since zone 1 is for background air, use a short (one foot or 30 cm) length of tubing. Continue in sequence with the remainder of the selected remote air zones. Install the coarse filters at the pickup end of each tube. Mount the optional in-line filter/separator assemblies in series with the tubing for those zones that are particularly dirty and/or where there is any risk that water can enter the system. It is recommended that these units be mounted at a convenient point close to the pickup end of the tube run.

Installation Layout



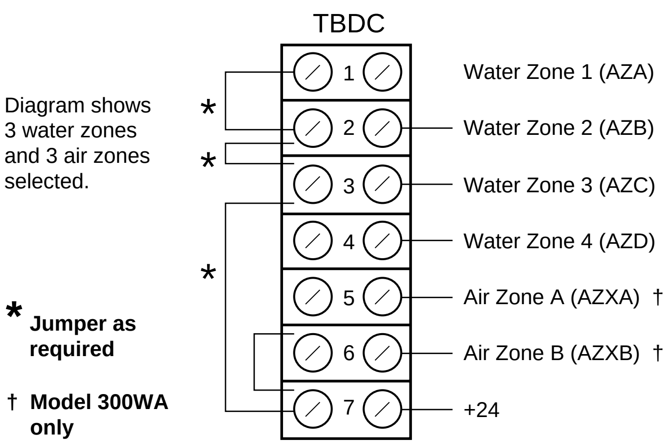
Installation Layout Chart

Item	Description	Required	Supplied with Unit	Supplied by Customer	Optional	Available from SenTech	Comments
1	16 Gauge, 3 Conductor Cable	yes	no	yes		no	
2	18 or 22 Gauge, 2 Conductor Cable	no			yes	no	Required for horn, strobe or combination
3	2 Conductor Twisted Pair Shielded Cable	no			yes	no	Required for remote analog output or RS485 communication
4	Horn	no			yes	yes	
5	Strobe Light	no			yes	yes	
6	Combination Horn and Strobe	no			yes	yes	
7	3/8" OD X 1/4" ID (10 mm OD X 7 mm ID) Plastic Tubing (recom-mend flame retardant, smoke resistant)	yes (3004WA only)	no			yes	Available in 500 foot (150 m) reels
8	3/8" (10 mm) Tube Union	no (3004WA only)			yes	yes	May be required to optimize tubing usage
9	Coarse Filter	yes (3004WA only)	yes				For mounting at the end of the tubing
10	In-line Filter/Separator Assembly	no (3004WA only)			yes	yes	Recommended for particularly dirty environments and/or where there is any risk that water could enter the system
11	Pipe or Hose	yes	no	yes		no	
12	Water Regulator	See comments	no	yes		no	Required if condenser outlet pressure is greater than 150 p.s.i. (105 kpa)
13	Pump	See comments	no	yes		no	Required if condenser outlet pressure is less than 5 p.s.i. (3 kpa)

(2-9) Zone Selection

Water Zones: The System 3000 allows you to select the number of zones to be monitored. Refer to terminal board TBDC and the zone selection chart (Fig. 2) Each of the water zones can be selected by installing jumpers between +24 volts and the appropriate terminals on TBDC. Figure 2 shows an example in which water zones 1, 2, and 3 are selected. When it becomes necessary to shut down a selected chiller for maintenance, that particular zone must be deselected. If it is not, the system 3000 will detect an error when it tries to sample the zone and their is no water flow. (Refer to the Maintenance section for a more detailed discussion.)

Air Zones (Model 3004WA only): Unlike the water zones, the air zones must be selected in sequence. Zone 1 is always active since it is the background air zone. The additional remote air zones must be selected in sequence. In the example shown, there are two remote zones selected in addition to background air.



AIR ZONE SELECTION CHART†

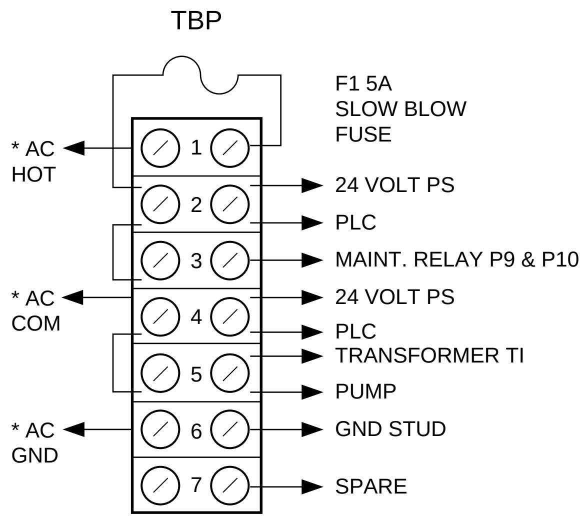
Zones Allowed	Air Zone A	Air Zone B
Zone 1 (Background)	open	open
Zones 1 and 2	24 volts	open
Zones 1, 2 and 3	open	24 volts
All Air Zones	24 volts	24 volts

Fig. 2
Zone Selection

(2-10) Primary Power

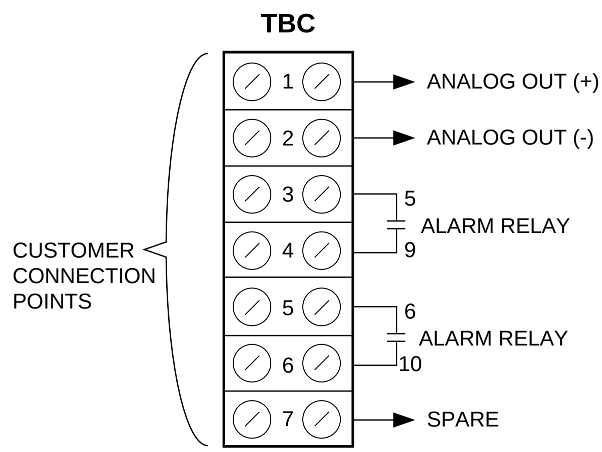
Refer to terminal board TBP (Fig. 3). The primary power required is 115 volt 50 or 60 HZ. Power is supplied to the unit through the bushing located on the left side of the control box.

It is strongly recommended that power be supplied from a separate disconnect, NOT by plugging into a wall socket. The System 3000 is a continuous monitor, if a wall socket is used there is a risk that the unit will inadvertently be unplugged putting it off line.



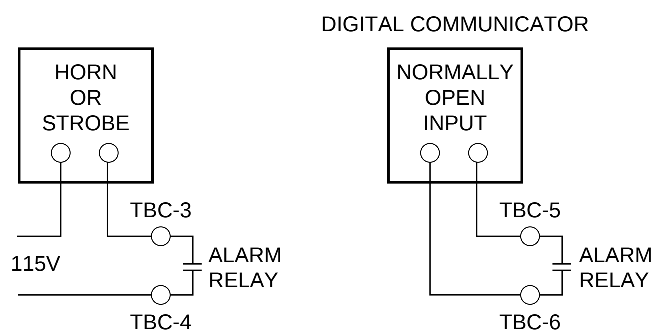
*Customer Supplied

Fig. 3
Primary Power Wiring



Note: Two more sets of contacts available on alarm relay (7 & 11) and (8 & 12)

TYPICAL INTERCONNECTIONS



NOTE: ALARM RELAY CONTACTS ARE RATED 5 AMPS MAXIMUM.

Fig. 4
Customer Connections

(2-11) Optional Connections

See the terminal board TBC (Fig. 4).

Analog signal available on pins 1 and 2 of TBC.

Alarm relay contacts used for actuating horns or strobes, as input for actuating an Automatic Dialer, as input to a customer control system etc. (See examples shown in Figure 4.) Use an auxiliary contactor for heavy loads such as exhaust fans.

RS 485 communications port: Refer to the instruction material provided with this option.

IMPORTANT

DOUBLE CHECK THE WIRING

III. OPERATIONS

Before applying primary power to the System 3000, read this section in its entirety.

WARNING

THE SENSOR OPERATES AT A TEMPERATURE OF 900° CELSIUS (1650° FAHRENHEIT). IF THERE IS ANY REASON TO SUSPECT THE PRESENCE OF A COMBUSTIBLE ATMOSPHERE, THE SYSTEM SHOULD NOT BE TURNED ON UNTIL THAT HAS BEEN ELIMINATED.

(3-1) Modes of Operation

The System 3000 has two basic operating modes, Automatic and Manual.

(3-2) Automatic Mode

When power is applied, the system starts in Automatic, Standby, Warm-up, and in the first selected water zone.

Warm-up: When power is first applied or after an alarm condition has been reset, the Sensor System goes through a three (3) minute warm-up period.

Normal Sequencing: After a 20 second hold in Standby, the system proceeds to test the first selected water zone following the steps outlined in the Water Test Cycle section above. Additionally it starts the air tests described in the Air Test Cycle section. It proceeds through all the selected zones. After all selected zones have been tested, the unit goes back to the first selected zone, goes through the cycle repeat timing sequence and repeats the cycle. The system continues to repeat the process until a potential leak is detected.

Leak Wait: The purpose of Leak Wait is to avoid going into alarm for a brief transient increase in the halogen level. During Leak Wait, the Leak Wait Light is lit and the meter oscillates between 0 and the measured PPM level. Normal Leak Wait time can range from 7 seconds to 3 minutes. The greater the PPM level the shorter the time. When the sensor electronics has decided there is an excess of refrigerant, the Alarm Sequence is executed. If during Leak Wait the signal drops below the trip point, Leak Wait is aborted and the system goes back to normal monitoring. This sequence is the same for either a water or air leak.

(3-3) Alarm Sequence

Water Zone Alarm

1. Alarm Relay is energized.
2. Alarm Light for that zone starts flashing.
3. Sensor electronics are reset.
4. The zone is taken out of the scan sequence.
5. The Warm-up sequence is initiated.
6. The test chamber is drained and the system switches to the next selected water zone.

Background Air Alarm

1. Alarm Relay is energized.
2. Alarm Light for that zone starts flashing.
3. The Maintenance Relay is energized, the sensor electronics and the pump are deenergized, and the system waits for corrective action to be taken to eliminate the background leak.

Remote Air Zone Alarm (3004WA only)

1. Alarm Relay is energized.
2. Alarm Light for that zone starts flashing.
3. Sensor electronics are reset.
4. The zone is taken out of the scan sequence.
5. The Warm-up sequence is initiated.
6. The system switches to the next selected air zone.

Multiple Alarms: If a second zone goes into alarm before the first problem is cleared, the system goes through the same procedure as for the first alarm. In the event all selected water zones go into alarm, the Maintenance Relay is energized, the sensor electronics and the pump are deenergized, and the system waits for corrective action to be taken.

(3-4) Manual Mode

Manual mode is used for confirming reported leaks, making certain they have been corrected, and for troubleshooting the equipment. In Manual mode, the system remains in the selected zone. To move from one water zone to the next it is necessary to switch to Standby and depress the Advance push-button. In Manual, each of the various steps of the water cycle can be individually selected. The operator can manually proceed through a complete cycle, double checking that there is a leak condition.

If there is an excess of refrigerant, the unit will go through the Leak Wait and Alarm sequences. However, unlike Automatic mode the unit will not reset itself and go on to the next zone.

Each of the individual controls and indicators are described below. See the illustrations for the Model 3003W control panel (Fig. 5) and the Model 3004WA control panel (Fig. 6).

Leak Wait Light: The Leak Wait light is lit during Leak Wait mode and at no other time.

Warm-Up Light: The Warm-up light is lit during warm-up and at no other time.

Auto/Manual lighted Push-button: The push-button alternately selects Automatic or Manual mode. The lights indicate which mode is active.

Reset Push-button: The Reset push-button resets Alarm and Maintenance modes. It also resets the sensor electronics and the unit enters Warm-up.

Zone Lights: The green light indicates the zone is active. The flashing red light indicates the zone is in alarm.

Maintenance Lighted Push-button: This control provides a dual function. The light is an indication that a failure has occurred or that all zones or background is in Alarm. The push-button provides a "Push to Test" facility. When the push-button is depressed, the Alarm Relay is momentarily energized and all zone alarm lights are lit. This provides a means of testing any warning horns, lights or other alarm devices.

Advance Push-button: The Advance push-button allows the operator to manually move from one zone to the next. Note water zones only advance when the the water cycle is in Standby Mode.

Standby/Hold Lighted Push-button: The push-button allows selection of standby Mode when the control is in Manual. The Standby light indicates that mode is selected, The Hold light indicates the Cycle Repeat timing sequence is active.

Flush Lighted Push-button: The push-button allows selection of Flush Mode when the control is in Manual. A steady light indicates Flush Mode. A flashing light indicates an error condition in the flush cycle.

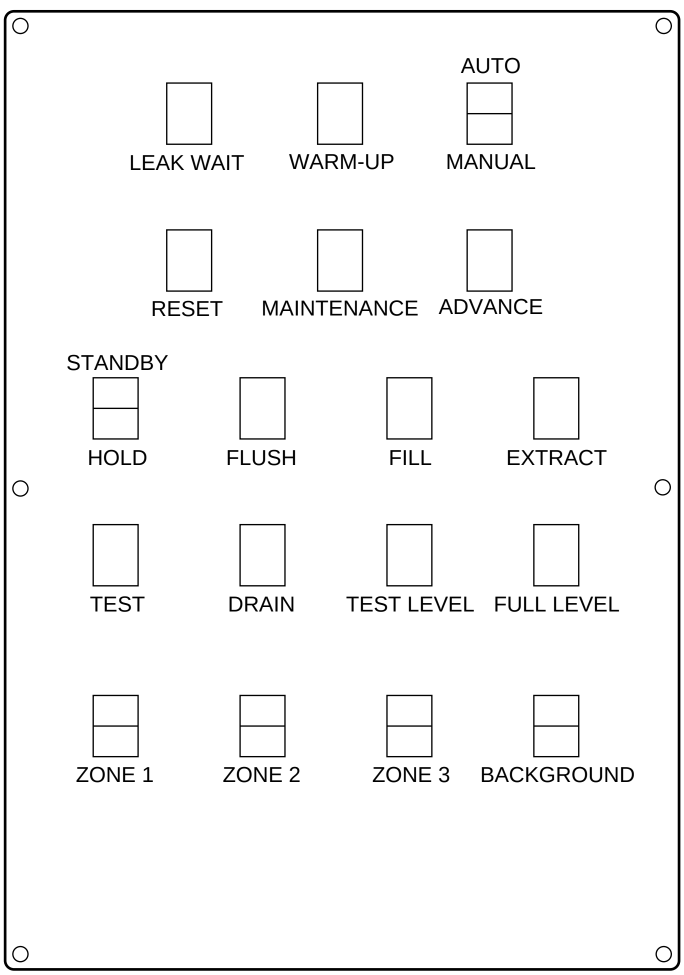


Fig. 5
Control Panel 3003W

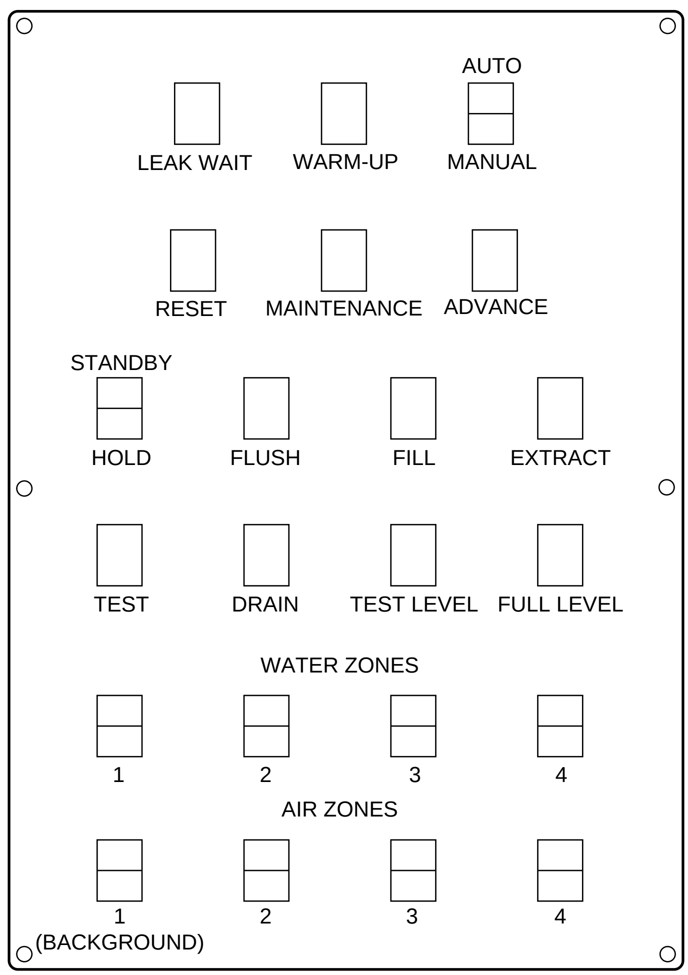


Fig. 6
Control Panel 3004WA

Fill Lighted Push-button: The push-button allows selection of Fill Mode when the control is in Manual. A steady light indicates Fill Mode. A flashing light indicates an error condition in the fill cycle.

