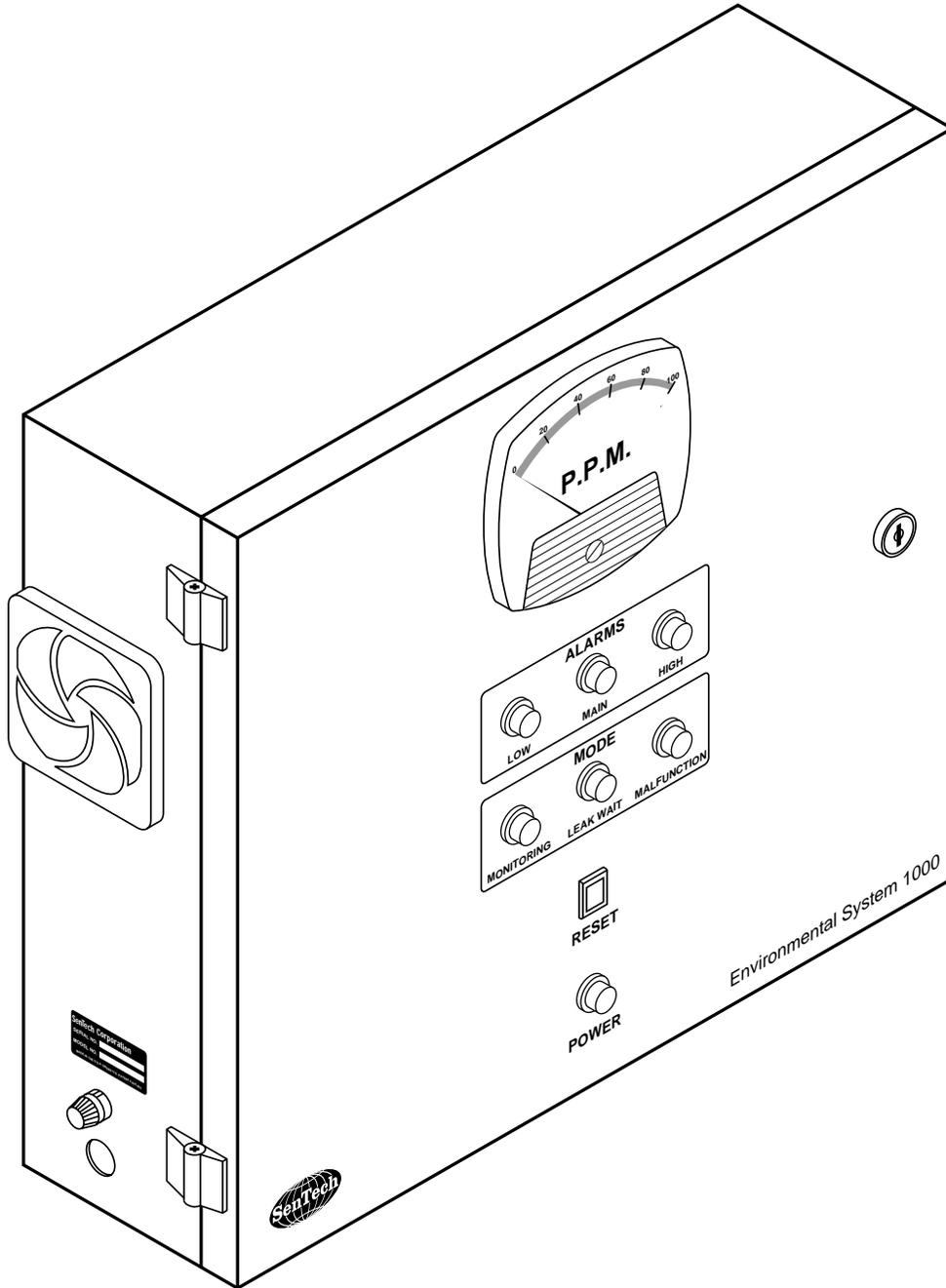




INSTALLATION AND OPERATION MANUAL ENVIRONMENTAL SYSTEM 1000 MODEL 1033 (Series II)



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Model 1033 Specifications

Size: 16 1/2" X 15" X 6 3/4"
(42 cm X 38.1 cm X 17 cm)

Weight: 25 lbs
(11.4 kgs)

Power: 120/240 Volt, 50/60 Hz (60 Watt)
100/200 Volt, 50/60 Hz (60 Watt)

Temperature: 32°- 125° Fahrenheit
(0°- 50° Centigrade)

Range: 0 - 100 P.P.M. Standard
0 - 1000 P.P.M. (For HFC's)

Trip Point: Low Alarm 0 - 15% of FS
Main Alarm 0 - 100% of FS%
High Alarm 100% of FS% (fixed)

Leak Wait: Varies from seven (7) seconds to
three (3) minutes depending on
refrigerant concentration

Alarm Output: Low, Main, and High Alarm Relays
Four (4) form C contacts rated 5
Amps maximum

INTRODUCTION/OVERVIEW

The SenTech Environmental System 1000, Model 1033 provides an early warning of developing refrigerant leaks. The unit continuously samples ambient air and measures the amount of halogen based refrigerant gases in the air sample. When the proportion of halogens present exceeds a trip point, the system goes into Alarm Mode notifying the user. By discovering the existence of a leak before the refrigerant loss has become great enough to be evident from a loss in equipment performance, the potential refrigerant loss is reduced saving money and helping protect the environment.

Basic Concept

Refer to the Model 1033 Block Diagram (Fig. 1). The diaphragm pump draws room air from the pickup tube, through the 5 micron filter, the orifice, and flowmeter into the sensor. The air flows across a heating element in the sensor which ionizes any halogen based molecules present. The ionized halogens cause a current to flow which is proportional to the amount of ions present. The microprocessor controlled circuitry measures the current and provides an output reading of the concentration in PPM (parts per million).

Sensitivity

The system is sensitive in varying amounts to all of the normal halogen based refrigerants, that is those molecules that contain either fluorine, chlorine, or both. Because of the variation in sensitivity each unit is calibrated at the factory for the specific refrigerant it is to monitor. In the event no refrigerant has been specified, it is calibrated for R-22. When appropriately calibrated, the Model 1033 can sense concentrations as low as 1 ppm.

