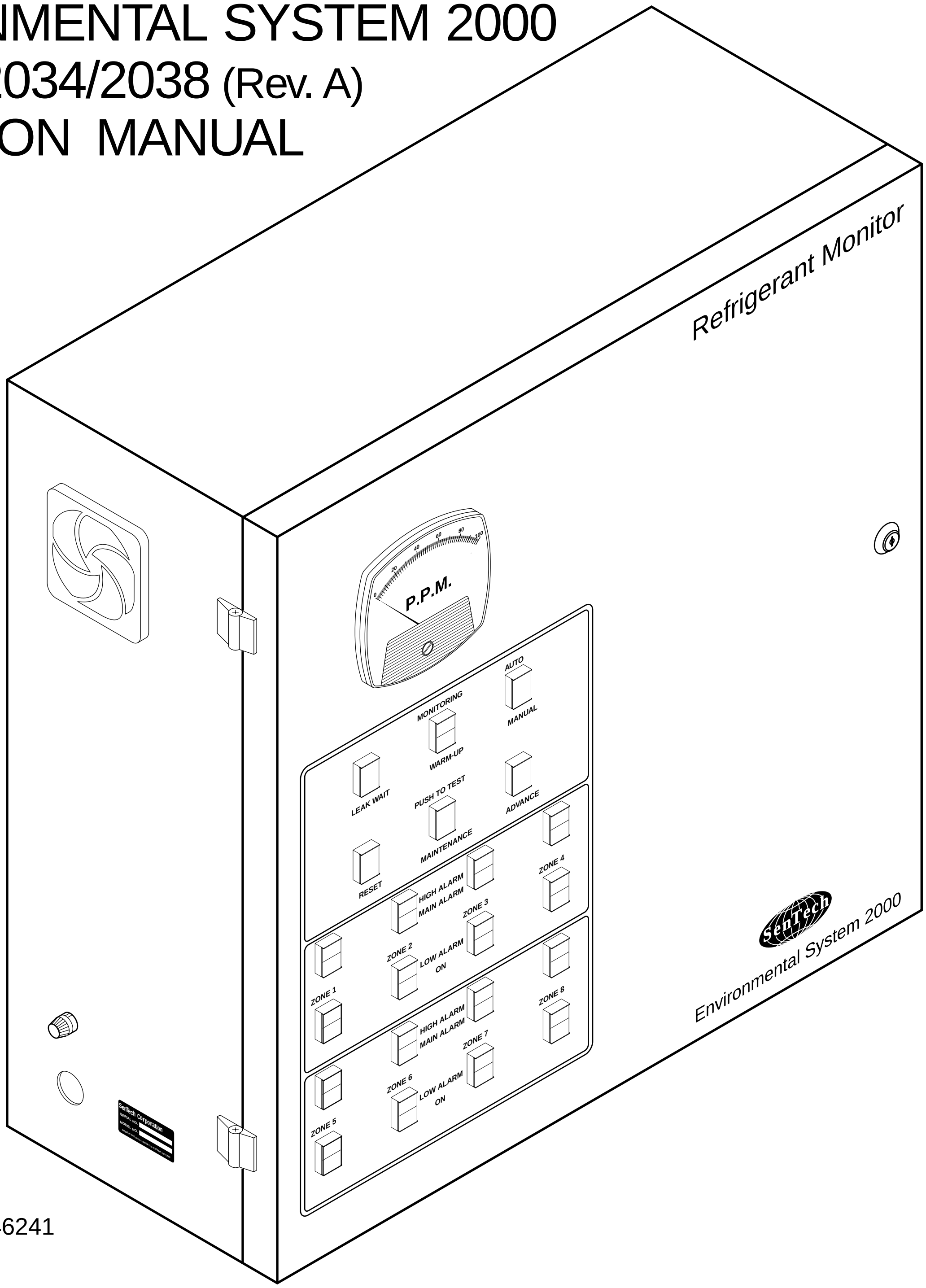
ENVIRONMENTAL SYSTEM 2000
MODEL 2034/2038 (Rev. A)
OPERATION MANUAL



SenTech Corporation
5745 Progress Rd.
Indianapolis, Indiana 46241
PH: 317/248-1988
FAX: 317/248-2014