Extract Lighted Push-button: The push-button allows selection of Extract Mode when the control is in Manual. The light indicates Extract Mode.

Test Lighted Push-button: The push-button allows selection of Test Mode when the control is in Manual. The light indicates Test Mode.

Drain Lighted Push-button: The Push-button allows selection of Drain Mode when the control is in Manual. A steady light indicates Drain Mode. A flashing light indicates an error condition in the drain cycle.

Test Level Light: The light indicates that the water in the chamber has reached the test level.

Full Level Light: The light indicates that the water in the chamber has reached the full level.

IV. Start-Up

WARNING

THE SENSOR OPERATES AT 900° CELSIUS (1650° DEGREES FAHRENHEIT) AND 180 VOLTS. NEVER TOUCH THE SENSOR WHILE POWER IS APPLIED.

Having confirmed the wiring is correct, apply power to the unit. Switch to Manual mode.

(4-1) Checking for Proper Water Flow

The purpose of this procedure is to check for any leaks that may have developed during shipping and to set the flow control valves.

If the condenser outlet pressure is high, above 100 psi. (70 kpa), open the first selected zone flow control valve 1 or 2 turns clockwise (in) reduces flow. If the pressure is near the low end 10 or 20 psi. (7 or 14 kpa), open the valve the full 8 turns.

Push the Flush push-button to start the flush cycle. After 10 to 20 seconds (depending on flow rate), the Test Level light should illuminate. Observe the top of the test chamber. After an amount of time approximately equal to that required to reach the test level, the water should reach the full level. At that point, the inlet valve will shut and the drain valve open. No water should splash out of the small opening in the chamber.

If there is any splash, turn the flow control valve in and repeat the test.

If it takes longer than 45 seconds to reach the test level, open the flow control valve to increase the flow rate, and repeat the test.

Repeat the procedure for each selected water zone. Also check for any leaks in the water system.

Note that the PLC allows a total of 5 minutes for the complete flush cycle. If you leave the unit in Flush mode for longer than 5 minutes, the system will enter Flush Error.

(4-2) Checking the Tubing Runs for Remote Air Zones (3004WA only)

The purpose of this test is to make certain that there are no discontinuities, breaks, or blockages in the tubing runs for the remote air zones.

Set the unit in Manual Mode with the water cycle in Standby. switch to air zone l (background air). Put your hand near the exhaust port for the air pump (right side near the bottom), to get a rough sense of the amount of flow for a short tube run. Switch to the next air zone. If the tubing run is near the maximum length, there will be a drop in the flow. If there is a blockage, the flow will continue to drop and the air pump motor will start to strain as it pulls a vacuum. Check all the remaining zones.

Check for no breaks or leaks in the tubing runs. This test can be done most conveniently with two people, one stationed at the monitor and the other at the tubing pickup points. At the monitor, switch to zone 2. At the pickup point, unscrew the coarse filter from the end of the tube. Place your finger over the end to block air flow.

If there are no breaks or leaks, you should feel a suction at the tube end.

The longer the tube run the more gentle the suction. Proceed to check all selected zones. This test will confirm continuity and that the right tube is connected to the correct zone.

(4-3) Checking Alarm and Option Wiring

Momentarily depress the Maintenance push-button to energize the Alarm Relay. This step will double check the wiring of horns, lights, and/or the automatic dialer that are set to operate when the unit goes into Alarm. It will also light all the selected Zone Alarm lights.

(4-4) Checking Zone Selection

Put the system in Manual mode by depressing the Auto/ Manual push-button. Using the Advance push-button step through all the selected zones. This test should confirm that all the zones required have been selected and there are no unused zones in the sequence. If any of the desired zones are missing from the sequence or there are any unused zones in the sequence, go back to the zone selection section of the manual and double check the jumpers.

(4-5) Checking the Sensor System

The following test will confirm that the sensor system is operating properly. By now the system should have been operating for several hours and should be thoroughly warmed up. If that is not the case, allow the system to warm-up for at least 30 minutes before proceeding (2 or 3 hours is preferable since the system has been off for a number of days or weeks since shipped from the factory).

Step 1: Set the system to Manual mode and the water Cycle in Standby. We will be using the background air input for these tests. For the model 3003W, find the tube that is suspended in the test chamber area with a porous brass filter at the loose end This is the background air inlet tube. For the model 3004WA, set the unit at zone 1 background air. Observe the PPM meter reading. The reading should be less than 5 PPM. If the reading is 10 PPM or higher or the system has gone into the Leak Wait Mode or Alarm Mode, there is a likelihood that there is a leak present. A high reading may also result from the recent use of a chlorinated cleaning agent. Many industrial degreasers do use chlorine based compounds. Some examples are trichloroethylene and perchloroethylene based solvents or cleaners. If you are convinced that there is no leak, and that there are no other sources of halogen vapors in the room, turn to the Maintenance section of the manual.

Step 2: The trip point setting of the unit is written on the inside front cover of the control console. Make a note of the setting.

Step 3: To check for proper operation of the Monitoring, Leak Wait, and Alarm modes, it is necessary to prepare a sample of the refrigerant gas being used.

CAUTION

VERY HIGH CONCENTRATIONS OF REFRIGERANT CAN SIGNIFICANTLY SHORTEN SENSOR LIFE. NEVER SQUIRT PURE REFRIGERANT TOWARD THE INLET TUBING.

a. **Gaseous Refrigerants:** Obtain a small plastic garbage bag (waste basket size is fine). Open the bag and "fluff" it so that it is full of air. Insert a refrigerant fill hose into the bag opening. Close the mouth of the bag around the hose. Crack the valve for a second or less so that a small "squirt" of refrigerant enters the bag. Keep in mind the monitor reads in parts per million and a tiny amount of gas will make a relatively high concentration sample. Pull out the hose, and hold the bag tightly closed.

b. **Liquid Refrigerants:** Obtain a small plastic "Zip-lock" food storage bag. Open the bag slightly and put in a few drops of liquid refrigerant. Flatten the bag so that there is little air and seal it as tightly as you can. Warm the bag to gasify the refrigerant. The bag will expand as the liquid evaporates, but the seal should be good enough to keep any from escaping.

Step 4: Test to see that Leak Wait and Alarm Mode work. We are going to use our refrigerant sample to simulate a concentration of refrigerant in the air that is reasonably higher than the trip point.

NOTE: THE MORE THE READING EXCEEDS THE TRIP POINT THE SHORTER THE LEAK WAIT TIME.

a. **Gaseous refrigerants:** Holding the bag tightly closed, bring the bag up to the tube inlet. Carefully loosen your grip on the bag to allow some contents to come out. Watch the meter as you do this. You should try and allow enough gas to leak to cause the meter to rise to 60 to 90 PPM. Precision is not possible, and the goal is to see that the unit enters Leak Wait mode and then Alarm mode.

b. **Liquid refrigerants:** Using a pin or paper clip, prick a hole in the bag. Hold the bag just under the tube inlet. Squeeze the bag slightly and watch the meter. You should try and allow enough gas to leak to cause the meter to rise to 60 to 90 PPM. Precision is not possible, and the goal is to see the unit enter Leak Wait mode and then Alarm mode.

In either a. or b. there will be a 15 second or so time delay before the meter starts to react.

Step 5: The system should now be in background alarm. Confirm that the Alarm light is flashing, the system is in Maintenance Mode (because it is a background alarm and the analog meter is steadily reading a PPM level. Check that any optional horns lights, or other devices are appropriately energized.

Step 6: Push the Reset push-button to clear the alarm.

Step 7: Dispose of the gas samples in an appropriate manner.

(4-6) Checking the Remote Air Zones (3004WA only)

After the unit has completed the warmup period, advance through each of the remote air zones and note the PPM readings. Spend a minute in each zone. If any of the zones have readings above 10 PPM, there may be leaks that need repairing.

(4-7) Checking the Water Zones

Before proceeding with these tests, it will be useful to refamiliarize yourself with the description of the water cycle in the overview section of the manual. You should also reread the Appendix B, "System 3000 Technical Process Considerations".

With the system in Manual and Standby Modes, select water zone 1. Put the system in Automatic mode and observe operation as it goes through Flush, Fill, Extract and Test. When it gets to Test Mode, observe the PPM reading and make a note of its maximum value. Assuming there are no problems and the unit has not gone into Alarm Mode, continue observing as it goes through the Drain Mode and the water cycle in the remaining selected water zones.

If you observe any problems with the water cycle, turn to the Maintenance section of the manual.

(4-8) Evaluating the PPM Readings

If the condenser cooling water has a chemical treatment which includes chlorine and/or bromine, the PPM readings will be higher than background.

1. All water zones have PPM readings 5 to 10 PPM higher than background. This is in the acceptable range and should present no problem. Check to make certain that the factory set trip point is at least twice as high as the maximum reading note (see the appendix titled "Trip Point and Function Switch Settings".

2. The unit goes into Alarm Mode in all the water zones. Set function switch Sl on the sensor electronics board to the Test Mode (see the appendix titled "Trip Point and Function Switch Settings"). This setting will disable the alarm circuitry, and allow you to see how high the PPM reading actually gets without going into alarm. Starting with water zone 1, have the system run through a complete cycle of tests for all water zones. Make a note of the maximum PPM readings in each zone.

   a. If all of the readings are less than 50 PPM and within 5 to 10 PPM of each other, it is an indication that the they are a result of chemical treatment of the cooling water. Reset the trip point switch (PPM trip point switch S2) so that it is 20 PPM higher than the maximum reading to allow a margin to avoid false alarms. Put switch Sl back into Run mode.

      You should review the chemicals used to treat the cooling water and consider using compounds that do not include any halogens so that the System 3000 trip point can be reset to a more sensitive level.

   b. If all of the readings are higher than 50 PPM, it could mean that either all the units have leaks or that the water treatment is substantially affecting the readings. Before checking for leaks, review the chemicals used to treat the cooling water.

   c. One or more of the water zones, but not all go into alarm. Unless there are differences in the water treatment for the different chillers (see the discussion above), the unit(s) that are going into alarm may be leaking refrigerant into the cooling water.

(4-9) Setting the Cycle Repeat Timer

The cycle repeat timer can be set from 99 hours 59 minutes to 0. This timer sets the time delay between testing the last selected water zone and starting the test of the first selected zone. There are 4 sets of settings. Starting from the left are tens of hours, units of hours, tens of minutes and units of minutes. Using the 4 sets of up/down push-button, set the desired time delay. While the timer is timing, the LED display shows time remaining. Each zone test discards 3 gallons . (12 liters) of water. Check your setting by putting the unit in Manual and Standby, and advancing to the last selected zone. Select Drain mode and switch to Automatic. Once drain is complete, the unit will switch to Standby and Hold, and the cycle repeat timer will display the time you have set. It will count down from that time in units of minutes. Once timed out, it will switch to Flush.

(4-10) Completing Start-Up

1. If during start-up you changed the trip point setting, make a note of the new setting, the date, and your initials on the trip point section of the decal on the door of the control console.

2. Make certain that the run/test switch on the sensor electronics board is in the run mode.

3. Replace the cover panels.

4. Put the system in Automatic Mode.

5. Fill out the CTS/Warranty card completely and return to SenTech.

IMPORTANT

TO VALIDATE YOUR WARRANTY, THE CTS FORM MUST BE COMPLETED AND RETURNED TO THE FACTORY WITHIN THIRTY (30) DAYS OF THE UNIT'S INSTALLATION.

6. Store this manual in safe place so that it will be available for future reference.

Basic installation and start-up are now complete, and the unit should be in Automatic Mode sequencing through the zones and on line and monitoring.

V. PERIODIC PERFORMANCE CHECKS

(5-1) Weekly

Check that the system is sequencing normally. Check the flowmeter.

CAUTION

THIS NEXT TEST WILL ALSO ACTUATE THE AUTOMATIC DIALER AND SIGNAL AN ALARM TO THE REMOTE MONITORING FACILITY. IF YOU HAVE THIS FEATURE, CHECK THE INSTRUCTIONS PROVIDED WITH THE AUTO DIALER BEFORE PERFORMING THIS TEST.

Momentarily depress the Maintenance push-button. Make certain that all Zone Alarm lights work, that any horns and strobes are actuated.

(5-2) Quarterly

Go through the Sensor System checks of the start up instructions, to check proper functioning of the Leak Wait and Alarm modes.

VI. PREVENTIVE MAINTENANCE

The only preventive maintenance that needs to be accomplished on a routine basis is to periodically clean the filters.

(6-1) Water Strainer

Each water zone has a strainer between the inlet flow control valve and the solenoid valve. If the strainer becomes clogged, the flow could decrease to a point that the flush and/or fill cycle cannot be completed within in the allotted time.

(6-2) Cooling Air

There are two air filters on the outside of the control console, one for inlet cooling air and the other for outlet cooling air. Dirty filters will reduce cooling air flow and could shorten the life of the solid state electronics.

(6-3) Sensor Fine Filter

In the control console is a fine filter (5 micron) to protect the diaphragm pump, orifice, flowmeter, and sensor.

(6-4) Tube End Coarse Filters

The Model 3003W has one coarse filter mounted on the end of the background air tube located in the test chamber area. The 3004WA has coarse filters for background air and the remote air zones all external to the unit. Dirt and grease on the tube end filters will restrict air flow and increase the time for a sample to reach the monitor.

(6-5) Pump Filters (Model 3004WA only)

There are two filters on the inlet and outlet of the remote air pump located in the area under the control console. Dirt will reduce air flow and increase the time it takes to get a sample from a distant air zone. Dirt will also shorten pump life.

(6-6) Optional In-line Filter Separators (Model 3004WA only)

These filters should be installed in any zones that are particularly dirty and/or where there is a risk of moisture entering the system.

How often to clean the water strainers will depend on how much rust and scale there may be in the system. How often to clean the air filters depends on how dirty the air is in the vicinity of the monitor and at the remote pickup points.

Our recommendations are:

1. For the first 3 months, check the strainers and filters monthly to establish a preventive maintenance schedule. For the strainers, check the amount of time it takes to fill to the test level for each zone. Check all the air filters to determine how quickly each gets dirty.

2. The pump outlet filter will collect some carbon dust during the first few months of operation. This is a result of the pump's graphite vanes seating themselves and should not be a concern unless the filter bottle starts to collect substantial quantities of dust and/or the flowmeter readings start to go down.

3. Because of the other filters in series, the pump outlet filter and the sensor fine filter should rarely require cleaning, but they should be checked when the other filters are cleaned.

4. At the very minimum, the cooling air filters should be cleaned and the other filters checked and cleaned, if necessary, at least quarterly.

(6-7) Checking for Water Zone Leaks, after an alarm has been reported (Model 3004WA only)

When the System 3000 reports a leak in one of the water zones, it is prudent to double check the likelihood of a leak before taking the chiller down for maintenance.

1. **Background Air**: Check the background air reading. Any refrigerant extracted from a water zone test is additive to the background level. If there is a small

refrigerant leak in the area of the monitor, it could raise the background to a level just below the trip point. As a result, the small additional halogen from the water zone is enough to cause an alarm.

Example: The normal background air reading is 2 to 3 PPM. The normal water zone reading is 10 PPM above background (due to the water treatment used). The trip point is set at 25 PPM. A refrigerant leak in the general area of the monitor causes the background reading to rise to 20 PPM which is insufficient to cause a background alarm. The normal 10 PPM from a water zone causes the unit to report an alarm in that zone. For this example, you should check for and fix any leaks in the area of the monitor first.

2. **Changes in the Condenser Water Treatment:** Check to make sure there has not been a change in the condenser water treatment since the unit was installed. Review the Start Up section of the manual.

Once you have eliminated the possibility of a false alarm, manually run through the water test cycle for the zone in question. Make a note of the maximum PPM reading. Refer to the appendix titled "System 3000 Technical Process Considerations". Knowing the PPM level and the condenser water flow, you can use Equation 5 to get an order of magnitude of the size of the leak.

When you are ready to take a chiller down for maintenance, remove the jumper at terminal board TBDC that selects that chiller (see the zone selection section of the manual). If you do not take this step, the System 3000 will report an error when it tries to test that zone.

VII. MAINTENANCE AND TROUBLESHOOTING

The System 3000 can be partitioned into three major sections: the water and air handling subsystem; the programmable logic controller (PLC); and the sensor electronics. The majority of the discussion applies to both models (3003W and 3004WA), any differences will be highlighted.

(7-1) Water and Air Subsystems

Condenser water enters the system (Fig. 7) at the flow control valve. It passes through the strainer to the zone solenoid valve. The zone valve is energized when that zone is selected and the PLC calls for adding water to the test chamber. The water enters the manifold which is connected to the fill solenoid valve by the fill hose. The fill and zone valves are energized during the first half of the Flush cycle and during the fill cycle.

Water leaves the test chamber through the drain port and drain solenoid valve. The drain solenoid is energized during Standby Mode, the second half of the Flush Cycle, and during Drain Mode.