There is no direct relationship between the amount of refrigerant leaking and the concentration level being measured. The size of the room, the location of the monitor relative to the leak point, and the air pattern, all will affect the actual concentration at the monitor. However, by judicious location of the monitor (see installation section) and maintaining the trip point at a level not too far above the ambient, leaks should be detected substantially before they otherwise would be noticed.

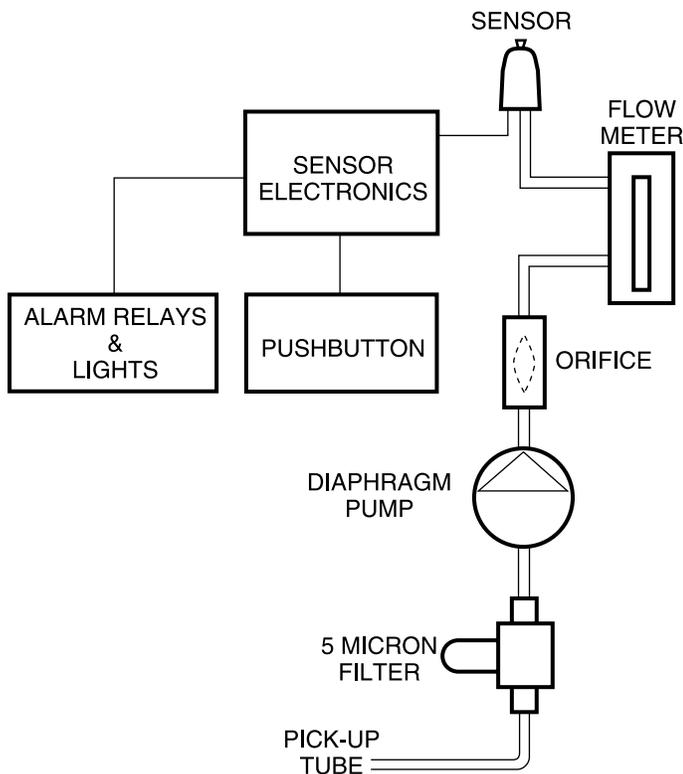


Fig. 1
Model 1033 Block Diagram

The unit also compares the ppm level to the trip points. When the low trip point is exceeded, the Model 1033 enters Low Alarm Mode. The Low Alarm light turns on, the Low Alarm relay is energized. As the Halogen level continues to increase, the unit enters Leak Wait, then Main Alarm and finally High Alarm. Each alarm level has its own Alarm light and relay.

INSTALLATION

Location

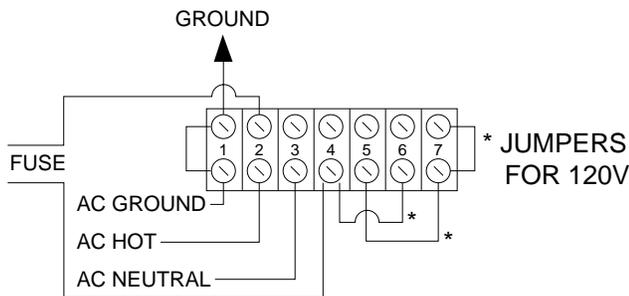
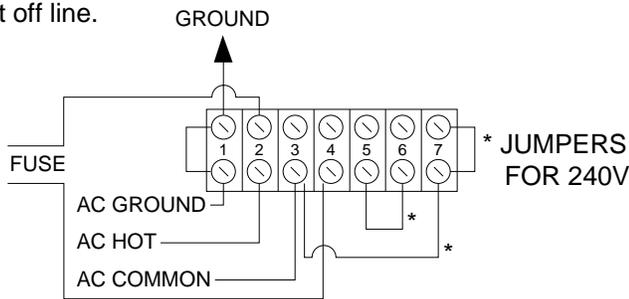
Since the sensor measures the concentration of refrigerant in air, the unit should be mounted where it is most likely to sense leaking refrigerant. The criteria to consider in selecting a location include:

1. As close to the area of potential leaks as possible. On the "downstream" side of the air flow pattern in the room.
2. The cooling and exhaust openings should be well clear of any obstructions, allowing the air to flow freely.
3. Since refrigerants are typically heavier than air, the pickup tube should be terminated 20 inches (50 cm) above the floor.
4. The unit includes sensitive electronics and a sensor operating at 900° Celsius, the area should be free from vibration to the extent practical.

Mounting and Primary Power Wiring

Packed within the Model 1033 is the container for the sensor and the CTS/Warranty card which is to be completed and returned after start-up.

1. Drill the necessary holes and mount the unit.
2. Mount the filter and secure the pickup tube.
3. Unpack the sensor and carefully insert the sensor into its socket. Make certain that the sensor is well seated.
4. Refer to wiring diagram (Fig. 2). Primary power should be supplied to the unit through the bushing located on the left side of the box. It is strongly recommended that power be supplied from a separate disconnect, **NOT** by plugging in to a wall socket. The Model 1033 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.



NOTE: UNITS FOR USE IN JAPAN ARE 100V/200V.

Fig. 2
Primary Power Wiring Diagram

OPTIONAL CONNECTIONS

Alarm Relay Contacts

Using customer supplied power, warning lights and or horns are to be connected in the manner shown (Fig. 3). Use an auxiliary contactor for heavy loads such as exhaust fans. Note: Alarm relay contacts are rated five (5) Amps maximum.

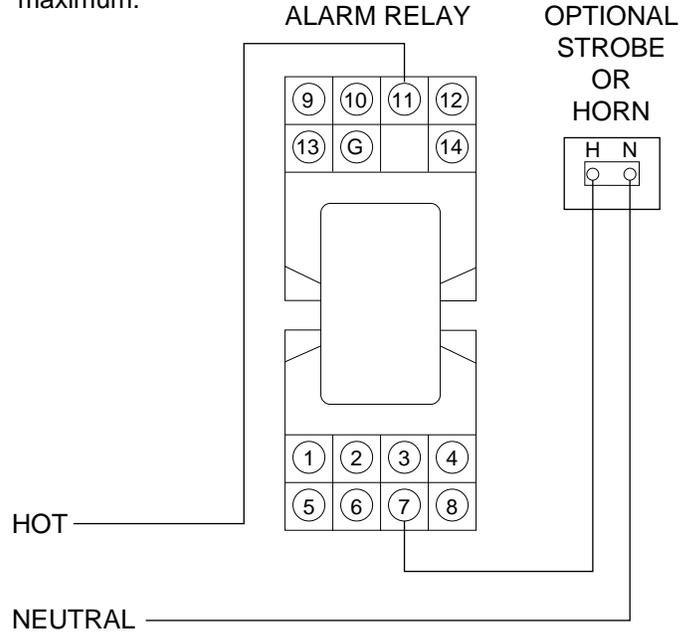


Fig. 3
Option Connection Wiring Diagram

0-5 Volt DC Analog Output

The 0-5 volt analog output is available at TB-2 (Fig. 4). Terminal 6 is the positive side of the output and terminal 7 is the negative side of the output.