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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System 2000 Specifications	
Size:	22" X 22" X 8" (55.8 cm X 55.8 cm X 20.3 cm)
Weight:	70 lbs (31.8 kgs)
Power:	120 Volt, 60 Hz (250 Watt) 240 Volt, 50 Hz (250 Watt)
Temperature:	32°- 125° Fahrenheit (0°- 50° Centigrade)
Range:	0 - 100 P.P.M. Standard 0 - 100 P.P.M. (for HFC's)
Tube Length:	0 - 500 ft (150 meters) maximum
Trip Point:	Low Alarm 0 - 15% of FS Main Alarm 0 - 100% of FS High Alarm 100% of FS (fixed)
Zones:	Model 2034 - 1 to 4 (jumper selectable) Model 2038 - 1 to 8 (jumper selectable)
Sample Time:	One (1) minute per zone selected
Leak Wait:	Varies from seven (7) seconds to three (3) minutes depending on refrigerant concentration (main alarm only)
Alarm Output:	3 Relays (Low Alarm, Main Alarm, High Alarm) - Four (4) form C contacts rated 5 Amps maximum

INTRODUCTION/OVERVIEW

The SenTech Environmental System 2000 provides an early warning of developing refrigerant leaks. The unit sequentially samples ambient air in each active zone and measures the amount of halogen based refrigerant gases in the air sample. When the proportion of halogens present in a zone 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 System 2000 Block Diagram (Fig. 1). Tubing from each area to be monitored is connected to the inlet manifold/valve assembly. The PLC (programmable logic controller) sequentially energizes the solenoid valves for each zone. The vacuum pump draws air from the selected zone and delivers it to the air sampling subsystem. The air sampling system delivers a controlled portion of the sample air to the sensor and exhausts the remainder. The system uses, an industry proven reliable halogen gas sensor.

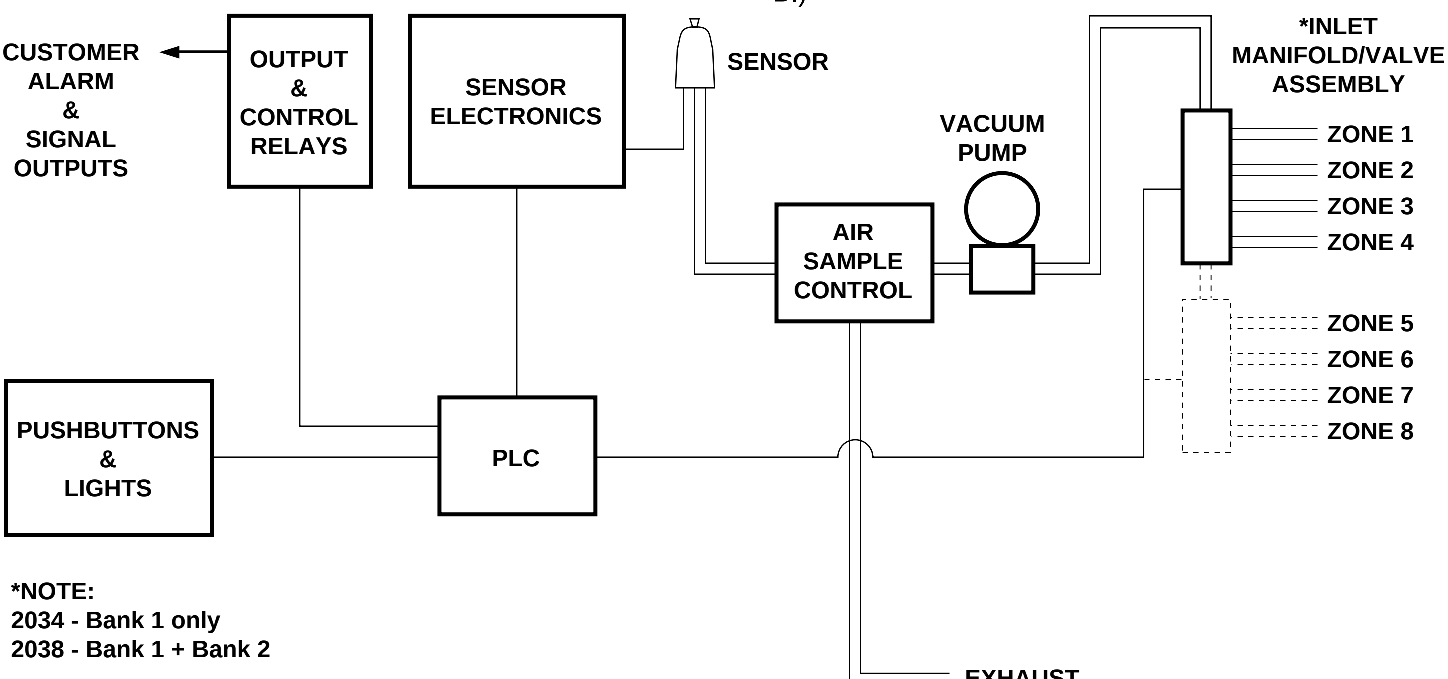
The sample air flows across a heating element element in the sensor which ionizes any halogen molecules Present. The ionized halogens cause a current to flow which is proportional to the amount of ions present. The microprocessor controlled sensor electronics measures the current and provides an output reading of the concentration in ppm (parts per million).