The test chamber has two float level switches. A full level switch that actuates when the chamber is approximately 90% full, and a test level switch which actuates when there is approximately 1 gallon of water in the chamber.

Refrigerant is driven out of the water sample by means of the extraction motor which agitates the water to release the entrained refrigerant. The motor is actuated only during the Extract Mode.

The final connection to the test chamber is the port for drawing test air from the chamber. This port is connected to the test solenoid valve. The test valve is a 3-way air solenoid. The outlet of the valve is connected to the 5 micron air filter in the control console. One inlet is connected to the test chamber and the other to background air. In the model 3003W, this is a short length of tubing located in the test chamber area and terminated in a porous brass filter. In the model 3004WA, it is connected to the output of the vacuum pump.

Test air is drawn through the 5 micron filter by the sample pump. The output of the pump passes through a .010 inch orifice to the flowmeter. The output of the flowmeter is passed through the sensor which measures the concentration of refrigerant.

(7-2) Air Sampling System (Model 3004WA only)

The model 3004WA air sampling system starts with a four station solenoid valve and air manifold assembly mounted on the left side of the system. The outlet of the manifold is connected to the input filter of the vacuum pump. The outlet of the pump passes through a filter and a tee. One leg of the tee is connected to the background air inlet of the test solenoid valve. The other leg is connected to an exhaust port on the right side of the unit.

During the second half of the Flush Cycle and during Extract Mode, the PLC selects zone 1 (background air port) of the manifold. During all other portions of the water cycle, the PLC sequences through each of the selected air zones. It spends one minute in each zone testing for leaks.

(7-3) Water System Adjustments

The water flow control is the only adjustment that may have to be made in the water/air subsystem. The procedure for making this adjustment is described in detail in the start-up section of the manual in the paragraph titled "Checking for Proper Water Flow.

(7-4) Water System Strainers

It may be necessary to periodically clean the strainers located in each leg of the water zone inlets. This is done by unscrewing the cap from the bottom angled leg of the strainer, removing the strainer element and cleaning it.

(7-5) Air System Filters

Model 3003W. There is a porous brass filter at the end of the background air inlet tube which may need occasional cleaning. Additionally, there is the 5 micron air filter in the control console, which should be replaced if it gets clogged.

Model 3004WA. In addition to the filters common to both models, the 3004WA should have porous brass filters at the end of each remote air zone tube, plus the two filters on the inlet and outlet of the vacuum pump.

One sign of dirty filters is a drop in the flowmeter reading in the control console.

(7-6) Ratings of Water and Air System Components

Water Zone, Fill, and Drain Solenoid Valves: These are identical 120 volt AC valves rated 0 to 150 psi (0-100 kpa).

Test Solenoid Valve: This is a 24 volt DC valve rated 0 to 12 psi (0-8 kpa).

Full and Test Level Float Switches: These units operate off the 24 volt DC supply.

Extract Motor: This unit operates on 120 volt AC. Built into the plug is an electronic speed control circuit.

Four Station Air Solenoid and Manifold Assembly (3004WA only): This unit operates on 24 volts DC.

Sample Pump and Vacuum Pump: Both are 120 volt AC.

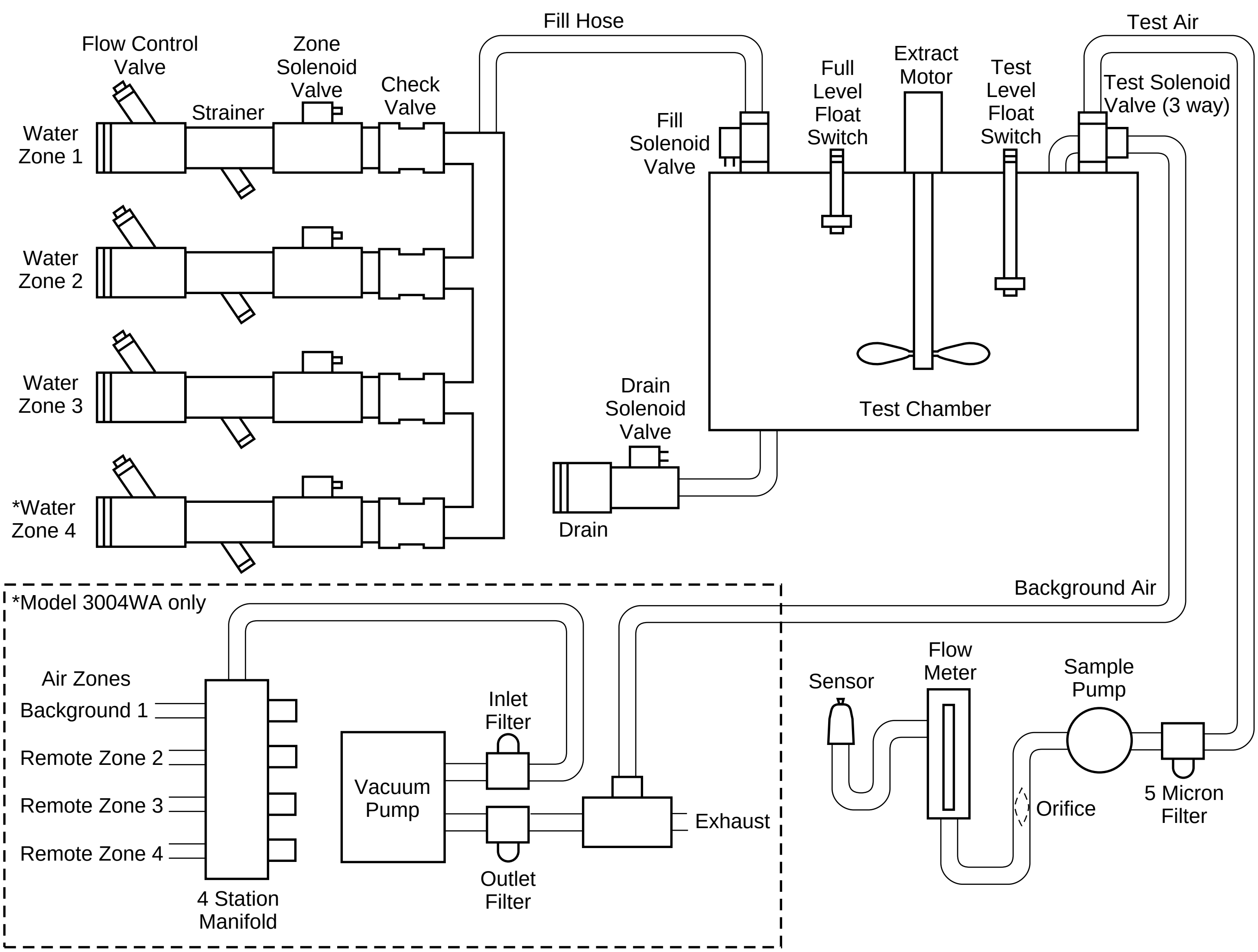


Fig. 7
Water and Air Subsystem

(7-7) Description of the Water Cycle

Standby: Each water cycle starts/ends in Standby Mode. The control allows switching from one water zone to the next only in Standby. In Standby, the zone and fill valves are deenergized, the drain valve is energized, the test valve is deenergized which allows background (or remote air zone) air to be passed to the sensor system.

Flush: There are two steps the Flush Cycle. First the selected zone valve and fill valve are energized, and the drain valve and test valve are deenergized. The PLC waits for the test level and full level switches to be actuated. When both are actuated, it deenergizes the zone and fill valves and energizes the drain valve. It now waits for both the full level and test level float switches to deenergize. When both switches are deenergized, the PLC starts a 90 second timer to allow ample time for the chamber to empty.

Flush Error: When the Flush Cycle is initiated (in either Automatic or Manual Mode) the PLC starts a 5 minute timer. If the entire Flush Cycle is not completed within the 5 minutes, the PLC assumes a Flush Error. As with any error, the system switches to maintenance mode, energizes the alarm relay, and shuts down operation. In the case of Flush Error, it starts flashing the Flush Light. To clear a Flush Error. switch to Standby Mode and do a Reset.

Possible Causes of Flush Error

1. Failure of either the fill or selected zone solenoid valve blocking entry of water into the chamber.

2. Failure of the drain solenoid valve.

3. Failure of either of the level switches.

4. Misadjustment of the flow control valve, or insufficient pressure at the zone inlet because of actions taken upstream from the water inlet (such as shutting down the chiller being tested).

Fill: The selected zone and fill solenoid valve are energized and the drain and test valve are deenergized. When the water reaches the test level limit switch, the Fill Cycle is complete.

Fill Error: There are two types of Fill Error. When the Fill Cycle is initiated, the PLC starts a 90 second timer. If the test level switch is not actuated within the 90 seconds, a Fill Error occurs. If the full level switch is actuated at any time during the Fill Cycle, a Fill Error occurs. The system switches to maintenance mode, energizes the alarm relay, and shuts down operation. It starts flashing the Fill Light. To clear a Fill Error, switch to Standby Mode and do a Reset.

Possible Causes of Fill Error

1. The failure of either the fill or selected zone solenoid valve.

2. Failure of the test level switch.

3. Misadjustment of the flow control valve, or insufficient pressure at the zone inlet because of actions taken upstream from the water inlet (such as shutting down the chiller being tested).

Extract: The extract motor is energized for 3 minutes. The fill, zone, drain, and test valves are deenergized.

Test: The zone, fill, and drain valves are deenergized. The test valve is energized and air from above the chamber is drawn to the sensor by the sample pump for 90 seconds. If a Leak Wait occurs during this period the timing is stopped. If the Leak Wait signal goes away, the 90 second timer is reinitiated. If the system detects an alarm, it goes into warm-up mode and switches to drain. There is the special case in which the refrigerant level is approximately equal to the trip point. In these circumstances, it is possible that the system will enter Leak Wait and drop out again. The third time the system enters Leak Wait, the PLC assumes an alarm.

Drain: The zone, fill, and test valves are deenergized and the drain valve is energized. When the test level switch deenergizes, a 90 second timer is initiated to allow ample time for the chamber to empty.

Drain Error: When the Drain Cycle starts, a 2 minute timer is initiated. The timer is reset when the test level switch deactuates.

Possible Causes of Drain Error: Failure of the drain solenoid valve.

General Comments

1. Whenever one of the chillers being tested is taken off line for whatever reason, it necessary to remove that zone from the sequence.

2. The water cycle error detection logic is active in both the Manual and Automatic Mode. The flush and fill errors depend upon their cycle being completed within a certain time period. In Manual Mode, the system remains in the selected mode until another mode is manually selected. Therefore, if the system is left in Flush or Fill Mode, it will ultimately go into error.

3. To reset any of the water cycle errors, it is necessary to switch to Standby Mode first and then hit Reset.

(7-8) Troubleshooting Hint

CAUTION

DO NOT ATTEMPT TO USE THE PROCEDURE OUTLINED BELOW UNLESS YOU HAVE SHUT OFF ALL THE CONDENSER OUTLET WATER TO THE SYSTEM 3000 AND YOU ARE THOROUGHLY FAMILIAR WITH THE SYSTEM 1000 OPERATION. FAILURE TO FOLLOW THESE PRECAUTIONS COULD RESULT IN CONDENSER WATER OVERFLOWING THE TEST CHAMBER AND SPILLING INTO THE UNIT.

When troubleshooting the System 3000, occasionally it may be desirable to put the unit through its paces, without having the water flowing into and out of the unit. This cannot be done by simply shutting off the water. To go through the complete cycle the unit has to have the Test and Full Level switches actuate at the appropriate times.

The PLC software does have a "hidden" mode that by-passes the limit switches and simulates water flowing into and out of the unit. This mode is activated by installing a jumper between X37 and 24V on the PLC.

When X37 is ON, the system ignores the Test and Full Level limit switches. The water level in the chamber is simulated by an internal up/down counter. When water is supposed to be entering the chamber, the counter counts up and after 20 seconds a simulated Test Level is reached. After 40 seconds, a simulated Full Level is reached. When water is supposed to be drained, the counter is counted down. In effect, the up/down counter substitutes for the chamber water level.

In the simulation mode, all of the other functions operate exactly the same as in normal operation. In particular, the appropriate solenoid valves turn on and off just as in normal operation. It is imperative that the water to the system be off because the control has no way of knowing what the actual water level is.

IMPORTANT

IF YOU USE THE SIMULATION MODE IN TROUBLE SHOOTING THE SYSTEM, MAKE CERTAIN YOU REMOVE THE JUMPER TO X37 BEFORE GOING BACK TO NORMAL OPERATION.

VIII. Programmable Logic Control (PLC)

The System 3000 is under the continuous control of the Programmable Logic Controller (PLC). As soon as power is supplied to the system (or after a power interruption), the PLC starts running. It comes on in Automatic mode, at zone 1, and in Warm-up. The major difference between the models are that a model 3003W has a PLC base unit and a relay output block, and the 3004WA has an additional transistor type output block for the 4 air zones. For the following discussion, refer to the system schematic and wiring diagram.

Inputs to the PLC include: the front panel Push-buttons, 2 inputs from the sensor electronics, zone selection inputs, level switch signals, and an input from the cycle repeat timer. Outputs from the PLC control the lights, solenoid valves, three relays, extract motor, and the cycle repeat timer. All the inputs are 24 volts DC. The outputs are 24 volts DC except for the water zone valves, drain and fill valve, extract motor, and the cycle repeat timer which are 115 volts AC. Power to the PLC can be 100 to 240 volts AC, 50 to 60 Hz. An input logical "1" or "ON" is 24 volts, a logic "0" is 0 Volts. Similarly an output logic "1" is 24 or 115 volts.

(8-1) Input/Output Names and Locations

Chart 1 shows the PLC inputs and outputs for the model 3003W and Chart 2 for the model 3004WA. The logic X's are inputs and the Y's are outputs. The first column of the chart is the logic designation that is used by the internal program. The second column shows the connection point to the PLC. PLC1T-X0 means the X0 connection on the upper set of terminal strips of PLC unit 1 (the left most unit). PLC2B-Y7 means the Y7 connection on the lower set of terminal strips of unit 2. The third column "Mnemonic" is the abbreviated name of the logic signal. The fourth column is a description of the signal. The final column shows the connection point(s) in the System 3000.

(8-2) Logic Description

All of the inputs except the Leak Wait signal are positive logic. That is a logic 1 or +24 volts means something should happen or the signal is present or ON. The Leak Wait signal is the only reverse logic input. When the +24 is present, it is NOT Leak Wait, 0 volts indicates that the system is in Leak Wait mode. All of the push-buttons are momentary signals, any necessary latching is done internally by the PLC logic. To eliminate contact bounce and "relay race" problems, the Auto/Manual and Manual Reset push-buttons complete their actions only after they are released. The Push to Test signal (Maintenance push-button) takes effect immediately. The Advance push-button steps the sequence one zone when it is actuated, but it must be released and depressed again to move to the following zone. All of the outputs are positive logic, +24 or 115 volts means the output is on.