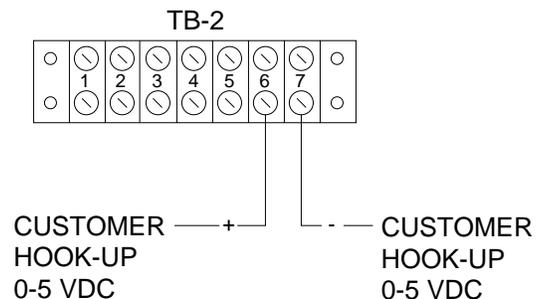


Fig. 4
Analog Output

4-20MA Output (Optional)

If the 4-20MA option has been purchased, the output is available at TB3 (Fig. 5). The positive side is at terminal 6 and the common is at terminal 7.

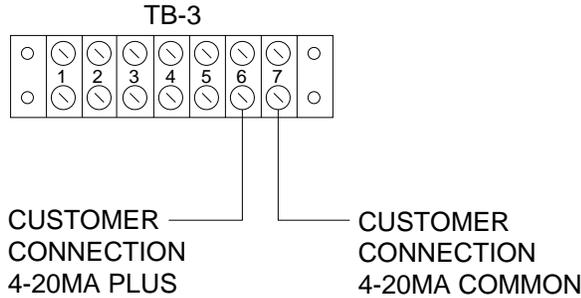


Fig. 5
4-20MA Option

RS485 Communications Port

Refer to the instruction material provided with this option.

After double checking the wiring, turn to the section on Start-up and Operations before applying primary power.

START-UP AND OPERATIONS

Before applying primary power to the Model 1030, 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.

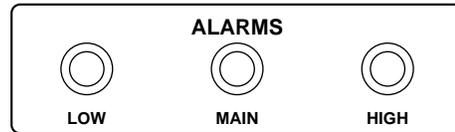
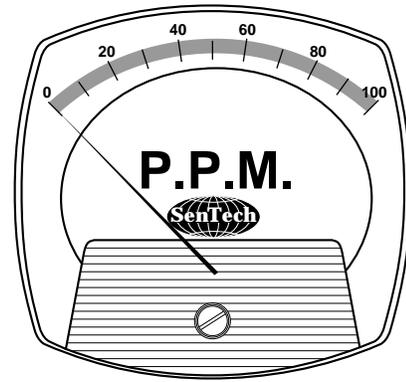
Modes of Operation

The Model 1033 has two modes of operation (Fig. 6). The Run or automatic mode that is used for normal monitoring, and a Test mode that is only used for trouble shooting. The modes are selected by a DIP switch inside the monitor enclosure (See Appendix A).

Run Mode

There are seven (7) different states or combinations of states that can occur in the Run Mode.

1. Warm-up: When power is applied or after an alarm condition has been reset, the system goes through a three (3) minute warm-up period. During Warmup, only the Power On Light is lit.



RESET



POWER

Fig. 6
Front Panel

- 2. Monitoring:** After warm-up, the system enters into Monitoring Mode. It continuously samples ambient air and provides a readout of the refrigerant concentration. The Monitoring Light is lit.
- 3. Low Alarm:** If the refrigerant concentration exceeds the low alarm level trip point, the unit enters Low Alarm state. The Low Alarm Light is lit and the Low Alarm Relay is energized. If the concentration level falls below the low alarm trip point, the unit will go back to normal monitoring, and the Low Alarm Light and Relay will be deenergized.
- 4. Leak Wait:** If the refrigerant concentration in the ambient air continues to increase and it exceeds the main alarm trip point, the system enters Leak Wait state. The system stays in Leak Wait for a period of time ranging from seven (7) seconds to three (3) minutes. The larger the ppm reading the shorter the wait period. The purpose of the wait is to avoid going into Main Alarm for a brief transient increase in halogen background. During Leak Wait, the PPM meter oscillates between zero (0) and the ppm reading. The Leak Wait Light is lit.

START-UP

- 5. Main Alarm:** After the leak wait timing is complete, the system enters Main Alarm. The Main Alarm Relay is energized and the Main Alarm Light flashes once per second. The system maintains the Main Alarm Relay and Light until the system is reset, even if the concentration falls below the main alarm trip point.

The Main Alarm Light and Relay are also actuated if a malfunction occurs (see below). During malfunction alarm, the Main Alarm Light flashes twice per second.

When the system is reset, the Main Alarm Light flashes three (3) times to indicate a proper reset (the relay is not energized).

If the system is put into Test Mode (see below), the Main Alarm Light is lit (the relay is not energized).

- 6. High Alarm:** If the concentration of refrigerant increases to above full scale, the system enters the High Alarm State. The High Alarm Relay and the High Alarm Light are energized. As with the Low Alarm, if the concentration falls below full scale, the system will drop out of High Alarm.

Summary of Alarm Conditions: The unit is in Low Alarm, if and only if the PPM level is above the low alarm trip point. The unit enters Main Alarm after a variable Leak Wait period. Once the Main Alarm condition is entered, the unit stays in Main Alarm until a reset. The unit is in High Alarm, if and only if, the concentration is above full scale.

In effect, the alarms are cumulative. If the PPM level is above full scale, all three alarms will be active. If an exhaust system is activated, the High Alarm should deactivate as the room clears, and even the Low Alarm may deactivate after a period of exhaust as the PPM level falls below the Low Alarm trip point. The Main Alarm will not deactivate until the system is reset.