More critically, it compares the ppm level to the preset trip points. When the low trip point is exceeded, the system enters Low Alarm Mode. The system Low Alarm Relay is energized, and the Low Alarm light for the zone being tested is lit. If the halogen level continues to increase, the unit enters Leak Wait, and then Main Alarm. The system Main Alarm Relay is energized and the Main Alarm light for the zone being tested is energized. If the halogen level exceeds the high trip point (100 PPM), the zone High Alarm light is lit. Once the High Alarm Level is reached, the zone is taken out of rotation.

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 R22. When appropriately calibrated the System 2000 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 zone, the location of the monitor inlet tubing relative to the leak point, and the air pattern, all will affect the actual concentration at each zone. However, by judicious location of the inlet points (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. (For a detailed discussion of room size considerations, refer to Appendix B.)



***NOTE:**
2034 - Bank 1 only
2038 - Bank 1 + Bank 2

Fig. 1
System 2000 Block Diagram

INSTALLATION

Location

Since the sensor measures the concentration of refrigerant in air, each zone inlet tube should be mounted where it is most likely to sense leaking refrigerant. The criteria to consider in selecting the 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.

* The control unit should be located such that the farthest pickup point will require no more than 500 feet (150 meters) of tubing.

⚠ CAUTION

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

Material Required (See the Installation Layout)

Packed within the System 2000 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. The CTS/Warranty card which is to be completed and returned after start-up.
5. The coarse tube end filters.

Mounting

Drill the necessary holes and mount the unit. Carefully remove the packing material that protects the pneumatic components. 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. Make certain that the tubing is not kinked.

Tubing Installation

Install 3/8 inch (100 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 upper left hand fitting, and continue in sequence until the tubing for each zone is installed. Install the coarse filters at the pickup end of each tube. Mount the optional inline 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.

Zone Selection

The System 2000 allows you to select the number of zones to be monitored. For example, if the system purchased is a 2038 (8 zone model) and you plan on monitoring only 6 zones, zones 7 and 8 can be disabled and will be bypassed by the control. Zones 1 through 6 will be the active zones.

It is necessary to inform the control of the number of zones selected. Refer to Terminal Board TBDC (Fig. 2) and the Zone Selection Chart. Selecting the number of zones is accomplished by installing jumpers between the appropriate terminals and +24 Volts dc. The first three positions on the terminal board are designated AZA, AZB, and AZC. Position 4 is +24 Volts. The Zone Selection Chart 1 shows the locations that require jumpers for the number of zones desired.