MODEL 3003W PLC INPUT/OUTPUT

PLC LOGIC DESIGNATION	PLC LOCATION	MNEMONIC	SIGNAL DESCRIPTION	3003W CONNECTION
X0	PLC1T-X0	AM	AUTO/MANUAL SELECTION	AUTO/MANUAL PB
X1	PLC1T-X1	$\overline{MBLW}$	MOTHER BOARD LEAK WAIT	TBJ-1, LEAK WAIT LIGHT
X2	PLC1T-X2	MRES	MANUAL RESET	RESET PB
X3	PLC1T-X3	ADV	ADVANCE	ADVANCE PB
X4	PLC1T-X4	MBALRM	ALARM SIGNAL FROM SENSOR ELECTRONICS	CONTROL BOARD J2-7
X5	PLC1T-X5	PTT	PUSH TO TEST	MAINTENANCE PB
X6	PLC1T-X6	AZA	ALLOW ZONE A	TBDC-1
X7	PLC1T-X7	AZB	ALLOW ZONE B	TBDC-2
X10	PLC1T-X10	AZC	ALLOW ZONE C	TBDC-3
X11	PLC1T-X11	STBYB	STANDBY SELECTION	STANDBY PB
X12	PLC1T-X12	FLSHB	FLUSH SELECT	FLUSH PB
X13	PLC1T-X13	FILLB	FILL SELECT	FILL PB
X14	PLC1T-X14	AGITB	EXTRACT SELECT	EXTRACT PB
X15	PLC1T-X15	TSTB	TEST SELECT	TEST PB
X16	PLC1T-X16	DRNB	DRAIN SELECT	DRAIN PB
X17	PLC1T-X17	TSTLV	TEST LEVEL	TBB1-4
X20	PLC1T-X20	FULLV	FULL LEVEL	TBB1-3
X21	PLC1T-X21	CRYPT	CYCLE REPEAT TIMER INPUT TO PLC	CYCLE REPEAT TIMER P6
X22-X37	NOT USED	NOT USED	NOT USED	NOT USED
Y0	PLC1B-Y0	AUTO	AUTOMATIC	AUTO LIGHT
Y1	PLC1B-Y1	MAN	MANUAL	MANUAL LIGHT
Y2	PLC1B-Y2	RESR	SENSOR BOARD ALARM RESET	RESET RELAY P13
Y3	PLC1B-Y3	ALRMR	ALARM	ALARM RELAY P13
Y4	PLC1B-Y4	WUP	WARMUP	WARMUP LIGHT
Y5	PLC1B-Y5	MNR	MAINTENANCE	MAINTENANCE RELAY P13
Y6	PLC1B-Y6	MNL	MAINTENANCE LIGHT	MAINTENANCE LIGHT
Y7	PLC1B-Y7	STBYL	STANDBY	STANDBY LIGHT
Y10	PLC1B-Y10	FLSHL	FLUSH	FLUSH LIGHT
Y11	PLC1B-Y11	FILLLT	FILL LIGHT	FILL LIGHT
Y12	PLC1B-Y12	AGITL	EXHAUST	EXHAUST LIGHT
Y13	PLC1B-Y13	TSTL	TEST	TEST LIGHT
Y14	PLC1B-Y14	DRNL	DRAIN	DRAIN LIGHT
Y15	PLC1B-Y15	TSTLVL	TEST LEVEL	TEST LEVLE LIGHT
Y16	PLC1B-Y16	FULLVL	FULL LEVEL	FULL LEVEL LIGHT
Y17	PLC1B-Y17	NOT USED	NOT USED	NOT USED
Y20	PLC1B-Y20	NOT USED	NOT USED	NOT USED
Y21	PLC1B-Y21	TSTSV	TEST SOLENOID VALVE	TBB1-5
Y22	PLC1B-Y22	NOT USED	NOT USED	NOT USED
Y23	PLC1B-Y23	CYRPTA	CYCLE HOLD	HOLD LIGHT
Y24	PLC1B-Y24	Z1ON	ZONE 1 ON	ZONE 1 ON LIGHT
Y25	PLC1B-Y25	Z2ON	ZONE 2 ON	ZONE 2 ON LIGHT
Y26	PLC1B-Y26	Z3ON	ZONE 3 ON	ZONE 3 ON LIGHT
Y27	PLC1B-Y27	BKGON	BACKGROUND ON	BACKGROUND ON LIGHT
Y30	PLC1B-Y30	Z1ALRM	ZONE 1 ALARM	ZONE 1 ALARM LIGHT
Y31	PLC1B-Y31	Z2ALRM	ZONE 2 ALARM	ZONE 2 ALARM LIGHT
Y32	PLC1B-Y32	Z3ALRM	ZONE 3 ALARM	ZONE 3 ALARM LIGHT
Y33	PLC1B-Y33	BKGALRM	BACKGROUND ALARM	BACKGROUND ALARM LIGHT
Y40	PLC1B-Y0	CRYPTAC	REPEAT CYCLE TIMER ALLOW AC	CYCLE REPEAT TIMER P2
Y41	PLC2T-Y1	AGITAC	EXTRACT MOTOR AC	TBB2-4
Y42	PLC2T-Y2	FILLSV	FILL SOLENOID VALVE AC	TBB2-6
Y43	PLC2T-Y3	DRNSV	DRAIN SOLENOID VALVE A	TBB2-7
Y44	PLC2B-Y4	Z1SV	ZONE 1 SOLENOID VALVE AC	TBB3-4
Y45	PLC2B-Y5	Z2SV	ZONE 2 SOLENOID VALVE AC	TBB3-5
Y46	PLC2B-Y6	Z3SV	ZONE 3 SOLENOID VALVE AC	TBB3-6

MODEL 3004WA PLC INPUT/OUTPUT

PLC LOGIC DESIGNATION	PLC LOCATION	MNEMONIC	SIGNAL DESCRIPTION	3003WA CONNECTION
X0	PLC1T-X0	AM	AUTO/MANUAL SELECTION	AUTO/MANUAL PB
X1	PLC1T-X1	$\overline{MBLW}$	MOTHER BOARD LEAK WAIT	TBJ-1, LEAK WAIT LIGHT
X2	PLC1T-X2	MRES	MANUAL RESET	RESET PB
X3	PLC1T-X3	ADV	ADVANCE	ADVANCE PB
X4	PLC1T-X4	MBALRM	ALARM SIGNAL FROM SENSOR ELECTRONICS	CONTROL BOARD J2-7
X5	PLC1T-X5	PTT	PUSH TO TEST	MAINTENANCE PB
X6	PLC1T-X6	AZA	ALLOW ZONE A	TBDC-1
X7	PLC1T-X7	AZB	ALLOW ZONE B	TBDC-2
X10	PLC1T-X10	AZC	ALLOW ZONE C	TBDC-3
X11	PLC1T-X11	STBYB	STANDBY SELECTION	STANDBY PB
X12	PLC1T-X12	FLSHB	FLUSH SELECT	FLUSH PB
X13	PLC1T-X13	FILLB	FILL SELECT	FILL PB
X14	PLC1T-X14	AGITB	EXTRACT SELECT	EXTRACT PB
X15	PLC1T-X15	TSTB	TEST SELECT	TEST PB
X16	PLC1T-X16	DRNB	DRAIN SELECT	DRAIN PB
X17	PLC1T-X17	TSTLV	TEST LEVEL	TBB1-4
X20	PLC1T-X20	FULLV	FULL LEVEL	TBB1-3
X21	PLC1T-X21	CRYPT	CYCLE REPEAT TIMER INPUT TO PLC	CYCLE REPEAT TIMER P6
X22-X27	NOT USED	NOT USED	NOT USED	NOT USED
X30	PLC1T-X30	AZD	ALLOW ZONE D	TBDC-P4
X31	PLC1T-X31	AZXA	ALLOW AIR ZONE A	TBDC-P5
X32	PLC1T-X32	AZXB	ALLOW AIR ZONE B	TBDC-P6
X33-X37	NOT USED	NOT USED	NOT USED	NOT USED
Y0	PLC1B-Y0	AUTO	AUTOMATIC	AUTO LIGHT
Y1	PLC1B-Y1	MAN	MANUAL	MANUAL LIGHT
Y2	PLC1B-Y2	RESR	SENSOR BOARD ALARM RESET	RESET RELAY P13
Y3	PLC1B-Y3	ALRMR	ALARM	ALARM RELAY P13
Y4	PLC1B-Y4	WUP	WARMUP	WARMUP LIGHT
Y5	PLC1B-Y5	MNR	MAINTENANCE	MAINTENANCE RELAY P13
Y6	PLC1B-Y6	MNL	MAINTENANCE LIGHT	MAINTENANCE LIGHT
Y7	PLC1B-Y7	STBYL	STANDBY	STANDBY LIGHT
Y10	PLC1B-Y10	FLSHL	FLUSH	FLUSH LIGHT
Y11	PLC1B-Y11	FILLLT	FILL LIGHT	FILL LIGHT
Y12	PLC1B-Y12	AGITL	EXHAUST	EXHAUST LIGHT
Y13	PLC1B-Y13	TSTL	TEST	TEST LIGHT
Y14	PLC1B-Y14	DRNL	DRAIN	DRAIN LIGHT
Y15	PLC1B-Y15	TSTLVL	TEST LEVEL	TEST LEVLE LIGHT
Y16	PLC1B-Y16	FULLVL	FULL LEVEL	FULL LEVEL LIGHT
Y17	PLC1B-Y17	NOT USED	NOT USED	NOT USED
Y20	PLC1B-Y20	NOT USED	NOT USED	NOT USED
Y21	PLC1B-Y21	TSTSV	TEST SOLENOID VALVE	TBB1-5
Y22	PLC1B-Y22	NOT USED	NOT USED	NOT USED
Y23	PLC1B-Y23	CYRPTA	CYCLE HOLD	HOLD LIGHT
Y24	PLC1B-Y24	Z1ON	ZONE 1 ON	ZONE 1 ON LIGHT
Y25	PLC1B-Y25	Z2ON	ZONE 2 ON	ZONE 2 ON LIGHT
Y26	PLC1B-Y26	Z3ON	ZONE 3 ON	ZONE 3 ON LIGHT
Y27	PLC1B-Y27	Z4ON	ZONE 4 ON	ZONE 4 ON LIGHT
Y30	PLC1B-Y30	Z1ALRM	ZONE 1 ALARM	ZONE 1 ALARM LIGHT
Y31	PLC1B-Y31	Z2ALRM	ZONE 2 ALARM	ZONE 2 ALARM LIGHT
Y32	PLC1B-Y32	Z3ALRM	ZONE 3 ALARM	ZONE 3 ALARM LIGHT
Y33	PLC1B-Y33	BKGALRM	ZONE 4 ALARM	BACKGROUND ALARM LIGHT
Y40	PLC1B-Y0	CRYPTAC	REPEAT CYCLE TIMER ALLOW AC	CYCLE REPEAT TIMER P2
Y41	PLC1B-Y1	AGITAC	EXTRACT MOTOR AC	TBB2-4
Y42	PLC1B-Y2	FILLSV	FILL SOLENOID VALVE AC	TBB2-6
Y43	PLC1B-Y3	DRNSV	DRAIN SOLENOID VALVE A	TBB2-7
Y44	PLC1B-Y4	Z1SV	ZONE 1 SOLENOID VALVE AC	TBB3-4
Y45	PLC1B-Y5	Z2SV	ZONE 2 SOLENOID VALVE AC	TBB3-5
Y46	PLC1B-Y6	Z3SV	ZONE 3 SOLENOID VALVE AC	TBB3-6
Y47	PLC1B-Y7	Z4SV	ZONE 4 SOLENOID VALVE AC	TBB3-7
Y50	PLC3T-Y0	AZ1ON	AIR ZONE 1 (BACKGROUND) ON	AIR ZONE 1 ON LIGHT, TBB4-4
Y51	PLC3T-Y1	AZ2ON	AIR ZONE 2 ON	AIR ZONE 2 ON LIGHT, TBB4-5
Y52	PLC3T-Y2	AZ3ON	AIR ZONE 3 ON	AIR ZONE 3 ON LIGHT, TBB4-6
Y53	PLC3T-Y3	AZ4ON	AIR ZONE 4 ON	AIR ZONE 4 ON LIGHT, TBB4-7
Y54	PLC3T-Y4	AZ1ALRM	AIR ZONE 1 ALARM	AIR ZONE 1 ALARM LIGHT
Y55	PLC3T-Y5	AZ2ALRM	AIR ZONE 2 ALARM	AIR ZONE 2 ALARM LIGHT
Y56	PLC3T-Y6	AZ3ALRM	AIR ZONE 3 ALARM	AIR ZONE 3 ALARM LIGHT
Y57	PLC3T-Y7	AZ4ALRM	AIR ZONE 4 ALARM	AIR ZONE 4 ALARM LIGHT

(8-3) Inputs

Push-buttons: The functions of the push-buttons are described in some detail in the Operations section of the manual.

Leak Wait X2: When the Leak Wait signal is 0 volts, the sensor electronics is in the Leak Wait mode.

Alarm X4: When 24 volts, the sensor electronics is in Alarm mode. Note that during System 3000 Automatic operation, Alarm mode is immediately reset by the PLC and the system is switched to the next zone. In Manual mode, the signal is present until there is a Manual Reset.

Allow Zone X6-X10 (plus for 3004WA X30-X32): These signals are used to select the zones to be tested. Refer to the Zone Selection section of the manual for a description of their functions.

Test and Full Level X17 and X20: When 24 volts, the level has been reached or exceeded.

Cycle Repeat Timer X21: When 24 volts, the cycle repeat timing is completed. Note once the timer has finished, it is shut off, therefore X21 is a very brief transient (10 milliseconds).

(8-4) Outputs

Control Panel Lights: The functions of the lights are described in some detail in the Operations section of the manual.

Reset Relay Y2: The Reset relay is energized by the PLC when a reset is required. A contact of the relay is used to reset the sensor electronics.

Alarm Relay Y3: The Alarm relay is energized by the PLC when an alarm condition occurs. It is maintained until there is a Manual Reset. The Alarm relay contacts are available to the user for external signalling devices.

Maintenance Relay Y5: The Maintenance relay is energized by the PLC whenever any of the Maintenance Mode conditions occur. Its contacts are used to deenergize the vacuum pump(s) and the sensor electronics.

Test Solenoid Y21: Energizes the test solenoid at the appropriate times in the water cycle.

Y40-Y46 (Model 3004WA Y47): These are all the outputs for devices that require 115 volts AC including the cycle repeat timer, extract motor, fill and drain solenoids, and the water zone solenoids.

Y50-Y57 (Model 3004WA only): These outputs are used to actuate the solenoid valves of the 4 station manifold assembly and the associated zone on and zone alarm lights.

(8-5) Miscellaneous PLC Connections

In addition to the inputs and outputs there are several other connections to the PLC. These include: line voltage to power the unit, a jumper from the internal 24 V to the run input, a jumper between SS and OV to define a +24 input as a logic 1, a connection between the PLC OV and the System 3000 common, jumpers to connect all the SG terminals, and the +24 or 115 volts to power the outputs.

(8-6) Checking for PLC Failures

Each PLC unit has two sets of red light emitting diodes, LED's associated with each bank of inputs and outputs. When the LED is lit, it means the input or output is in the logic 1 or ON condition. The LED's provide a useful tool for troubleshooting. For example, if depressing a push-button the desired affect does not occur, by checking the LED you can determine whether the signal is reaching the PLC. Additionally, the PLC base unit has two green LED's that show power on, and whether the system is running the program. There are also two red LED's, one for low battery voltage and one that shows a program error.

The Program in the PLC is in EPROM memory so there is no need to be concerned about internal battery life. When power is applied to the system, the PLC loads the EPROM program into active memory. If the error LED is lit or there is a concern that there may be a problem with the program, deenergizing the system and then reapplying power will reload the program.

If the green RUN Led is not lit, check for the jumper between the PLC 24V and RUN.

(8-7) Sensor Electronics

The sensor operates by heating the sampled air to a temperature of approximately 900° Celsius. This ionizes any halogen based hydrocarbons present in the sample. The ions are attracted to the collector of the sensor, resulting in a small current flow. The amount of current is proportional to the relative concentration of the refrigerant in the air.

The sensor electronics are divided into two major sections. One section provides the necessary current and voltages to the sensor and detects the output signal current. The second section contains the microprocessor digital control elements that analyze the sensor signal, compare it to the trip point, and provides the necessary outputs to the PLC.

Sensor Power Circuit: Figure 8 is a block diagram of the sensor power circuit. Power for the sensor drive enters the main board on pins J1-1 and J1-2. After fuse F1, bridge BR2 provides DC power to the sensor filament circuit. Note that the filament current portion of the circuit is tied to the high voltage so that the entire filament supply portion of the electronics is referenced to the 180 volts DC and not to ground or common.

Filament current is provided to the sensor through power transistor Q2 which is controlled by the pulse width modulator (PWM). The pulses from Q2 are smoothed by the filter section, and then output to the sensor on pins J2-2 and J2-3.

During operation, the filament current is controlled by the small bridge board mounted next to the main board. The sensitivity and calibration of the unit depend strongly on the temperature of the heated air sample. The filament is a platinum wire which is an excellent temperature sensor. Therefore, to compensate for changes in ambient air temperature and any fluctuations in air flow through the sensor, it is necessary to accurately control the temperature of the filament.

Control of the filament temperature is accomplished by the bridge board. The filament and the 0.1 OHM resistor are two legs of a Wheatstone bridge. The other two legs are a combination of precision resistors and a current (hence temperature) setting potentiometer. The error signal from the Wheatstone bridge is summed with a base current setting, and the combined signal is the input to the PWM. Any external changes such as ambient air temperature will be detected by the bridge and will change the signal to the PWM, which will then adjust the filament current to compensate for the change.

The filament enable signal comes from the digital electronics and it either allows or blocks the filament current depending on the status of the system. Similarly the high voltage enable (HV) signal either blocks or allows high voltage to be applied to the sensor depending on system status. Additionally the PWM logic provides a current limiting signal to the PWM. When the tube is cool the filament resistance is quite low, so current is limited to a maximum of 5 amps.

Once the sensor is warmed up, its normal operating current ranges from 3.5 to 4 amps dc.

When the sensor is at operating temperature and high voltage is enabled, the signal current flows through the voltage divider network composed of R9 and R11. The voltage across R11 is buffered by a unity gain amplifier and then supplied to the analog to digital convertor of the digital control portion of the main board. The sensor signal can range from 0.1 volts or less when there are no refrigerants present to a high of 1.5 volts at 100 ppm when the system is calibrated for 100 ppm full scale.

Digital Control: Figure 9 is a block diagram of the microprocessor based control circuit. This circuitry provides two main functions. First, it analyzes the sensor signal and takes any action required. Second, it controls the process and does the necessary interfacing with the rest of the system.