- 7. Malfunction:** The Model 1033 monitors the sensor system, and should a failure occur, the system enters Malfunction Mode. The Malfunction Light and the Main Alarm Relay are energized. The Main Alarm Light flashes at a rate of twice per second.

Test Mode

Test Mode is only used for maintenance and troubleshooting. When the Test Mode is selected by the DIP switch, the Main Alarm Light is lit steadily. All other lights and relays are deenergized, and the unit continuously displays the PPM level.

WARNING

NEVER LEAVE THE SYSTEM IN TEST MODE SINCE IT WILL NOT ALARM IN THE PRESENCE OF A LEAK.

Step 1: Having confirmed that the wiring is correct, apply power to the unit. The normal warm up period is three (3) minutes. However, since power has been off since the unit was tested at the factory, allow the unit to warm up for a minimum of thirty (30) minutes (6-8 hours is preferable).

WARNING

THE SENSOR OPERATES AT 900° CELSIUS, 1560° FAHRENHEIT, AND 180 VOLTS. NEVER TOUCH THE SENSOR WHILE POWER IS APPLIED.

Step 2: The PPM meter should be reading less than 5.

If the unit is reading higher than 5 or has gone into Low Alarm, Leak Wait, or higher, 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. 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, contact SenTech.

Step 3: The Low Alarm and Main Alarm trip point settings are written on the inside front cover of the unit. Make a note of the settings. Check that the flowmeter is reading within 50 cc/min, of the amount noted on the inside front cover. If the flowmeter reading is off by more than 50 cc/min, turn to the trouble shooting section of the manual.

Step 4: To check for proper system operation, 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 TOWARDS THE SENSOR OPENING.

- 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 gas will make a relatively high concentration sample. Pull out the hose and hold the bag tightly closed.
- Liquid refrigerants: Obtain a small plastic "Ziplock[®]" type food storage bag. Open the bag slightly and put in a few drops of refrigerant. Flatten the bag so that there is little air and seal it as tightly as possible. 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 gas from escaping.

PREVENTIVE MAINTENANCE

Step 5: Test to see that Low Alarm, Leak Wait, and Main Alarm are operating properly. We are going to use the refrigerant sample to simulate a concentration of refrigerant in the air that is reasonably higher than the trip points. **NOTE: THE MORE THE READING EXCEEDS THE MAIN ALARM TRIP POINT THE SHORTER THE LEAK WAIT TIME.** Disconnect the pickup tube from the input filter.

- a) Gaseous refrigerants: Holding the bag tightly closed, bring the bag to just under the filter inlet. Carefully loosen your grip on the bag to allow some gas to escape, watching the meter and lights 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 the unit enter Low Alarm, Leak Wait, and then Main Alarm Mode.
- b) Liquid refrigerants: Using a pin or paper clip, prick a hole in the bag. Hold the bag just under the filter inlet. Squeeze the bag slightly and watch the meter and lights. 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 Low Alarm, Leak Wait, and then Main Alarm Mode.

In either a) or b) there will be a 5 second or so time delay before the meter starts to react.

Step 6: The system should now be in Main Alarm. The unit will likely also be in Low Alarm. With the gas sample removed, the PPM meter will be slowly decreasing in value as the refrigerant is cleared from the system. Check that any optional horns, lights, or other devices are appropriately energized.

Step 7: Push Reset to clear the alarm, and reconnect the pickup tube.

Step 8: Dispose of the gas sample in an appropriate manner.

Step 9: Fill out the CTS/Warranty card completely and return to SenTech. This is an important step and must not be overlooked.

Step 10: Store this manual in a safe place so that it will be available for future reference.

Basic installation and start-up are now complete, and the unit is on line and monitoring.

Air Filters:

The only preventive maintenance that needs to be accomplished on a routine basis is to periodically clean or replace the cooling air inlet and outlet filters. Dirty filters will reduce cooling air flow and could shorten the life of the electronics. The cooling air filters should be cleaned at least once per quarter.

5 Micron Sensor Inlet Filter and Orifice:

At least once per quarter, compare the flowmeter reading to the initial flow noted on the decal on the inside of the door. If the flow has dropped by 100 cc's/min or more, either the orifice or the 5 micron filter or both have become partially blocked.

Periodic Performance Check:

Once a week, push the reset pushbutton and check that the analog reading goes to zero and the system goes through the normal warmup procedure. After the unit is back on line, check that the ambient ppm reading is in the normal range for your environment.

Quarterly:

Go through steps 4 through 8 of the start-up instructions.

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". Switch S1 is for setting the Low Alarm trip point and for selecting RUN or TEST mode. Switch S2 is used to set the trip point for Main Alarm.

S1 LOW ALARM TRIP POINT/RUN/TEST

Positions 1 through 4 Low Alarm Trip Point

These positions are used to set the trip point for Low Alarm. See the following page Trip Point Calibration which displays how to set the switch.

Positions 5, 6, and 7

These positions are used to set parameters for communicating to external computers. Refer to the instructions provided. If you are not using the external communications capabilities, you can ignore these switch positions, 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 position 8 must be in RUN Mode. In Test Mode, all front panel lights except Power On remain deenergized.

S2 MAIN ALARM TRIP POINT

Switch 2 is used to set the Main Alarm trip point, the PPM reading at which the unit will go into Main Alarm Mode. See the following page Trip Point Calibration which shows how to set the switch.

Both trip points have been preset at the factory. There is a label on the inside front cover of the unit with the value of the preset trip points. If the switch setting is changed, note this change on the label to indicate the new trip point(s). This can be a big help in trouble shooting should a problem develop.

The switches essentially provide the microprocessor with a binary fraction of the maximum trip point possible in each case. For example, for the main alarm trip point, if the system full scale is 100 PPM, 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 to position 1 which is on two hundred and fifty-fifth of full scale. For the Low Alarm, position 4 is 8% of full scale, or 8 PPM in the example. Position 3 is a 4% or 4 PPM on down to position 1 which is 1% of full scale or 1 PPM in the example. By combining switch positions, it is possible to get the trip points desired. For ease of use, it is suggested that you use the charts provided.