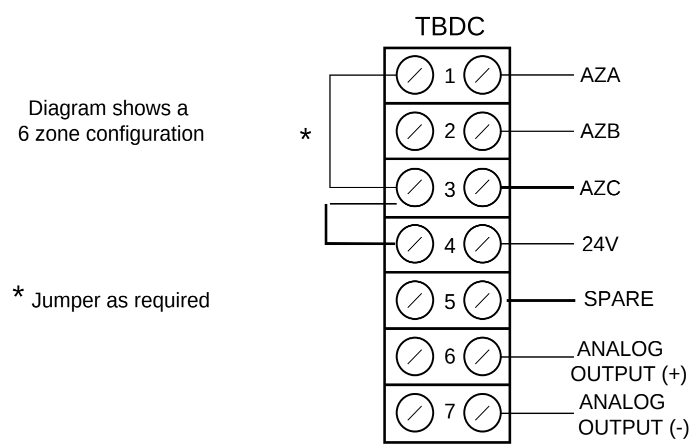


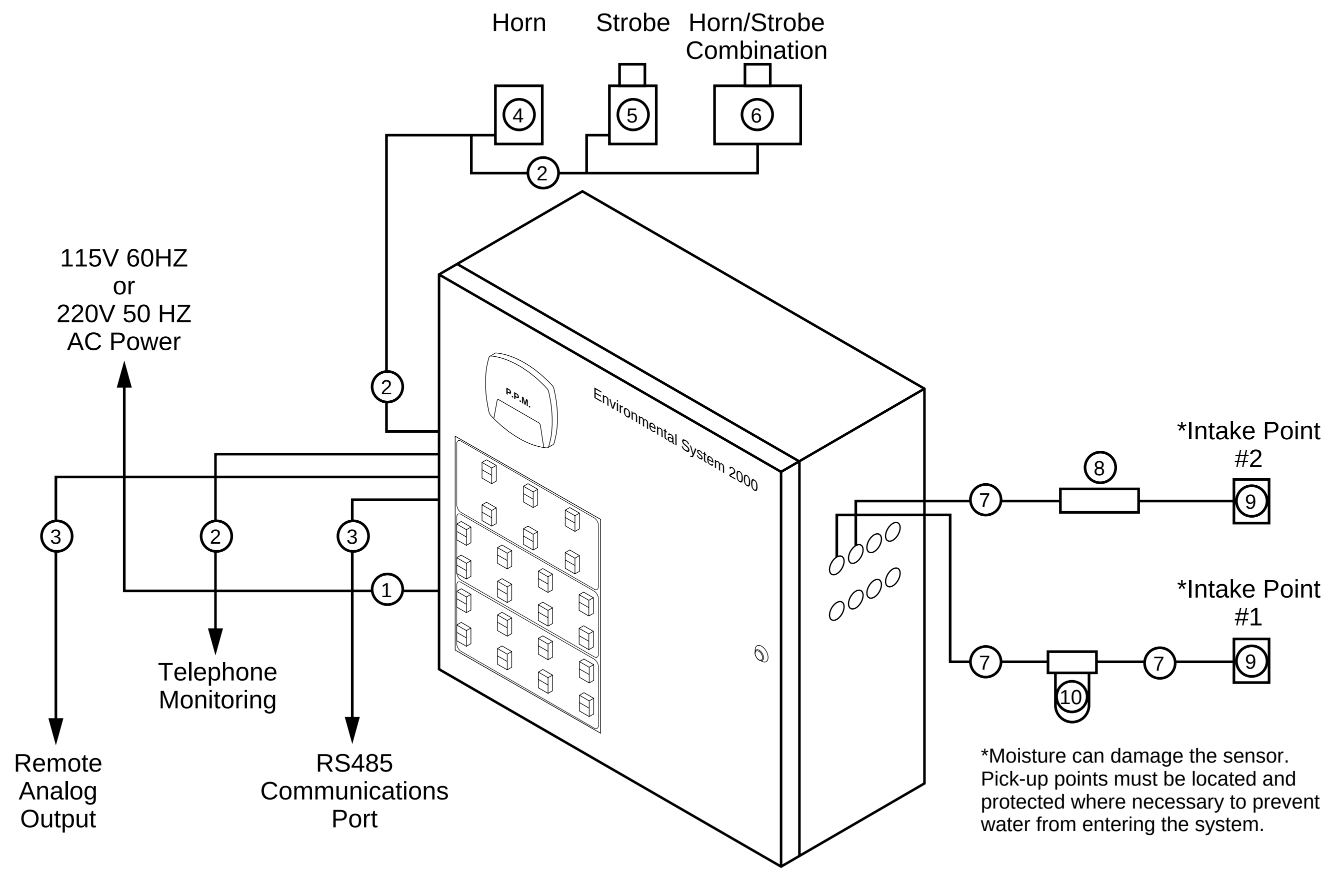
Fig. 2
Terminal Board TBDC

ZONE SELECTION CHART			
Zones Allowed	**AZA**	**AZB**	**AZC**
zero	(Not Allowed)		
one	open	open	open
two	24	open	open
three	open	24	open
four	24	24	open
five	open	open	24
six	24	open	24
seven	open	24	24
eight	24	24	24

Note: Open means no jumper, 24 means jumper to 24 Volt dc (position 4 of TBDC).