The first step in analyzing the sensor signal is to convert the analog voltage to a digital word. Because the sensor output is not linearly related to the refrigerant concentration, the next step is to compare the digital value to a calibration table, and develop a digital word that is directly proportional to the ppm level. The “refined” sensor level is then input to a digital to analog converter which supplies a 0 to 5 volt output signal that goes to the ppm meter and is available to the user.

The calibrated sensor level is also compared to the trip point setting on switch S2. If the sensor level equals or exceeds the trip point, the system goes through the leak wait timing procedure. If the sensor level remains equal or above the trip point, the system goes into Alarm Mode.

The EPROM contains the program for running the system. The RS485 circuitry provides a means for the system to talk to an external computer via a serial communications port. The latch and output drivers provide an interface to the sensor power circuit.

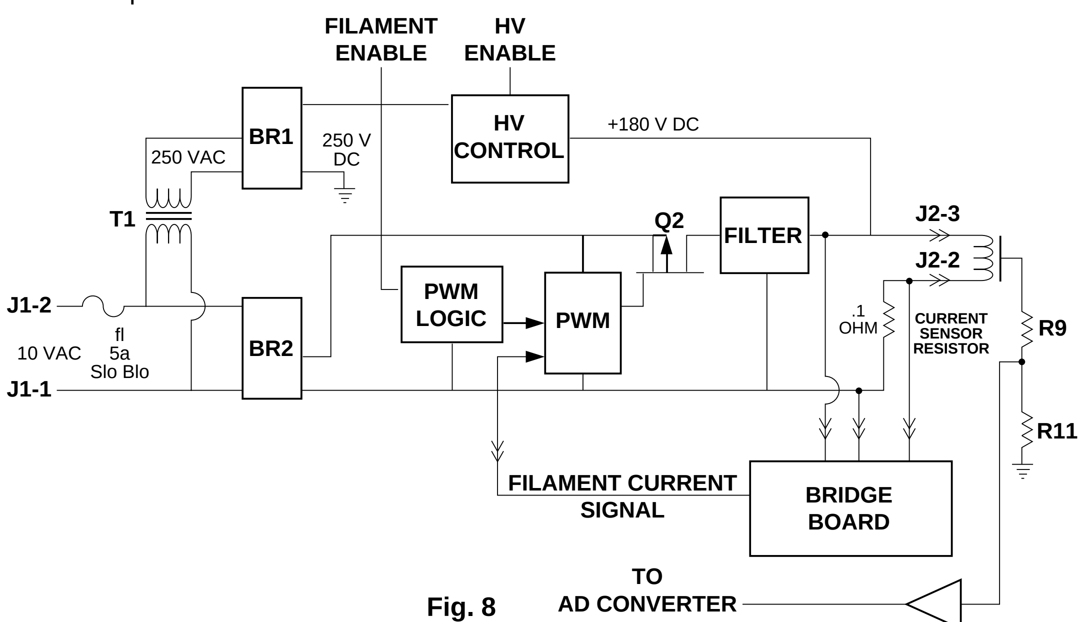


Fig. 8
Sensor Power Circuit

The system has several operating modes. When power is first applied or after a reset, the system is in Warm-up Mode. The filament is enabled. High voltage is off. The D/A output is set at 0 volts and the Alarm relay is deenergized. After 2.5 minutes, high voltage is enabled and the D/A displays the calibrated sensor signal, but there is no testing for a leak condition. After an additional 30 seconds, the system goes into normal monitoring mode waiting for a potential leak.

When the sensor signal equals or exceeds the trip point, the system enters Leak Wait mode. In Leak Wait, the D/A output is alternately turned on and off causing the meter reading to oscillate between 0 and the actual ppm level and the Leak Wait signal is turned on. The system waits for 5 seconds to confirm that there is a leak condition. Should the PPM level fall below the trip point during this period, the system reverts to monitoring mode.

If the ppm level remains at or above the trip point, the system starts another leak wait timing period. This second time period is variable depending on the size of the difference between the trip point and the actual ppm level. For maximum signals, the delay is two (2) seconds, and for minimum signals the delay can be up to three (3) minutes. This timing is to eliminate false alarms caused by transient conditions. If during this second time period, the ppm signal falls below the trip point, the second timer is stopped and the original five (5) second timer is reinitiated. If the signal stays below the trip point, leak wait is aborted and the system goes back to monitoring. If the ppm level rises to the trip point or above before the five (5) seconds are up, the second time period is resumed. After the second timer times out, the system goes into Alarm Mode.

In Alarm Mode, the Alarm Relay is energized. High voltage and filament current are shut off.

The D/A output is left at the the last ppm level that existed as the system went into Alarm mode. The system now waits for an external reset. If the System 3000 is in Automatic mode, the PLC switches to the next zone and resets the sensor electronics to Warm-up.

Function switch S1 provides a means of putting the system in Test Mode. Please note that Test Mode should only be used for trouble shooting. For normal operation, the function switch **MUST** be in Run Mode.

In Test Mode, high voltage and filament current are enabled. The system ignores the trip point setting and will not go into Leak Wait or Alarm. It simply continues to monitor the ppm level and provide an output to the analog meter.

The sensor electronics are calibrated at the factory with the specific sensor being used in the equipment. None of the potentiometers on the two sensor electronics boards should be readjusted in the field. If there is a problem with either the sensor or the sensor electronics, call the factory. The fuse may be replaced without disturbing calibration.

The RUN/CAL switch on the bridge board is used during the calibration procedure at the factory. In the CAL position, the Wheatstone bridge is bypassed and a constant signal is provided to the filament current amplifier. Generally in the CAL position, sensor current will be higher than in the normal RUN position. The switch **MUST** be in the RUN position for normal operation.

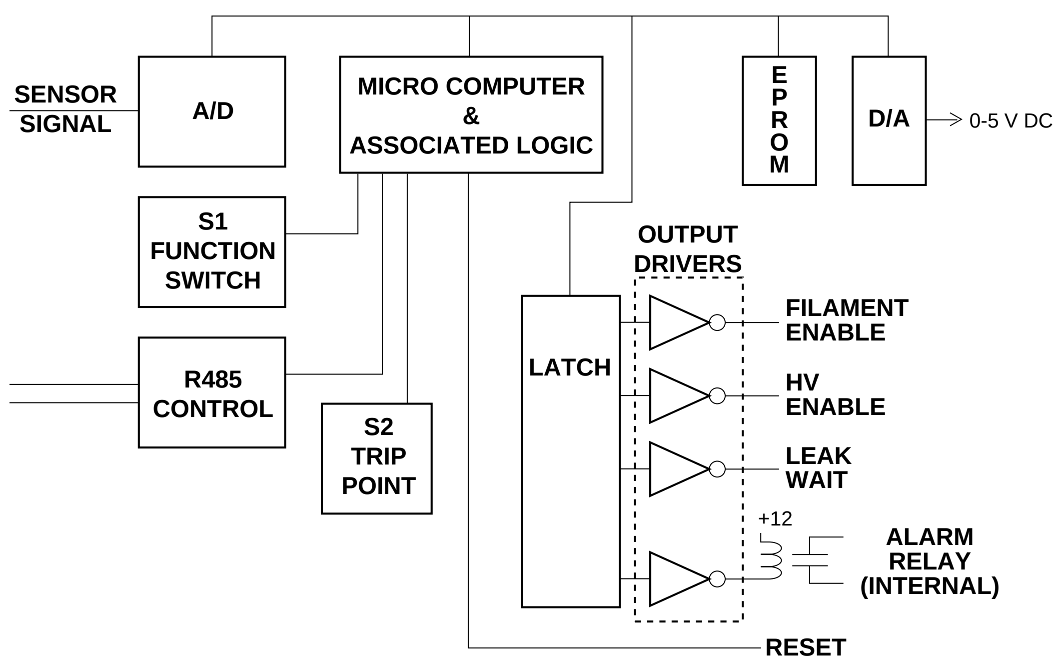


Fig. 9
Electronics Digital Control

APPENDIX A

TRIP POINT AND FUNCTION SWITCH SETTINGS

There are two 8-position dip (dual in-line package) switches on the main control board, see Appendix Diagram A-1. Switch S1 is a function switch. Switch S2 is used to set the trip point for Alarm Mode.

S1 Function Switch

Positions 1 through 7
These positions are used to set parameters for communicating to external devices and computers. If you have one of these options, refer to the instruction literature provided with the option for information on how to set the switches. If you are not using the external communications capabilities, you can ignore positions 1 to 7. They do not affect any other function.

Position 8 Run/Test
Position 8 determines whether the unit is in Run Mode or Test Mode. Test mode is used for trouble shooting and maintenance. For normal operation the position 8 must be in run mode. Appendix Diagram "A-1" shows the switch in the run position.

S2 Trip Point

Switch 2 is used to set the trip Point, the ppm reading at which the unit will go into Alarm Mode. See the following page, Trip Point Calibration displays how to set the switch for a variety of refrigerant levels. The switch has been preset at the factory. There is a label on the inside front cover of the unit with the value of the preset trip point. If the switch setting is changed, note this change on the label inside the front panel of the unit to indicate the new trip point, when it was set, and who set it. This can be a big help in troubleshooting should a problem develop.

The switch essentially provides the computer with an 8 bit binary fraction of the full scale of the unit. For example if full scale of the monitor is 100 ppm, setting position 8 will be a trip point of 50 or half of full scale. Position 7 is one fourth of full scale, and so on down to position 1 which is one two hundred and fifty-fifth of full scale. By combining switches, it is possible to get any trip point required. For ease of use, it is suggested that you use the chart provided (Diagram A-2).

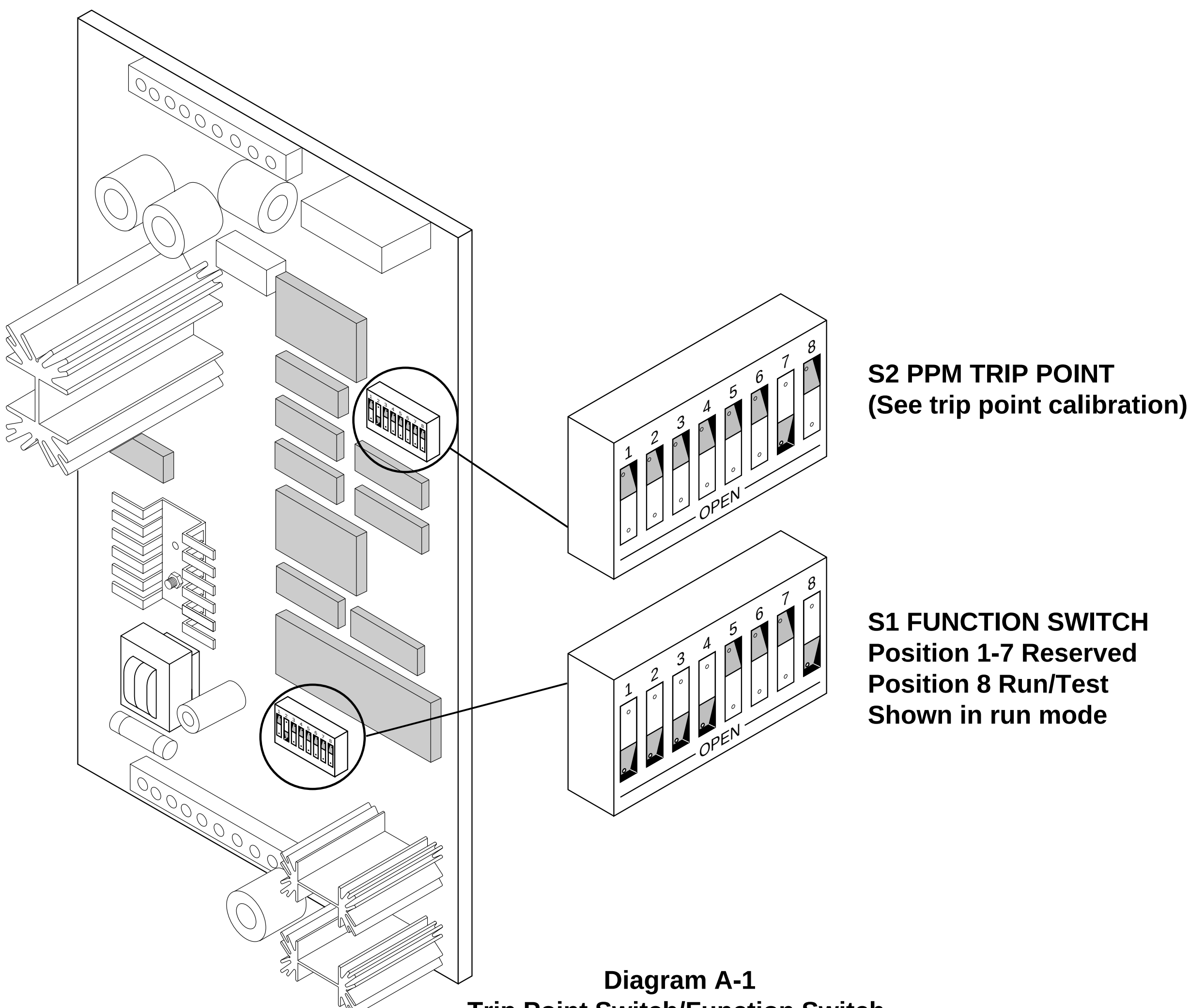


Diagram A-1
Trip Point Switch/Function Switch

TRIP POINT SETTINGS
100 PPM FULL SCALE CALIBRATION

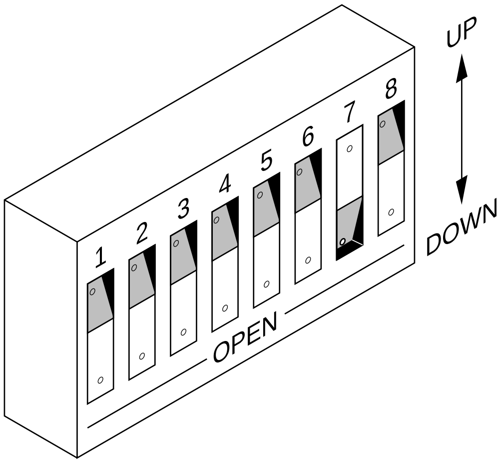


FIGURE 1
TRIP POINT SETTING
@ PPM - 25
(DIP SWITCH - 7)

PPM	DIP SWITCH DOWN
*0	NONE
5	1,3,4
6.75	5
10	1,4,5
12.5	6
15	2,3,6
20	1,2,5,6
25	7
30	1,3,4,7
35	1,4,5,7
40	2,3,6,7
45	1,2,5,6,7
50	8
60	1,4,5,8
70	1,2,5,6,8
80	3,4,7,8
90	2,3,6,7,8
*100	1,2,3,4,5,6,7,8

Not recommended unless normal ambient very high (40–90 PPM)

*** DO NOT USE**

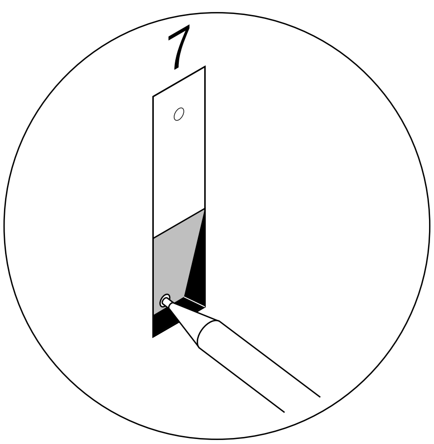


FIGURE 2
USE A PENCIL OR FINE TIP PIN
TO SET THE SWITCHES
(ILLUSTRATION SHOWS SWITCH #7 DOWN)

Diagram A-2
Trip Point Setting Chart

APPENDIX B
TECHNICAL PROCESS CONSIDERATIONS

A user of the SenTech Environmental System 3000 is interested in the amount of refrigerant that may be leaking per unit time (#'s/day or kgs/day). The System 3000 actually measures the Parts Per Million (PPM) by volume of refrigerant released into the test chamber. The technical discussion that follows will show the correlation between PPM reading and the actual leak rate.

Diagram B-1 is a schematic of the condenser side of a typical water-cooled chiller. Some systems may be open loop using river water, for example, but the results are the same as for a closed loop system.

Assumptions
The analysis is based on the following assumptions:

1. The refrigerant leak into the condenser is a constant amount per unit time.
2. The refrigerant mixes thoroughly with the cooling water. This assumption may not be completely valid if the leak is very close to the cool water outlet. However if that is the case, the system will show a higher leak rate than actual so the assumption is conservative.
3. The extraction process is 100% efficient and all of the refrigerant is released from the water sample into the test chamber. This is an optimistic assumption and will be discussed below.
4. Any refrigerant that has leaked into the system is sufficiently dissipated in the cooling tower such that there is no significant affect on the results.
5. Any chlorine, bromine, or other treatment of the cooling or makeup water will not affect the results.