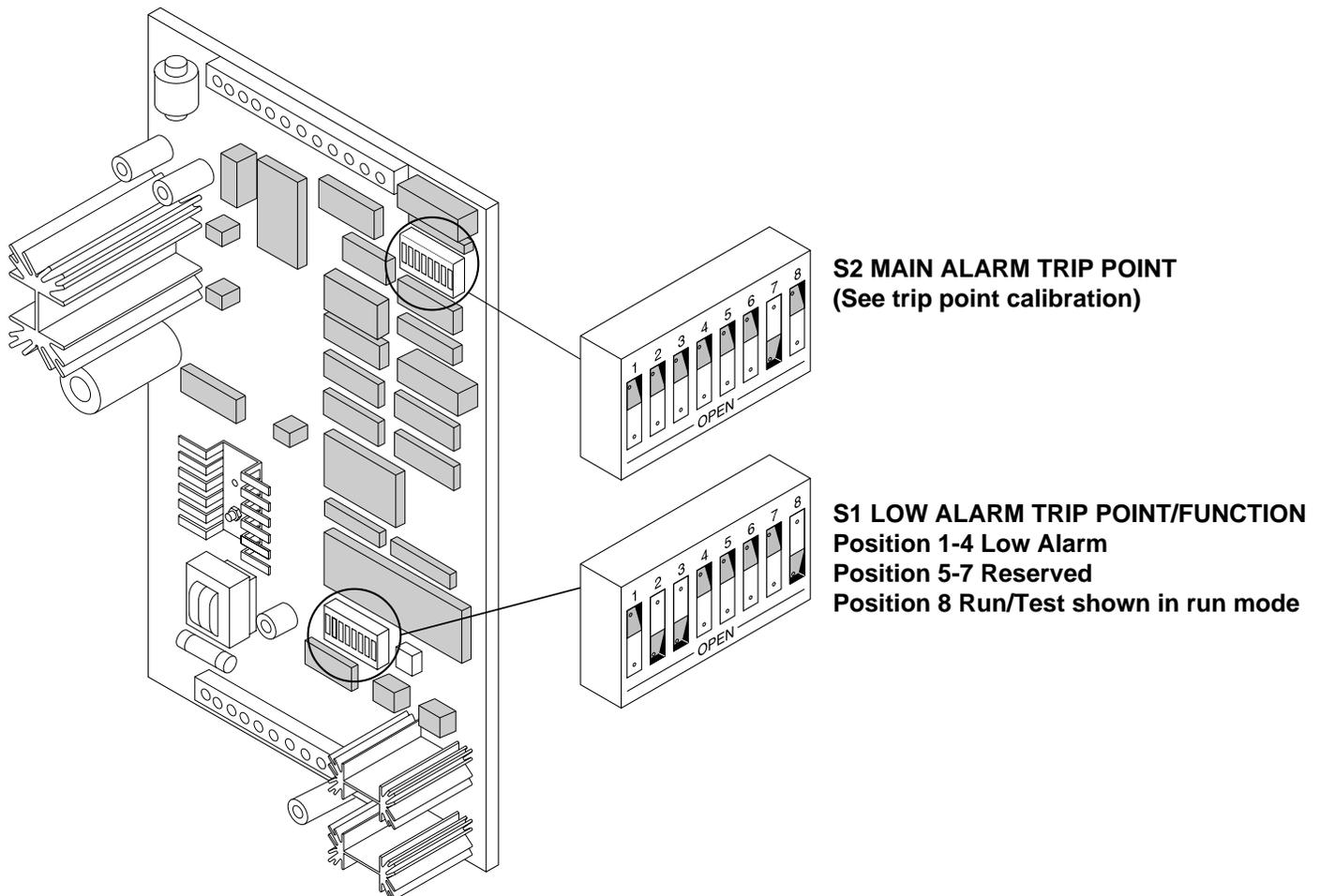


Diagram "A"

TRIP POINT SETTINGS: 100 PPM FULL SCALE CALIBRATION

(For 1000 PPM Models, multiply PPM levels by 10)

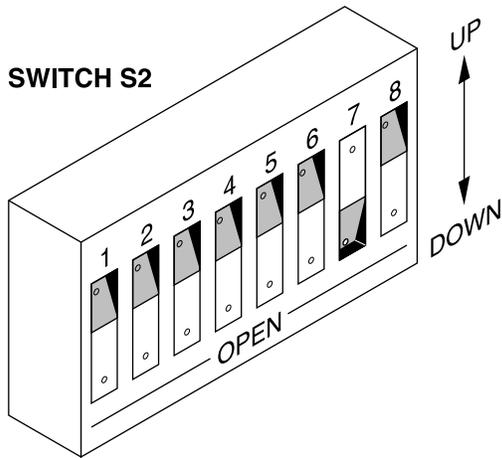


FIGURE 1
MAIN ALARM TRIP POINT SETTING
@ PPM - 25
(DIP SWITCH - 7)

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

*** DO NOT USE**

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

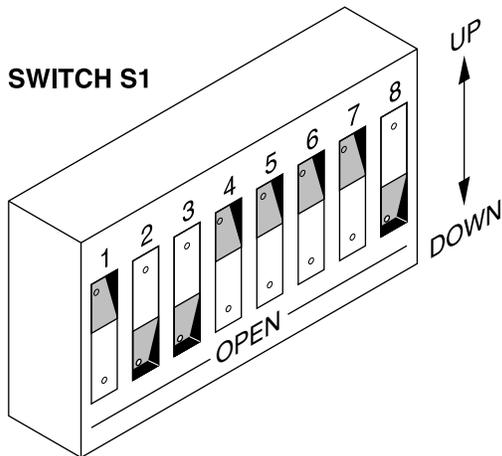
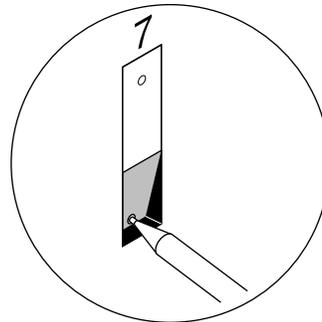


FIGURE 3
LOW ALARM TRIP POINT
SHOWN IN RUN MODE (6 PPM)

PPM DIP SWITCH DOWN

*0	-----	NONE
1	-----	1
2	-----	2
4	-----	3
6	-----	2,3
8	-----	4
10	-----	2,4

Not recommended
 unless normal
 ambient very low

Appendix B: 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.