For the six zone example, Position 1-AZA should be jumpered to position 3-AZC, and position 3-AZC jumpered to position 4-24 Volt dc. Position 2 (AZB) should be left open.

SenTech System 2000
Installation Layout

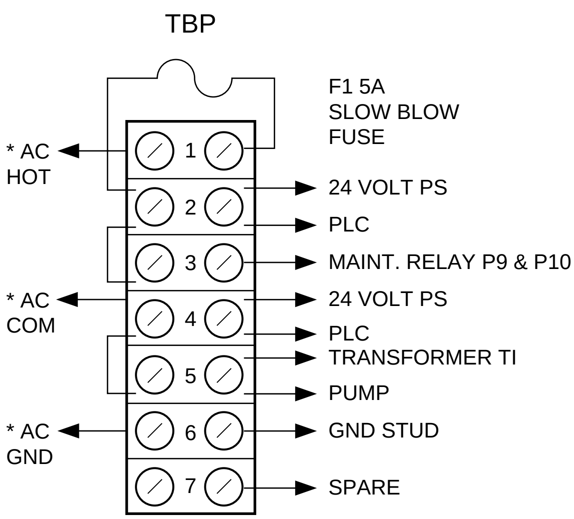


Item	Description	Required	Supplied with Unit	Supplied by Customer	Optional	Available from SenTech	Comments
1	16 Gauge, 3 Conductor Cable	yes	no	yes		no	
2	18 or 22 Gauge, 2 Conductor Cable	no			yes	no	Required for horn, strobe or combination
3	2 Conductor Twisted Pair Shielded Cable	no			yes	no	Required 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 (recommend flame retardant, smoke resistant)	yes	no			yes	Available in 500 foot (150 m) reels
8	3/8" Tube Union				yes	yes	May be required to optimize tubing usage
9	Coarse Filter	yes	yes				For mounting at the end of the tubing
10	In-Lline Filter/Separator Assembly	no			yes	yes	Recommended for particularly dirty environments and/or where there is any risk that water could enter the system

The monitor will be shipped with jumpers for the maximum number of zones available on the unit. That is a model 2034 will be jumpered for 4 zones, a 2038 for 8 zones. If you are using less than the full complement of zones, be sure to jumper for the number of zones you actually are using. If you leave the control jumpered for the full complement, time will be wasted by the control sampling the unused zones. Using our 6 zone example, 25% of the time will be lost monitoring zones 7 and 8. Caution do not jumper for more zones than are available.

Primary Power Wiring

Refer to Terminal Board TBP (Fig. 3). The Primary power required is either 115 volt 60 HZ or 220 volt 50 HZ depending on the unit purchased. Power is 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 into a wall socket. The System 2000 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

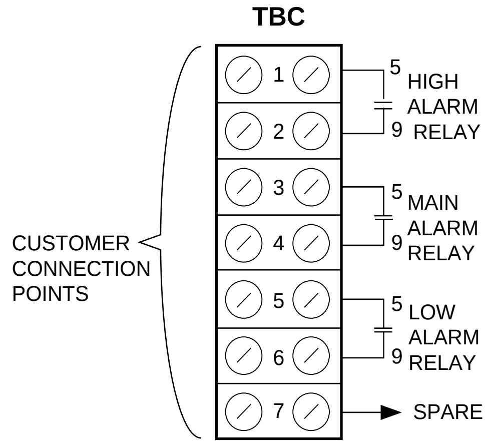
OPTIONAL CONNECTIONS

Refer to Fig. 2 and Fig. 4 which shows terminal board TBC.

Analog Signal: Available on Pins 6 and 7 of TBDC.

Alarm Relay Contact: Used for actuating horns or strobes, as input for actuating an Automatic Dialer, as input to a customer control system, etc. (See examples shown on Fig. 4).