Definition of Variables

C = Concentration of refrigerant in the condenser water in pounds/gallon (kgs/m^3)

D = Density of the refrigerant being used in pounds/cuft (kgs/m^3)

LR = Leak rate in pounds (kgs) per unit time

t = Time

V = Volume of the condenser in gallons (m^3)

W = Cooling water flow in and out in gallons/minute (m^3/minute)

When are steady conditions reached ?
In the steady state, the amount of refrigerant leaking into the system has to equal the amount of refrigerant leaving the condenser with the outlet cooling water. The question that has to be answered is, how long will it take for the steady state to be reached? The equation that describes this system is:

$$\text{Eqn 1:} \quad C = \frac{LR}{W}\left(1 - e^{-\frac{W}{V}t}\right)$$

Once W/V is equal to 2 or 3, the system has essentially reached steady state. That is when cooling water passing through the condenser is equal to two or three times the volume of water in the condenser, the system has reached steady state and transient conditions can be ignored.

Steady State Equations. In the steady state:

$$\text{Eqn 2:} \quad LR = C \times W$$

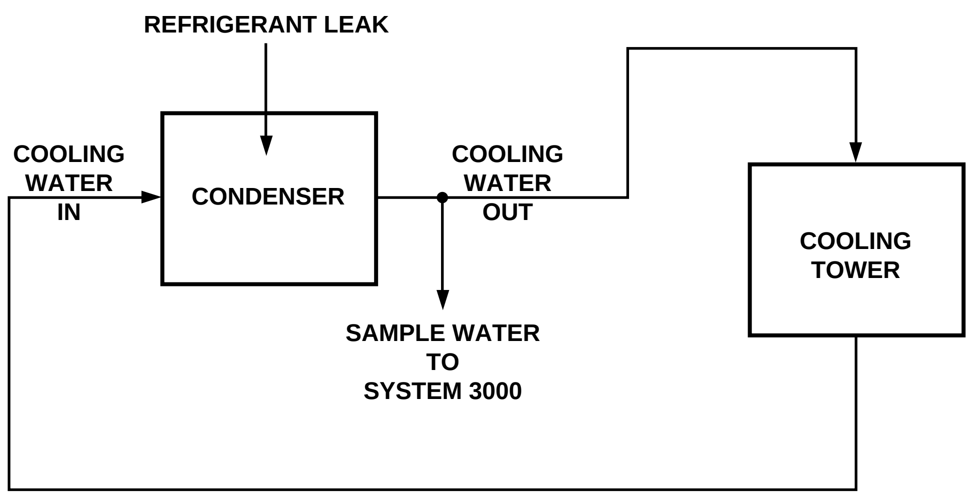


Diagram B-1
Condenser Schematic

English Units

(use this column for English units of measure)

The leak rate in pounds/min equals the concentration in pounds/gallon times cooling water flow in gallons per minute.

The concentration is directly related to the PPM reading except that the PPM reading is by volume rather than by weight. Basically the PPM reading is millionths of gallons per gallon. To convert to weight, we need to use the density of the refrigerant being used.

$$\text{Eqn 3: } C\,\frac{\#}{gal} = PPM \left(\frac{10^{-6}\,gal}{gal}\right) X\ D\left(\frac{\#}{cuft}\right) X \left(\frac{1cuft}{7.5\ gal}\right)$$

If we substitute Equation 3 for C in Equation 2, we will get leak rate in pounds per minute.

$$\text{Eqn 4: } LR\,\frac{\#}{min} = PPM\ X\ D\ X\ 1.33\ X\ 10^{-7}\ X\ W$$

Pounds per minute is an inconvenient number. To convert the results to pounds per day, multiply by 1440 (the number of minutes in a day).

$$\text{Eqn 5: } LR\,\frac{\#}{day} = PPM\ X\ D\ X\ 1.915\ X\ 10^{-4}\ X\ W$$

The densities for some commonly used refrigerants are:

Refrigerant	Density (#/cuft)
R12	.31
R22	.22

Typical Examples

Example 1. Given an R22 system with a cooling water flow rate of 2000 gallons per minute and a System 3000 reading of 50 PPM, what is the leak rate in #'s/day? Substituting the given conditions into Eqn 5:

LR = 50 X .22 X 2000 X .0001915
LR = 4.2 pounds/day

Example 2. Given an R12 system with a cooling water flow rate of 10,000 gallons per minute and a System 3000 reading of 40 PPM, calculate the leak rate. Substituting into Eqn 5:

LR = 40 X .31 X 10,000 X .0001915
LR = 23.8 pounds/day

Metric Units

(use this column for metric units of measure)

The leak rate in kgs/min equals the concentration in kg/m^3 times cooling water flow in m^3 per minute.

The concentration is directly related to the PPM reading except that the PPM reading is by volume rather than by weight. Basically the PPM reading is millionths of m^3 per m^3. To convert to weight, we need to use the density of the refrigerant being used.

$$\text{Eqn 3: } C\,\frac{kg}{m^3} = PPM \left(\frac{10^{-6}\ m^3}{m^3}\right) x\ D\ \frac{kg}{m^3}$$

If we substitute Equation 3 for C in Equation 2, we will get leak rate in kgs per minute.

$$\text{Eqn 4: } LR\,\frac{kg}{min} = PPM\ x\ D\ x\ 10^{-6}\ x\ W$$

kilograms per minute is an inconvenient number. To convert the results to pounds per day, multiply by 1440 (the number of minutes in a day).

$$\text{Eqn 5: } LR\,\frac{kg}{day} = PPM\ x\ D\ x\ 1.44\ x\ 10^{-3}\ x\ W$$

The densities for some commonly used refrigerants are:

Refrigerant	Density (kg/m^3)
R12	4.97
R22	3.53

Typical Examples

Example 1. Given an R22 system with a cooling water flow rate of 8 m^3 per minute and a System 3000 reading of 50 PPM, what is the leak rate in kgs/day? Substituting the given conditions into Eqn 5:

LR = 50 X 3.53 X 8 X 1.44 X 10^{-3}
LR = 2.0 kgs/day

Example 2. Given an R12 system with a cooling water flow rate of 40 m^3 per minute and a System 3000 reading of 40 PPM, calculate the leak rate. Substituting into Eqn 5:

LR = 40 X 4.97 X 40 X 1.44 X 10^{-3}
LR = 11.45 kgs/day

General Discussion

The equations developed are based on the assumptions listed above. One of the assumptions is that the extraction process is 100% efficient, or that all the refrigerant in the sample is driven out of the water into the test chamber. Test data show this is not the case.

For refrigerants whose boiling point is substantially below room temperature, 60% to 80% will extracted. As a result, the actual leak rate will be higher than that calculated from the PPM reading. As can be seen from the equations, the PPM reading and hence the detected leak rate is a function of the cooling water flow rate. Smaller leaks can be detected in smaller chillers with lower flow rates than in larger chillers. The size of leak that can be detected in any specific chiller will depend on how low the Alarm trip point can be set without experiencing false alarms.

There are two primary factors that will determine the minimum reliable trip point setting for a specific installation. The first factor depends on the normal background level of refrigerant in the air near the System 3000. If there are one or more small refrigerant leaks into air near the System 3000, they should be repaired before deciding on a trip point. The System 3000 monitors background air when it is not testing water. Should a leak into air, greater than the trip point occur, the System 3000 will go into Alarm and report a background leak.

The second factor determining the minimum reliable trip point depends on the type of chemical treatment (if any) that the cooling water receives. If the cooling water is heavily treated with chemicals containing halogen based compounds (chlorine or bromine for example), it may be necessary to adjust the trip point higher than otherwise to avoid false alarms.

Under normal, reasonably clean conditions, an Alarm Trip Point of 25 PPM should provide a good operating point. Diagrams B-2 and B-3 plot the theoretical minimum detectable leak versus cooling water flow rate, at a trip point of 25 PPM, for several common refrigerants (B-4 and B-5 plot metric units). Since the extraction process is not 100% efficient, the actual minimum detectable leak will be somewhat higher. However, the graphs provide a means of estimating how the System 3000 will perform under a particular set of conditions.

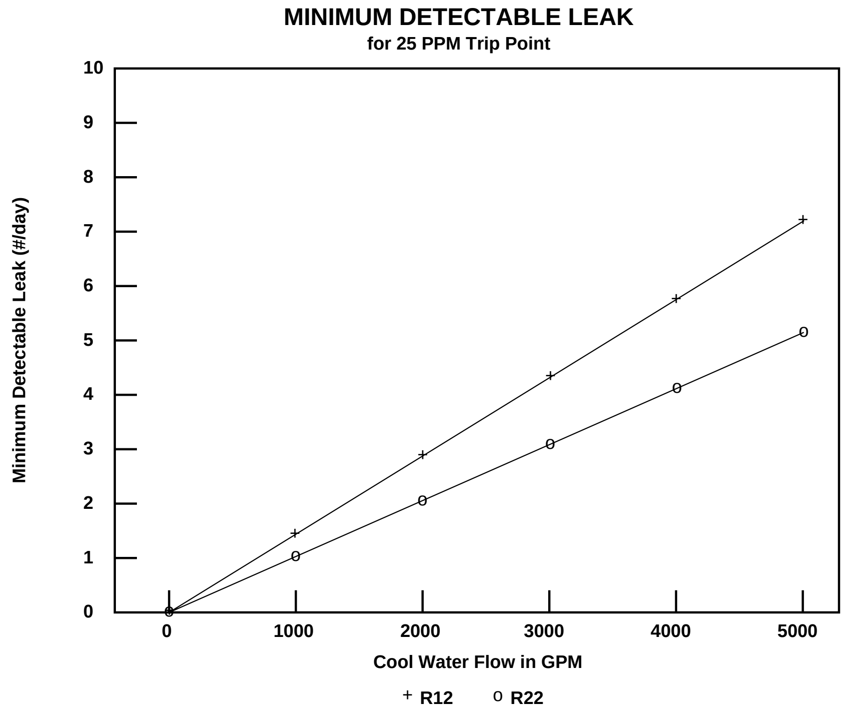


Diagram B-2 (English Units)
Theoretical Minimum Detectable Leak
versus
Cooling Water Flow Rate

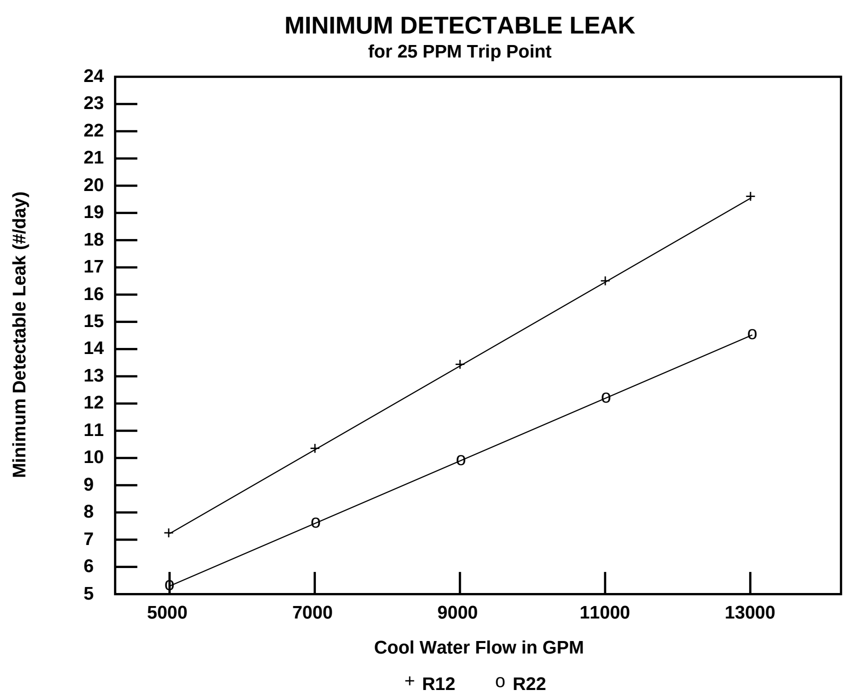


Diagram B-3 (English Units)
Theoretical Minimum Detectable Leak
versus
Cooling Water Flow Rate

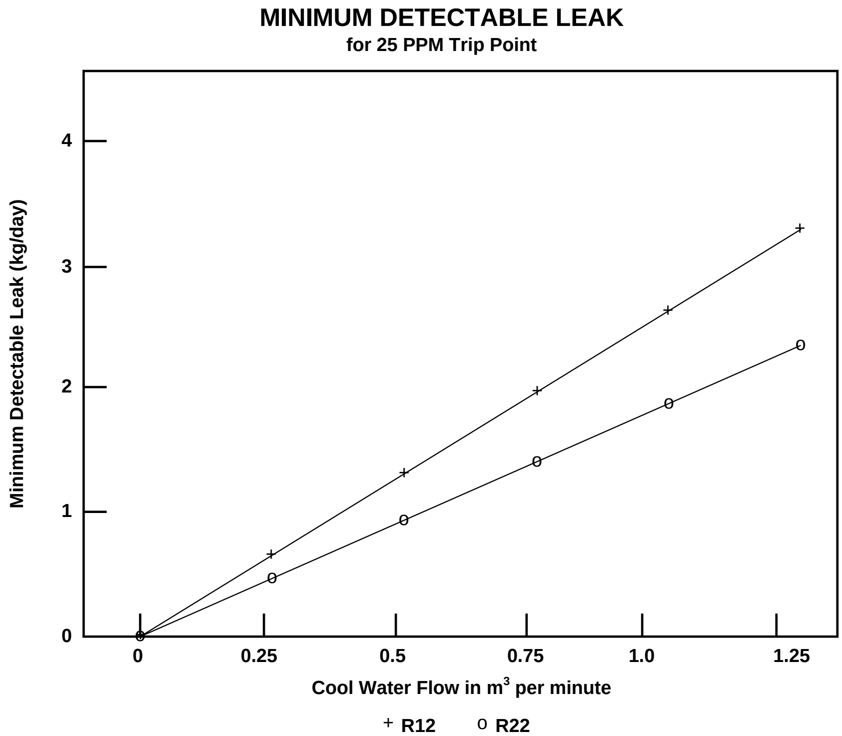


Diagram B-4 (Metric Units)
Theoretical Minimum Detectable Leak
versus
Cooling Water Flow Rate

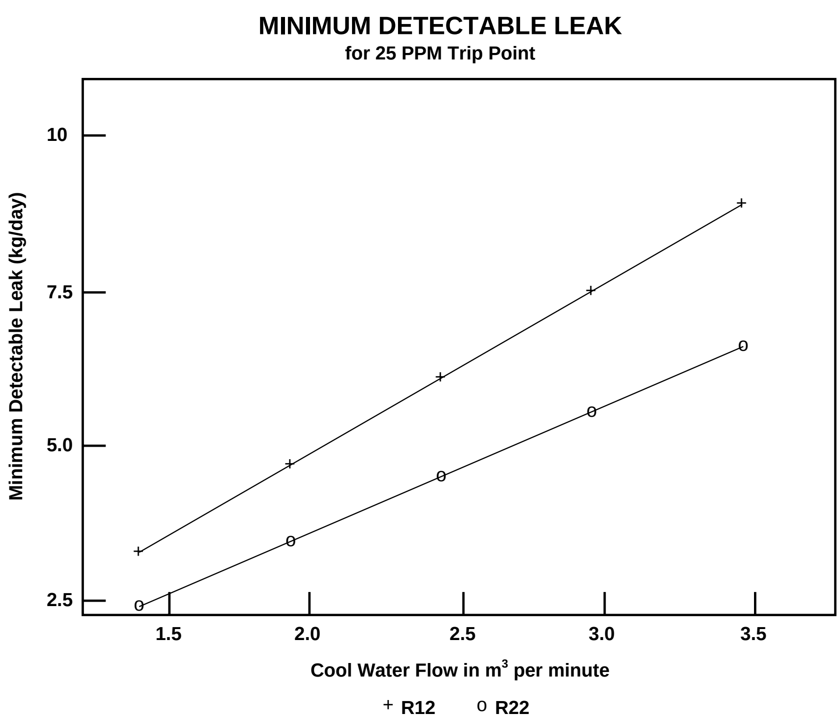


Diagram B-5 (Metric Units)
Theoretical Minimum Detectable Leak
versus
Cooling Water Flow Rate

APPENDIX C: SenTech Room Volume Considerations (English)

Normal industry practice is to think about refrigerant leaks in terms of pounds of refrigerant per unit time such as lbs/hr or ozs/yr. This is a natural and logical way of looking at it. The system monitors the amount of refrigerant present in the air in Parts Per Million (ppm) by volume of refrigerant molecules as compared to air molecules. In order to develop a relationship between the leak rate in weight per unit time and ppm reading of the monitor, there are a number of items that need to be considered and accounted for. These are:

1. Room Volume.
2. The relationship between refrigerant amount in weight compared to refrigerant volume at the temperature and pressure of the room.
3. The amount of time the refrigerant has been leaking.
4. The rate at which fresh air enters the room (stale air is exhausted).
5. The location of the monitor inlet relative to the leak, the air patterns of the room, and the rate at which the leaking refrigerant expands to fill the room.