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

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

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

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

Case II: Room with Air Changing

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

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

$$\text{LR}_{\text{min}} = \text{PPM} \times \text{FA} \times 10^{-6}$$

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 ?
 $R = 25 \times 12000 \times 10^{-6} = .3 \text{ cuft}$
 If it is R-22: $.3 \text{ cuft} \times .22 \text{ lb/cuft} = .066 \text{ lbs}$
2. If the leak rate is 300 lbs./year of R-22, how long will it take to reach 25 ppm ?

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

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

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 ?
 $\text{LR}_{\text{min}} = 25 \times 6000 \times 10^{-6} = .15 \text{ cuft/hr}$
 for R-22: $.15 \text{ cuft/hr} \times .22 \text{ lb./cuft} = .033 \text{ lbs/hr}$ or 289 lbs/yr
 2. How long will it take to detect a leak of 500 lbs/yr of R-22?
 $500 \text{ lbs/yr} = .26 \text{ cuft/hr}$
 $t = \frac{12000}{6000} \times \ln \left(\frac{.26}{.26 - 25 \times 6000 \times 10^{-6}} \right) = 1.72 \text{ hrs}$
 3. If the trip point is set at 10 ppm, what is the minimum leak rate of R-123 that will trigger the alarm ?
 $\text{LR}_{\text{min}} = 10 \times 6000 \times 10^{-6} = .06 \text{ cuft/hr}$
 for R-123: $.06 \times .41 \text{ lbs/ft} = .0246 \text{ lbs/hr}$ or 215 lbs/yr
 4. How long will it take to detect a leak of 300 lbs/yr of R-123 ?
 $300 \text{ lbs/yr of R-123} = .0825 \text{ cuft/hr}$
 $t = \frac{12000}{6000} \times \ln \left(\frac{.0825}{.0825 - 10 \times 6000 \times 10^{-6}} \right) = 2.6 \text{ hrs}$

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 B: 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.

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

As an example for R-22, Mol Wt = 86.48 gm/mole.
Therefore density = 3.59 kg/m³, or 0.28 m³/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

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

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

Case II: Room with Air Changing

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

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

$$\text{LR}_{\text{min}} = \text{PPM} \times \text{FA} \times 10^{-6}$$

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 m³ x 3.59 kg/m³ = .004 kg
2. If the leak rate is 150 kg/year of R-22, how long will it take to reach 25 ppm ?
$$\frac{150\text{kg}}{\text{yr}} \times \frac{1\text{ yr}}{8760\text{ hr}} \times \frac{.28\text{ m}^3}{\text{kg}} = 0.0048\text{ m}^3/\text{hr}$$

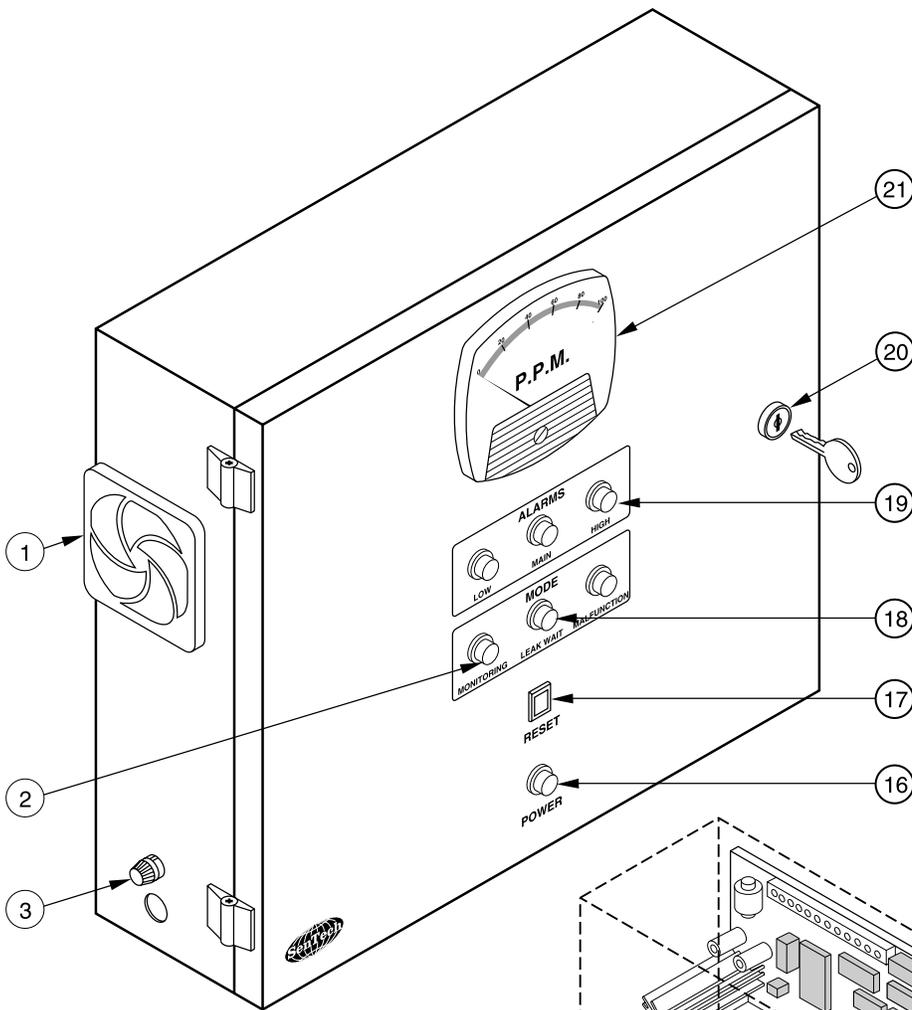
$$t = \frac{25 \times 450 \times 10}{0.0048} = 2.35\text{ hrs}$$

Case II: Room with Air Changing

- Assume the same room (450 m³).
Assume fresh air at 225 m³/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 m³/hr
for R-22:
0.0056 m³/hr x 3.59 kg/m³ = 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 m³/hr
for R-123: .00225 x 6.56 kg/m³ = .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 m³/hr
$$t = \frac{450}{225} \times \ln \left(\frac{.0026}{.0026 - 10 \times 225 \times 10^{-6}} \right) = 4.0\text{ hrs}$$