Double check the wiring.



Note: Three more sets of contacts available on alarm relays (6 & 10), (7 & 11) and (8 & 12)

TYPICAL INTERCONNECTIONS

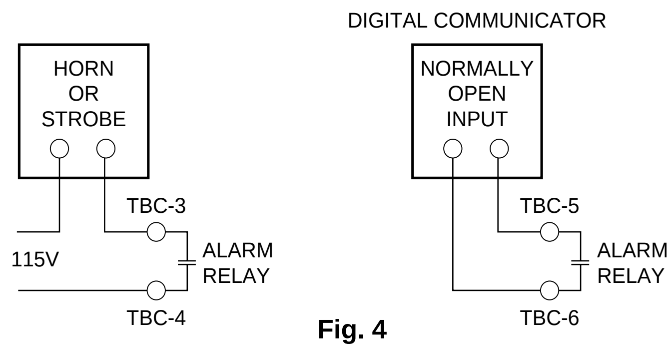


Fig. 4
Customer Connections

OPERATIONS

Before applying primary power to the System 2000, 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 System 2000 has 2 basic operating modes, Automatic and Manual.

Automatic Mode

When power is applied, the system starts in Automatic mode and Zone 1 (Fig. 5).

Warm-up:
When power is applied or after an alarm condition has been reset, the system goes through a 3 minute warm-up period.

Normal Sequencing:
After the warm-up period, the system enters normal Automatic operation. The Monitoring light is lit and the system sequentially scans each selected zone. The system remains in each zone for 1 minute, monitoring the air drawn from that zone. Assuming the ambient refrigerant level is less than the Low trip point, the system switches to the next zone. After monitoring the last selected zone, the unit switches back to zone 1 and repeats the process.

Low Alarm:
If the refrigerant concentration exceeds the Low Alarm trip point:

The Low Alarm light for the zone starts flashing.

The system Low Alarm relay is energized. The relay will remain energized until there is a Manual Reset.

A 60 second timer is initiated, allowing enough time to determine if the refrigerant concentration level is going to exceed the next trip level.

If the concentration level does NOT exceed the next trip point, the unit switches to the next zone, resets the sensor electronics and goes through the three (3) minute Warm-up period. The three (3) minute Warm-up allows time for the air system to be cleared of any refrigerant remaining from the zone that went into alarm.

Leak Wait:
The purpose of Leak wait is to avoid going into Main Alarm for a brief transient increase in halogen level. During Leak Wait, the Leak Wait Light is lit and the analog meter oscillates between 0 and the ambient PPM level.

Normal Leak Wait time can range from seven (7) seconds to three (3) minutes. The more the ambient refrigerant level exceeds the trip point, the shorter the wait period. When the sensor electronics has decided there is an excess of refrigerant, the Main Alarm Sequence is initiated (see below). If during the wait period the ambient level should drop below the trip point for more than five (5) seconds, the sensor electronics will abort Leak Wait. The 60 second timer is initiated allowing time to reinstate Leak Wait if the level crosses the Main Alarm trip point again. If the unit remains below the main trip point during the 60 seconds, the unit switches to the next zone, resets the sensor electronics, and goes through the three (3) minute Warm-up period.

Multiple Leak Wait:
If the ambient refrigerant level is right at the trip point, the unit may enter Leak Wait and then drop out again. The system keeps track of the number of times the unit enters Leak Wait mode. Should the unit enter Leak Wait mode three (3) times, the system assumes a Main Alarm condition (see below).

Main Alarm:
If the Main Alarm mode is entered:

The Main Alarm light for the zone starts flashing.

The system Main Alarm relay is energized. The relay will remain energized until there is a Manual Reset.

A 60 second timer is initiated, allowing enough time to determine if the refrigerant concentration level is going to exceed the next trip point.

If the concentration level does NOT exceed the next trip point, the unit switches to the next zone, resets the sensor electronics and goes through the three (3) minute Warm-up period.

If the concentration level of refrigerant increases to the level of the next trip point, the system enters High Alarm Mode.

High Alarm:
If the concentration level of refrigerant exceeds full scale, 100 PPM, the system enters High Alarm mode.

The High Alarm light for the zone starts flashing.