For a given specific situation items 1 through 4 are either known, can be calculated, or can be estimated. Item 5 is virtually unknowable, therefore in all the formulas and sample calculations it is assumed that leaking refrigerant expands immediately to fill the room. This is a reasonable and conservative assumption on the basis that you have located the monitor following the recommendations outlined in the installation section. If you have followed those recommendations, the monitor should see a higher concentration sooner than the idealized formulas.

The equations have been developed for two cases. **Case I** is for a sealed room, no air turnover. **Case II** is for a room with a known turnover of air.

To be able to convert between a leak rate in cubic feet per hour to a leak rate in pounds per hour the molecular weight of the refrigerant needs to be known. If you know the molecular weight of the refrigerant, you can calculate the necessary conversion factors at normal atmospheric pressure and room temperature.

$$\frac{\text{Mol Wt(gms)}}{\text{1(mole)}} \times \frac{\text{1(mole)}}{\text{22.4(ltr)}} \times \frac{\text{1(pound)}}{\text{454(gms)}} \times \frac{\text{28.32(ltr)}}{\text{1(cuft)}} \times \frac{273}{293} = \frac{\#}{\textbf{cuft}}$$

Substituting for R-22 which is 86.48 grams/mole, you get $0.22\frac{\#}{\text{cuft}}$.

Conversion Factors for Common Refrigerants

R-22	.22 #/cuft	4.46 cuft/#
R-12	.31 #/cuft	3.18 cuft/#
R-11	.36 #/cuft	2.80 cuft/#
R-502	.29 #/cuft	3.45 cuft/#
R-123	.41 #/cuft	2.41 cuft/#

PPM READINGS AND LEAK RATE RELATIONSHIP DEFINITIONS:

PPM = Monitor PPM reading or trip point PPM setting
LR = Leak Rate of refrigerant in cubic feet per hour
FA = Fresh Air into the room in cubic feet per hour
VOL = Volume of the room in cubic feet
t = Time in hours (There are 8760 hours in one year)
R = Amount of refrigerant in the room in cubic feet
LR_{min} = Minimum leak rate that will reach a given PPM

Case I: Sealed Room

$$PPM = \frac{LR \times t \times 10^6}{VOL} \qquad t = \frac{PPM \times VOL \times 10^{-6}}{LR}$$

$$R = PPM \times VOL \times 10^{-6}$$

Case II: Room with Air Changing

$$PPM = \frac{LR}{FA}\left(1 - e^{\frac{-FA}{VOL}t}\right)10^6$$

$$t = \frac{VOL}{FA} \times \ln\left(\frac{LR}{LR - PPM \times FA \times 10^{-6}}\right)$$

$$LR_{min} = PPM \times FA \times 10^{-6}$$

Sample Calculations (Assuming The room is 40 feet by 30 BY 10 feet = 12,000 cuft)

Case I: Sealed Room

1. How much refrigerant is necessary to cause a 25 ppm reading ?

$R = 25 \times 12000 \times 10^{-6} = .3$ cuft

If it is R-22: .3 cuft x .22 lb/cuft = .066 lbs

2. If the leak rate is 300 lbs./year of R-22, how long will it take to reach 25 ppm ?

$$\frac{\text{300 lbs}}{\text{yr}} \times \frac{\text{1 yr}}{\text{8760 hr}} \times \frac{\text{4.46 cuft}}{\text{lbs}} = .153 \text{ cuft/hr}$$

$$t = \frac{25 \times 12000 \times 10^{-6}}{.153} = 1.96 \text{ hrs}$$

Case II: Room with Air Changing

Assume the same room 12,000 cuft.
Assume fresh air at 100 cfm or 6000 cuft/hr (1 air changes in 2 hour).

1. What is the minimum leak that will reach 25 ppm ?

$LR_{min} = 25 \times 6000 \times 10^{-6} = .15$ cuft/hr

for R-22: .15 cuft/hr x .22 lb./cuft = .033 lbs/hr or 289 lbs/yr

2. How long will it take to detect a leak of 500 lbs/yr of R-22?

500 lbs/yr = .26 cuft/hr

$$t = \frac{12000}{6000} \times \ln\left(\frac{.26}{.26 - 25 \times 6000 \times 10^{-6}}\right) = 1.72 \text{ hrs}$$

3. If the trip point is set at 10 ppm, what is the minimum leak rate of R-123 that will trigger the alarm ?

$LR_{min} = 10 \times 6000 \times 10^{-6} = .06$ cuft/hr

for R-123: .06 x .41 lbs/ft = .0246 lbs/hr or 215 lbs/yr

4. How long will it take to detect a leak of 300 lbs/yr of R-123 ?

300 lbs/yr of R-123 = .0825 cuft/hr

$$t = \frac{12000}{6000} \times \ln\left(\frac{.0825}{.0825 - 10 \times 6000 \times 10^{-6}}\right) = 2.6 \text{ hrs}$$

These numbers represent worst case conditions. With the monitor placed close to the potential leak points and on the "downwind" side of the air flow, the trip points are likely to be activated sooner.

APPENDIX C: SenTech Room Volume Considerations (Metric)

Normal industry practice is to think about refrigerant leaks in terms of weight of refrigerant per unit time such as kg/hr or kg/yr. This is a natural and logical way of looking at it. The system monitors the amount of refrigerant present in the air in Parts Per Million (ppm) by volume of refrigerant per volume of air. In order to develop a relationship between the leak rate in weight per unit time and ppm reading of the monitor, there are a number of items that need to be considered and accounted for. These are:

1. Molecular weight of the refrigerant.
2. Density of the refrigerant at the temperature of the room.
3. Room volume.
4. The rate at which fresh air enters the room.
5. The location of the monitor inlet relative to the leak, the air patterns of the room, and the rate at which the leaking refrigerant expands to fill the room.

For a given specific situation items 1 through 4 are either known, or can be calculated. Item 5 is virtually unknowable, therefore in all the formulas and sample calculations it is assumed that leaking refrigerant expands immediately to fill the room. This is a reasonable and conservative assumption on the basis that you have located the monitor following the recommendations outlined in the installation section. If you have followed those recommendations, the monitor should see a higher concentration sooner than the idealized formulas.

The equations have been developed for two cases. **Case I** is for a sealed room, no air turnover. **Case II** is for a room with a known turnover of air.

To be able to convert between a leak rate in cubic meters per hour to a leak rate in kilograms per hour the density of the refrigerant must be known. At normal atmospheric pressure and room temperature.

$$\text{DENSITY(kg/m}^3) = \frac{\text{Mol Wt(gms)}}{22.4(\text{ltr})} \times \frac{273}{293} \times \frac{1(\text{kg})}{1000(\text{gms})} \times \frac{1000(\text{ltr})}{1(\text{m}^3)}$$

As an example for R-22, Mol Wt = 86.48 gm/mole.
Therefore density = 3.59 kg/m^3, or 0.28 m^3/kg

Conversion Factors for Common Refrigerants

R-22	3.59 kg/m^3	0.28 m^3/kg
R-12	4.96 kg/m^3	0.20 m^3/kg
R-11	5.76 kg/m^3	0.17 m^3/kg
R-502	4.64 kg/m^3	0.21 m^3/kg
R-123	6.56 kg/m^3	0.15 m^3/kg

PPM READINGS AND LEAK RATE RELATIONSHIP DEFINITIONS:

PPM = Monitor PPM reading or trip point PPM setting
LR = Leak Rate of refrigerant in cubic meter per hour
FA = Fresh Air into the room in cubic meter per hour
VOL = Volume of the room in cubic meter
t = Time in hours (There are 8760 hours in one year)
R = Amount of refrigerant in the room in cubic meters
LR_{min} = Minimum leak rate that will reach a given PPM

Case I: Sealed Room

$$PPM = \frac{LR \times t \times 10^6}{VOL} \qquad t = \frac{PPM \times VOL \times 10^{-6}}{LR}$$

$$R = PPM \times VOL \times 10^{-6}$$

Case II: Room with Air Changing

$$PPM = \frac{LR}{FA}\left(1 - e^{\frac{-FA}{VOL}t}\right) 10^6$$

$$t = \frac{VOL}{FA} \times \ln\left(\frac{LR}{LR - PPM \times FA \times 10^{-6}}\right)$$

$$LR_{min} = PPM \times FA \times 10^{-6}$$

SAMPLE CALCULATIONS (ASSUMING THE ROOM IS 15 METERS BY 10 METERS BY 3 METERS = 450 CUBIC METERS)

Case I: Sealed Room

1. How much refrigerant is necessary to cause a 25 ppm reading ?

R = 25 x 450 x 10 = .0011 cubic meter

If it is R-22:
Amount of refrigerant = .0011 m^3 x 3.59 kg/m^3 = .004 kg

2. If the leak rate is 150 kg/year of R-22, how long will it take to reach 25 ppm ?

$$\frac{150 \text{ kg}}{\text{yr}} \times \frac{1 \text{ yr}}{8760 \text{ hr}} \times \frac{.28 \text{ m}^3}{\text{kg}} = 0.0048 \text{ m}^3/\text{hr}$$

$$t = \frac{25 \times 450 \times 10}{0.0048} = 2.35 \text{ hrs.}$$

Case II: Room with Air Changing

Assume the same room (450 m^3).
Assume fresh air at 225 m^3/hr (1 air changes in 2 hour).

1. What is the minimum leak that will reach 25 ppm ?

LR_{min} = 25 x 225 x 10 = 0.0056 m^3/hr

for R-22:
0.0056 m^3/hr x 3.59 kg/m^3 = 0.02 kg/hr OR 175 kg/yr

2. How long will it take to detect a leak of 200 kg/yr of R-22?

200 kg/yr = 0.023 kg/hr

$$t = \frac{450}{225} \times \ln\left(\frac{.023}{.023 - 25 \times 225 \times 10^{6}}\right) = 4.0 \text{ hrs}$$

3. If the trip point is set at 10 ppm, what is the minimum leak rate of R-123 that will trigger the alarm ?

LR_{min} = 10 x 225 x 10 = .00225 m^3/hr

for R-123: .00225 x 6.56 kg/m^3 = .0148 kg/hr OR 130 kg/yr

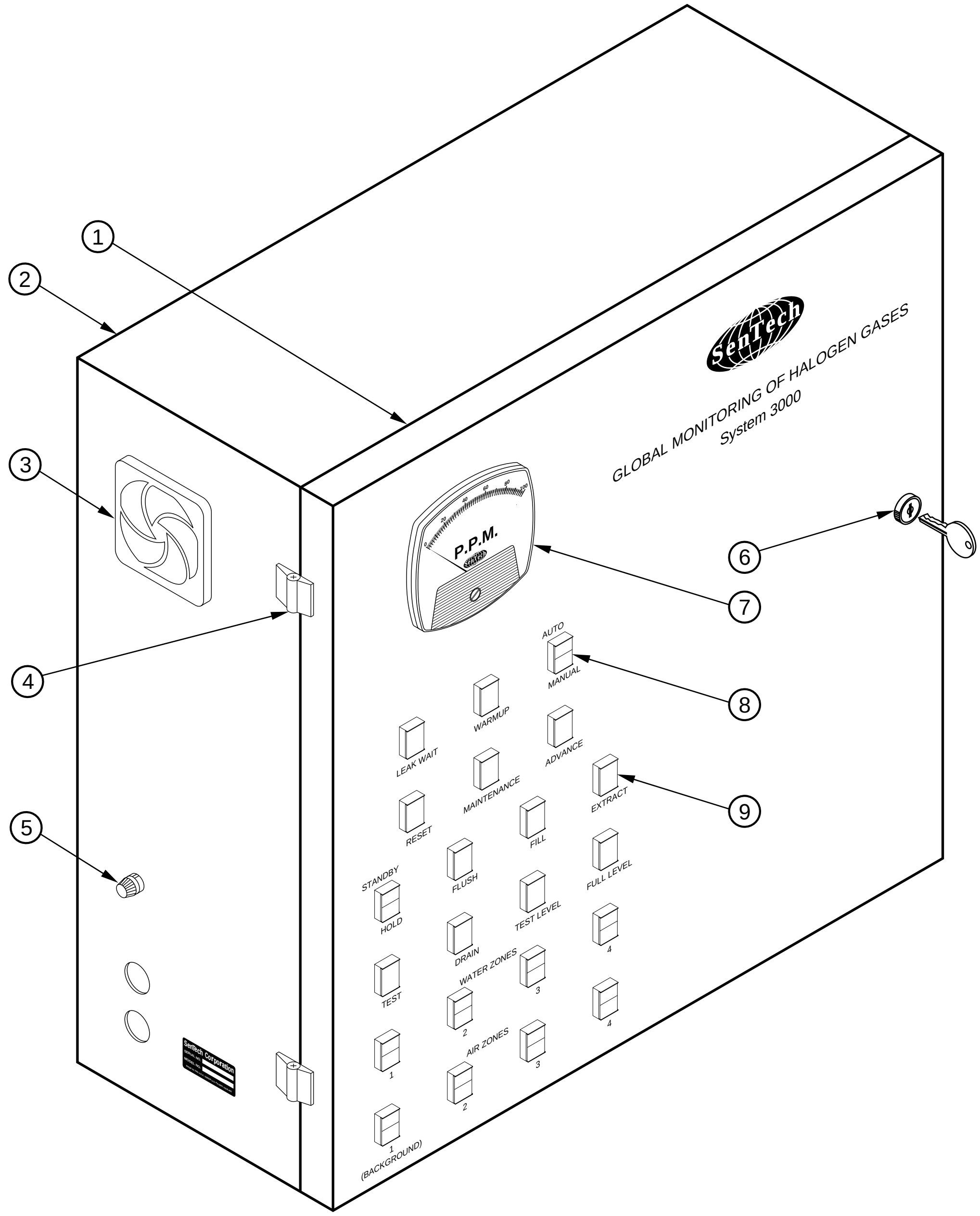
4. How long will it take to detect a leak of 150 kg/yr of R-123 ?

150 kg/yr of R-123 = .0026 m^3/hr

$$t = \frac{450}{225} \times \ln\left(\frac{.0026}{.0026 - 10 \times 225 \times 10^{-6}}\right) = 4.0 \text{ hrs}$$

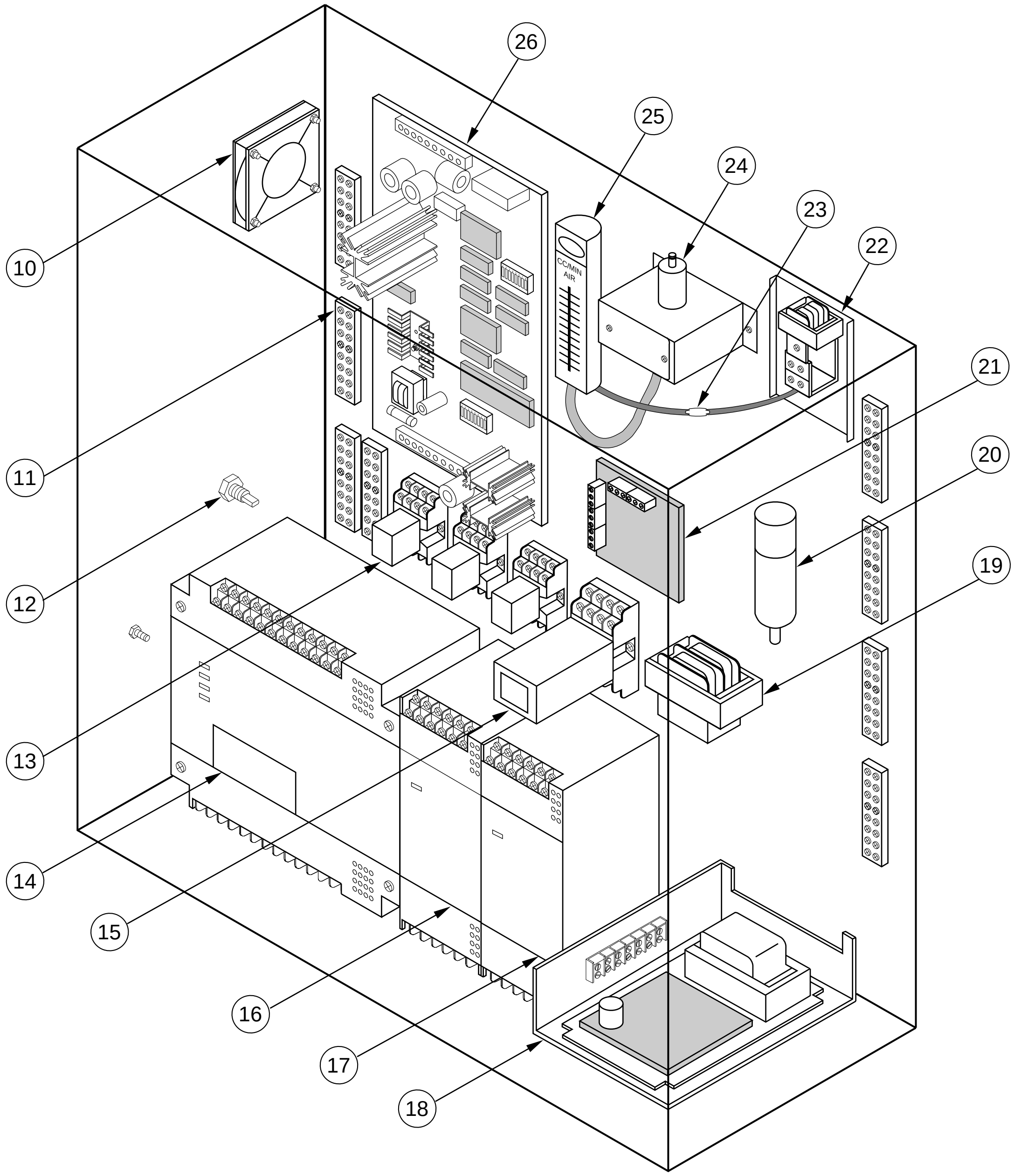
These numbers represent worst case conditions. With the monitor placed close to the potential leak points and on the "downwind" side of the air flow, the trip points are likely to be activated sooner.