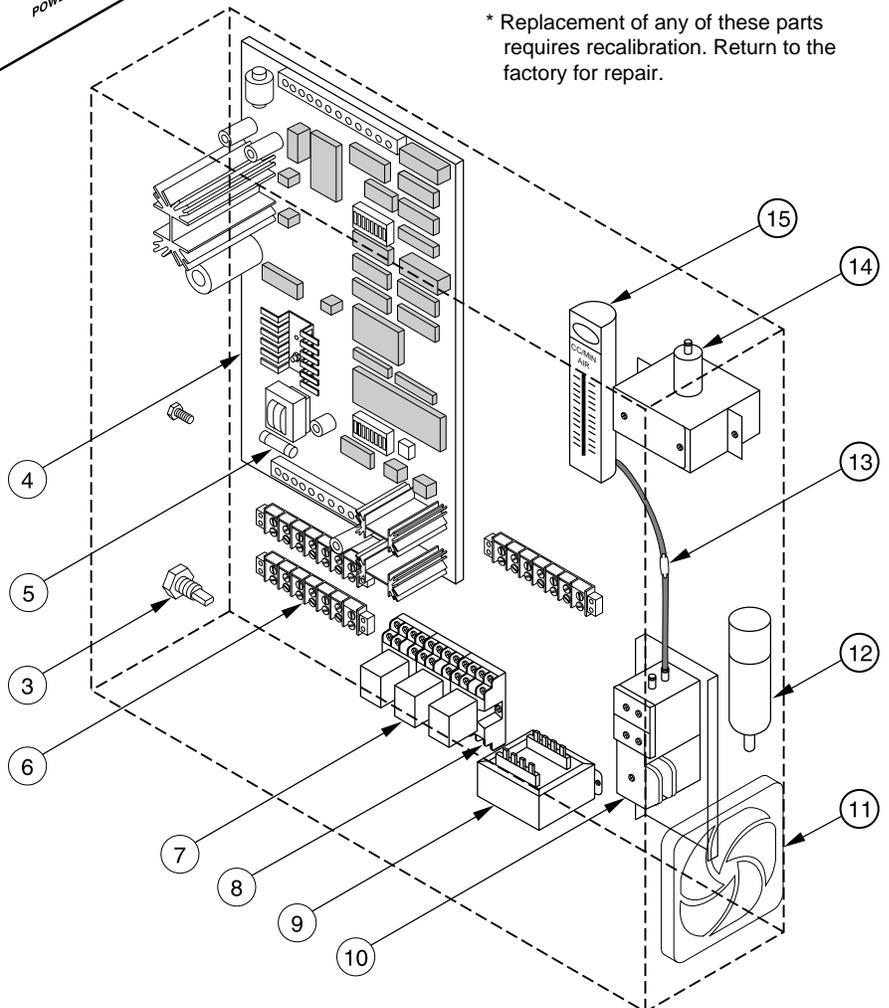
These numbers represent worst case conditions. With the monitor placed close to the potential leak points and on the "downwind" side of the air flow, the trip points are likely to be activated sooner.

SenTech System1000 Model 1033 - Series II Exploded View & Parts List



- | | |
|--------------------------------|--------|
| 1. Fan Guard/Filter | 410017 |
| Filter Replacement | 410018 |
| 2. Lamp, White | 410390 |
| 3. Main Power Fuse | 410034 |
| Main Power Fuse Holder | 410033 |
| 4. Control Board* | 410360 |
| 5. Filament Current Fuse | 410233 |
| 6. Connector, 7 position | 410041 |
| 7. Relay, Alarm | 410087 |
| 8. Relay Socket | 410040 |
| 9. Power Transformer | 410039 |
| 10. Diaphragm Pump | 410224 |
| 11. Fan Guard/Filter | 410017 |
| Filter Replacement | 410018 |
| 12. 5 Micron Filter | 410122 |
| 13. Orifice | 410136 |
| 14. Sensor* | 410027 |
| 15. Flowmeter | 410121 |
| 16. Lamp, Green | 410008 |
| 17. Switch, Panel Reset | 410009 |
| 18. Lamp, Amber | 410389 |
| 19. Lamp, Red | 410388 |
| 20. Key Lock Assembly | 410006 |
| 21. Meter, Analog | 410010 |

* Replacement of any of these parts requires recalibration. Return to the factory for repair.



Troubleshooting Guide

Before starting, refamiliarize yourself with the START-UP section of the manual. Depending on the problem, you may need to prepare a sample of refrigerant to use in testing. You should also check the appendix on setting the trip point and function switches. Certain of the tests will require the use of a volt/ohm multimeter.

If you determine that there is a problem in either the sensor or the main control board, the unit will have to be returned to the factory for repair and recalibration.

Symptom	Remedy
1. No power light.	<ol style="list-style-type: none">1. Check fuse f1 and replace if failed.2. Check incoming AC Power at TB1-2 and TB1-3 120 (240) volts AC.
2. Flowmeter reading 0 cc/min.	<ol style="list-style-type: none">1. Check that the diaphragm pump is operating and replace if it has failed.2. Check the tubing from the diaphragm pump output to the flowmeter and make certain that it has not come loose at any point.3. If the tubing run seems continuous with no obvious blockages or kinks, follow the trouble shooting procedures for low flow.
3. Flowmeter reading less than the initial reading by more than 100 cc/min.	<ol style="list-style-type: none">1. Either the orifice or the 5 micron filter or both have become partially or completely blocked blocked.<ol style="list-style-type: none">a). Unscrew the plastic bottle on the 5 micron filter and recheck the flow. If the flow has returned to normal, replace the 5 micron filter element.b). If the flow remains low, remove the orifice and clean it by blowing compressed air through it. Recheck the flow. If it is not back to normal, replace the orifice. Note, the orifice must be replaced with the arrow pointing towards the flowmeter.
4. Failure to detect a leak/ suspected low sensitivity.	<ol style="list-style-type: none">1. Main alarm on, not flashing.<ol style="list-style-type: none">a). The system is in TEST mode, see Appendix A. Set function switch S1 to RUN and push the reset button to go back into normal operation.2. Main Alarm light is flashing, indicating an alarm, but external alarm devices (horns, lights, etc) not actuated.<ol style="list-style-type: none">a). Check for 24 Volts DC at the alarm relay coil between p13 and p14. If there is no voltage, check for loose wires.b). If voltage is present, check that the relay is energized by testing for continuity at an unused set of normally open contacts (see diagram on the inside front cover of the enclosure). If the relay is not energized, replace it.c). If the relay is energized, check the wiring to the external devices, and check the devices themselves for proper operation.3. Check the Main Alarm and Low Alarm trip point setting of the unit to make certain that they have not been set too high. Typical trip point settings should be 30 PPM or less for the Main Alarm and 10 PPM or less for the Low Alarm. (see Appendix A). If the Main Alarm trip point is too high, reset it and repeat steps 3 through 6 of the start-up procedure to confirm proper operation.4. If steps 1 through 3 have not uncovered the problem, repeat steps 3 through 6 of the start-up procedure. If the system does not respond properly, there has been a failure in the main control board* or sensor*.5. If all of the checks indicate the unit is operating properly, yet it is still believed that a leak was not detected by the system. Review the Location section of the installation procedure. It may be that the unit is not located in an appropriate position.

*A failure in the control board or sensor require the unit be returned to the factory for repair and recalibration.

Symptom

Remedy

5. System has gone into alarm and is believed there is not leak.

1. The Malfunction Light is lit. When the unit senses a malfunction, it energizes the Main Alarm relay indicating an alarm. This is done to alert the user that there is a problem. Turn to the Malfunction light is lit portion of this section for a detailed discussion.
2. Depress the reset switch, and wait for completion of the warm-up period. If the system does not go into alarm, repeat steps 3 through 6 of the start-up procedure. If the unit appears to operate normally, there may have been a transient phenomenon that caused the alarm. Some examples are:

Someone using a halogen based degreaser such as trichloroethylene near the system.

A leaky purge that caused a transient increase in the refrigerant level.

Monitor the system closely for the next several weeks to see if it continues to operate normally.

3. If after going through the warm-up cycle, the system goes into Main Alarm yet the meter reading indicates a very low PPM, check that the Main Alarm trip point setting has not been changed to 0 PPM or a very low value that is likely to be below ambient conditions (see Appendix A). If that is the case, reset the trip point to the appropriate value for your environment, and recheck as in step 2 above.
4. If after going through the warm-up cycle, the system goes into alarm and the meter reading is above the trip point, set function switch S1 to the TEST mode (see Appendix A), and reset the system. In test mode, the alarm circuitry is bypassed and the unit continuously reads ambient PPM level.

Check that the RUN/CAL switch on the Main board is in the RUN position (to the right). If it is in the CAL position, switch to RUN and wait several minutes to see if the PPM decreases to a normal reading. If it is in the RUN position, flip the switch back and forth several times to make certain there is not a contact problem. Leave it in the RUN position, and again wait several minutes to see if the system returns to a normal reading. If the system appears to be working, put function switch S1 back into the run mode, and press the reset push-button. After the warm-up period, go through steps 3 to 6 of the setup procedure to confirm normal operation.

5. If the RUN/CAL switch test does not resolve the problem, there are three likely possibilities:

There is in fact a leak in the refrigerant system.

There is a high ambient level of a halogen based hydrocarbon. This may be the result of chemicals stored in the room (such as a leaking refrigerant cylinder).

The unit has failed.

There is one inconvenient but sure way of testing for system failure. Disconnect the unit and move it to another area of the building or take it outdoors and apply power to the unit. If you still have a high reading, it is likely there has been a failure in the control board* or sensor*.

Symptom

Remedy

6. The Malfunction light is lit.

The malfunction circuitry checks that the sensor is detecting at least a minimal background level.

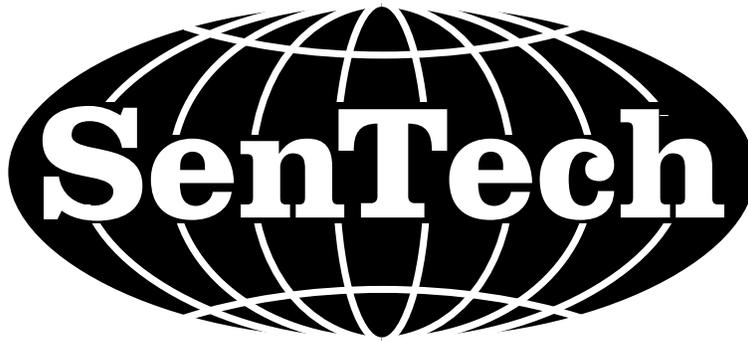
1. Sensor filament circuit check. Using function switch S1, put the unit in Test Mode (Appendix A). Reset the unit, and allow it to warm up for 2 or 3 minutes. Feel the top right of the System 1000 enclosure (just above the sensor area). If it feels warm to the touch, it indicates the sensor is getting current. A double check is to touch the large heatsink at the upper left hand side of the control board. It also should be warm to the touch. If the sensor is warm, go to item 2. If the sensor is not getting current:

- a). Check the fuse on lower left hand of the control board. If the fuse is blown, replace it with a 7 amp 250 volt slo blo.
- b). Check that the tube is well seated in the socket.
- c). Check and tighten the connections at pins 2, 3, and 4 of J2, the connector at the top of the main control board.
- d). Check for 10 volts AC between J1-1 and J1-2 the connector at the bottom of the main control board. If there is no voltage, or it is substantially below 10 volts, replace the main transformer.

If a) through d) check out OK, the main control board* or sensor* has failed.

2. Using function switch S1, put the unit back in Run Mode. Push the reset button and wait 3 minutes for the warm up period to end.

- a). If the Monitoring light comes on, there may have been a transient phenomena that caused the Malfunction to actuate. Repeat steps 3 to 6 of the Start-up procedure to confirm normal operation.
- b). If after warm up, the Malfunction light comes back on, the main control board* or sensor* has failed.



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 may they do not constitute warranties and shall not be relied upon.

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SenTech Corporation
5745 Progress Rd.
Indianapolis, Indiana 46241

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.

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.

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 aid you 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
5745 Progress Road
Indianapolis, Indiana 46241
7. All parts are sold f.o.b. factory.
8. Parts returned "collect" will be refused by our shipping department.



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