SenTech System 3000
Exploded View & Parts List



1. Lid, Finished 400142
2. Box, Finished............ 400144
3. Fan Guard & Filter 410017
   Filter Replacement ... 410018
4. Hinge (2) 410050
5. Main Power Fuse 410233
   Main Power Fuse Holder 410033
6. Key Lock Assembly .. 410006
7. Meter, Analog 410010
8. Push Button Switch .. 410153
9. Panel Light 410154
   Replacement Lamp (24VDC) 410159

SenTech System 3000
Exploded View & Parts List

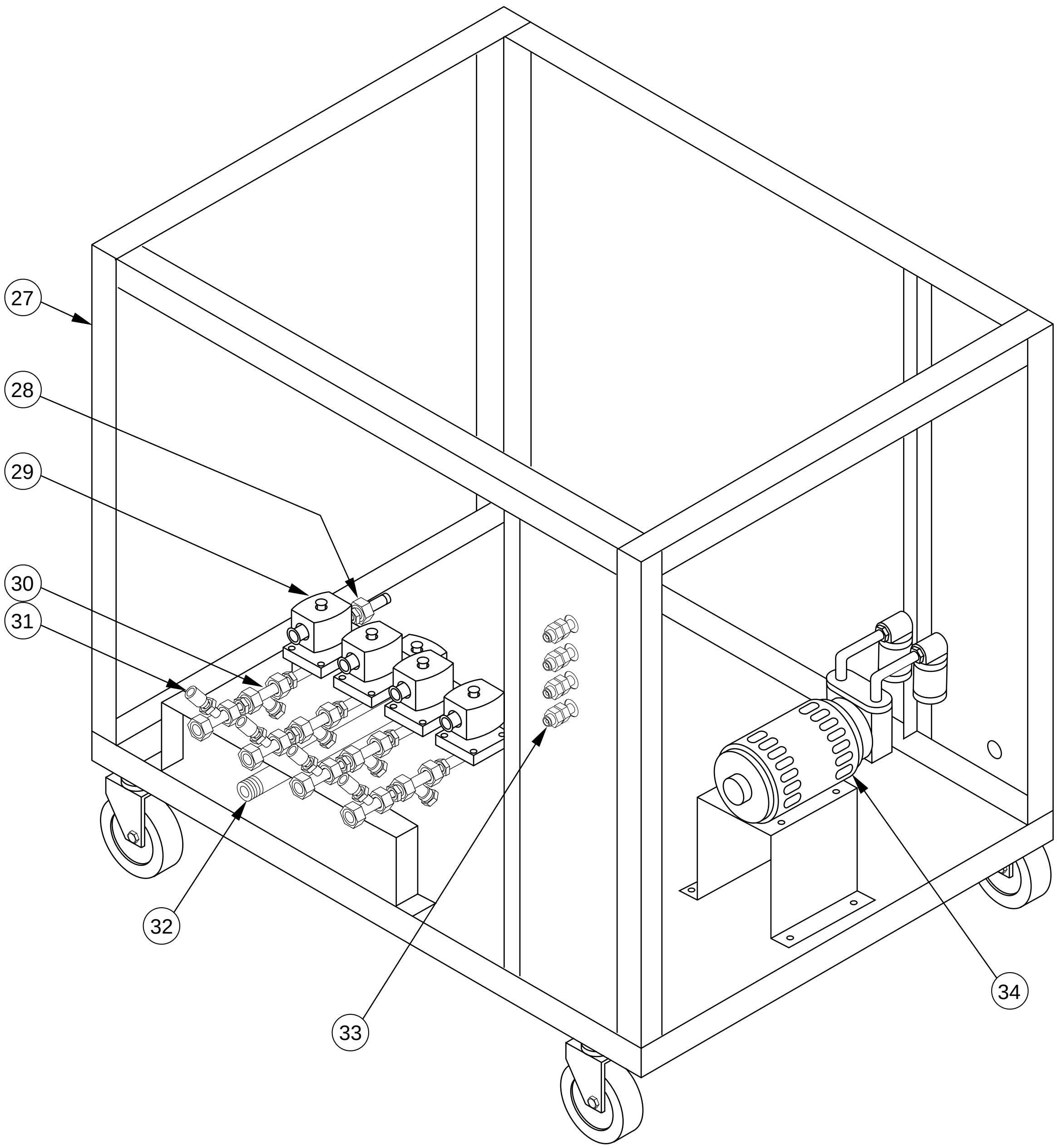


10. Exhaust Fan 410016
11. Terminal Strip,
    7 position 410041
12. Main Power
    Fuse 410233
    Main Power
    Fuse Holder 410033
13. Relay, 24 VDC (3) 410087
    Relay Socket (3) 410040
14. PLC Base Unit 410228
15. Cycle Repeat Timer . 410230
16. Relay Extension 410229
*17. Transistor
    Extension 410249
18. Power Supply
    (24 VDC) 410103
19. Transformer 410039
20. 5 Micron Filter 410122
    5 Micron Replacement
    Element 410162
†21. Bridge Board 410038
22. Diaphragm Pump ... 410224
23. Orifice Restrictor 410136
†24. Sensor 410027
25. Flowmeter 410121
    Flowmeter Bracket . 400057
†26. Control Board 410037

** Model 3004WA only*

† Replacement of any of these parts (bridge board, sensor, or control board) requires recalibration. Return to the factory for repair.

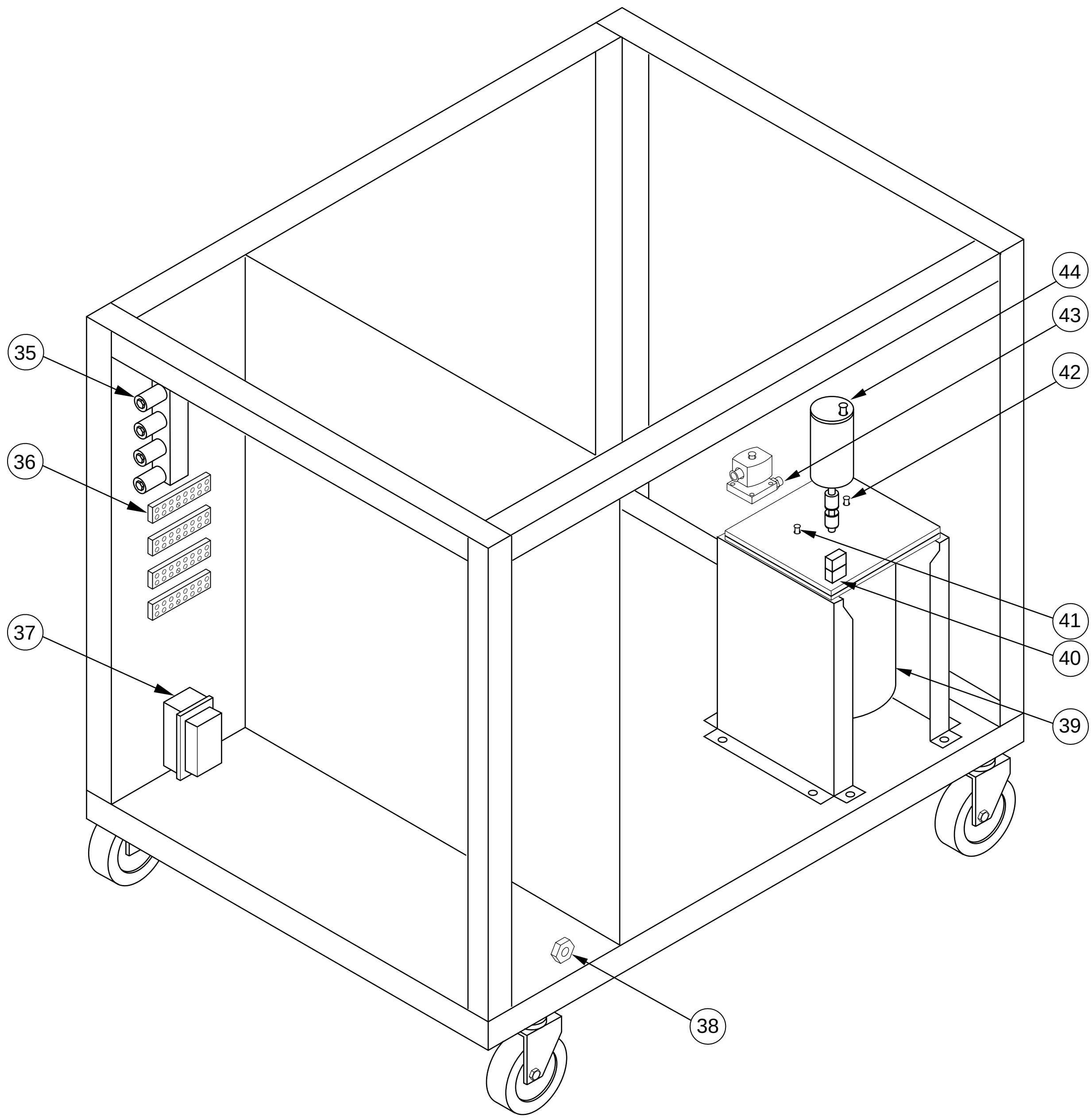
SenTech System 3000
Exploded View & Parts List



27. Frame 400097
28. Check Valve 410261
29. Water Valve 410219
30. Strainer 410221
31. Flow Control 410220
32. Drain Pipe 410267
*33. Male Connector 410132
*34. Vacuum Pump 410107

** Model 3004WA only*

SenTech System 3000
Exploded View & Parts List



*35. Air Manifold 410114
36. Terminal Strip 410041
37. Receptacle 410089
*38. Pressure Relief 410130
39. Test Chamber 410232
40. 3 Way Air Valve 410222
41. Full Switch 410225
42. Test Switch 410226
43. Fill Valve 410219
44. Mixer 410227

Model 3004WA only

ITEMS NOT ILLUSTRATED

*Course Tube Filter 410144
*Female Hose Barb 1/4" . 410151

OPTIONAL EQUIPMENT

Alarm, Visual Strobe...... 410061
Alarm, Audible Horn 410062
Alarm, Combination
Horn/Strobe 410036
Digital Display Meter 410096
*Tubing, 3/8" O.D. 410109
*Tubing Splice Fitting 410196
*20 Micron Filter Assy 410161
20 Micron
Replacement Element ... 410163

GLOBAL MONITORING OF HALOGEN GASES

SenTech, gives the following as its complete Limited Warranty Statement:

SenTech
Manufacturer's Limited Warranty

SenTech warrants to the original purchaser-user that its equipment, as originally supplied, is free from defects in materials and workmanship and will perform adequately under normal use and service, subject to the following conditions and limits:

If the equipment or any part or parts thereof prove to be defective in normal use, then such item or parts will be repaired or replaced at the option of **SenTech** by **SenTech**, provided that notice of such defect is given by original purchaser-user to **SenTech** within one (1) year from the date of original installation of the equipment.

Warranty is made on condition that such original purchaser-user has returned to **SenTech** the warranty registration form applicable to the equipment, duly and fully completed, within thirty (30) days of the date of purchase by the original purchaser-user.

SenTech's obligation under this warranty is limited exclusively to replacing without charge, or to repairing, at **SenTech's** option, upon return to Indianapolis, Indiana, transportation charges prepaid, any part or parts that shall be found to be defective in material or workmanship during the warranty period. Charges for labor (except for labor performed by **SenTech** factory for repairing defective parts) are not covered and these, plus all other costs and expenses for transportation, insurance, etc., shall be paid for by the Warrantee. If, upon inspection by **SenTech** or its Authorized Service Representative, it is determined that the equipment has not been used in an appropriate manner as described in the **SenTech** Operator's Manual or has been subject to misuse, alteration, accident, damage during transit or delivery, or that such part is from a machine on which the serial number has been altered or removed, then this warranty is void and of no further force or effect. All decisions regarding the existence of defects in material or workmanship or other causes shall be made by **SenTech's** Factory Representative and shall be final and binding upon the parties. Returns shall only be made upon the prior written authorization thereof by **SenTech**.

THE FOREGOING LIMITED WARRANTY IS EXPRESSLY MADE IN LIEU OF ANY AND ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The foregoing limited warranty shall not be enlarged or affected by, and no liability or obligation shall arise from, **SenTech's** rendering of technical or other advice, or service, in connection with any of its equipment or parts. Employees, agents, distributors, retailers, and sales representatives are not authorized to make warranties. Oral or written statements made by them do not constitute warranties and shall not be relied upon.

REPLACEMENT OR REPAIR OF DEFECTIVE EQUIPMENT OR PARTS AS PROVIDED ABOVE IS THE ORIGINAL PURCHASER-USER'S SOLE AND EXCLUSIVE REMEDY FOR CONTRACT, WARRANTY, NEGLIGENCE, TORT OR STRICT LIABILITY CLAIMS FOR ANY LOSS, DAMAGE OR EXPENSE ARISING OR ALLEGED TO ARISE OUT OF THE DESIGN, MANUFACTURE, SALE, DELIVERY OR USE OF SUCH EQUIPMENT AND/OR PARTS. IN NO EVENT SHALL SENTECH BE LIABLE FOR ANY AMOUNT IN EXCESS OF THE PURCHASE PRICE OF THE EQUIPMENT, OR FOR LOSS OF USE OR PROFITS, LOSS OF BUSINESS INTERRUPTION, ATTORNEY'S FEES, OR CONSEQUENTIAL, CONTINGENT, INCIDENTAL OR SPECIAL DAMAGES CAUSED OR ALLEGED TO CAUSED IN WHOLE OR IN PART BY THE NEGLIGENCE, TORT, STRICT LIABILITY, BREACH OF CONTRACT, BREACH OF WARRANTY, OR OTHER BREACH OF DUTY OF OR BY SENTECH.

SenTech
P.O. Box 42905
2020 Production Drive
Indianapolis, Indiana 46242-0905

THIS LIMITED WARRANTY IS NOT TRANSFERABLE.

Warranty Information

Remove the Check Test Start (CTS) form from the pocket of this manual and fill it out in its entirety. Return the original (top) copy to SenTech by folding as instructed on the reverse of copy. Dealer/Distributor retain second copy and Owner/Operator retain third copy.

Replacement Parts

When ordering replacement parts, specify the part numbers, give the description of the part, the model number and the serial number of the machine.

Parts Order Procedure

Always order parts from your SenTech dealer. If for some reason you cannot contact your dealer, you may order directly from the factory. Be sure to use the following order procedure:

1. Order on your purchase order letterhead.

2. Specify shipping instructions. If any order is received without specific shipping instructions, the order will be shipped best way.

3. Indicate the quantity desired, the part number, and the part description.

4. Always indicate the model number and the serial number of the machine for which the part is being ordered. In the back of this manual is an exploded view drawing and parts list of your SenTech machine. This will assist in ordering parts.

5. Regular mailed orders normally take three (3) days to process and ship.

6. All prices are subject to change without notice.

7. Parts Terms: All parts will be sent c.o.d. unless previous billing arrangements have been made. Customer is responsible for all freight and c.o.d. charges.

8. All shipments are made f.o.b. Indianapolis. By acceptance of a package, the carrier assumes liability for its deliveries to the customer in good condition. If a package is lost or damaged, immediately file a claim with the carrier, not SenTech.

Parts Return Procedure

1. No warranty parts shall be returned to SenTech without written authorization from the factory parts department.

2. When any part is returned to SenTech for any reason, such part must be properly identified.

3. Parts returned without proper identification will be kept for a reasonable period of time and disposed of as seen fit. In such cases, no credit will be issued.

4. Nondefective parts will be returned to the customer at the customer's expense.

5. If a letter is written pertaining to any refund part, this letter should be attached to the package containing the part.

6. All correspondence pertaining to parts must be directed to the SenTech Parts Department at:

SenTech
2020 Production Drive
Indianapolis, Indiana 46242-0905

7. All parts are sold f.o.b. factory.

8. Parts returned "collect" will be refused by our shipping department.

SenTech