The system High Alarm relay is energized. The relay will remain energized until there is a Manual Reset.

The sensor electronics are reset and the three (3) minute Warm-up period is initiated.

The zone in High Alarm is taken out of sequence.

The system switches to the next selected zone

All Zones in High Alarm:
In the event all zones are in alarm before the problems are cleared, the Maintenance Relay is energized, shutting off the pump and the sensor electronics.

Manual Mode

Manual mode is used for trouble shooting and for confirming that any reported leaks have indeed been repaired. In Manual Mode the system remains in the selected zone. To move from one zone to the next, it is necessary to momentarily depress the Advance Push-button. If there is an excess of refrigerant present, it will go through the Low Alarm, Leak Wait, Main Alarm, and High Alarm sequences.

Push-buttons and Indicators (Fig. 5)

Analog Meter:
The analog meter provides a display of ambient refrigerant levels in parts per million, during monitoring mode. In Warm-up, the meter reads 0 ppm. During leak wait, the meter oscillates between 0 and the refrigerant level present.

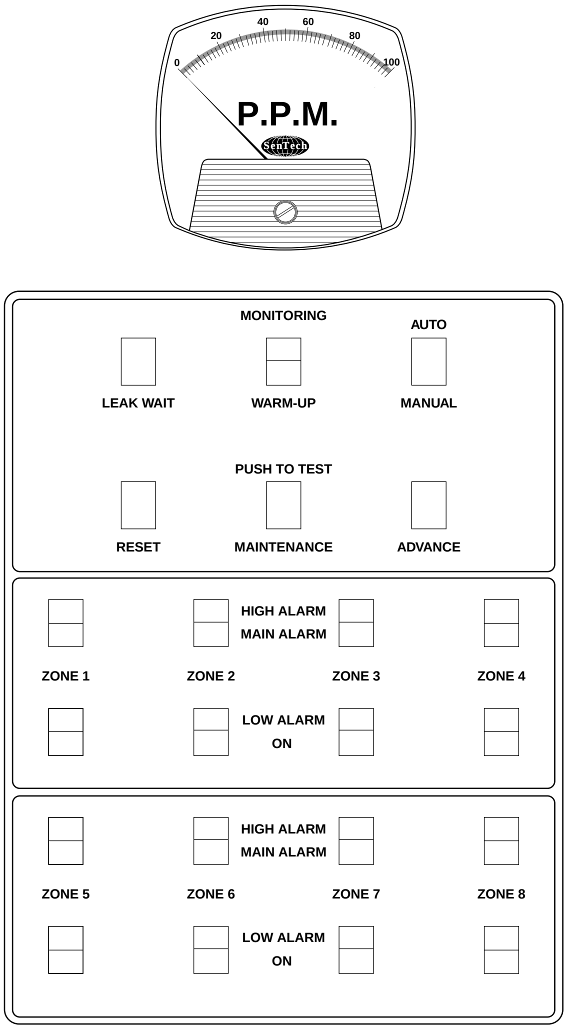


Fig. 5
Control Panel

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

Monitoring/Warm-up Light:
The Monitoring Light indicates that the system is in normal monitoring, none of the leak conditions are being detected.

The Warm-up Light indicates the unit is in Warm-up mode.

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

Reset Pushbutton:
The Reset push-button resets the Alarm Modes and Maintenance Mode. Whenever the Reset button is actuated, the control resets the sensor electronics, and the unit enters Warm-up Mode.

Advance Pushbutton:
Each time the Advance push-button is depressed, the system sequences to the next selected zone.

Push to Test/Maintenance Lighted Pushbutton:
This control provides a dual function. The light is an indication that a failure has occurred in the pneumatic circuit or in the sensor alarm circuitry (see the PLC section of the manual). 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, and testing of the zone alarm lights.

Zone Lights:
The green zone light indicates which zone is active. The red zone lights indicate the level of alarm in the zone.

START-UP

⚠WARNING

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

Having confirmed that the wiring is correct, apply power to the unit. Allow the unit to warm-up for 20 to 30 minutes before proceeding.

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, etc. that are set to operate when the unit goes into Alarm. It will also light all the selected Zone Alarm lights.

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 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.

Checking for Proper Air Flow:
These next series of tests are to confirm that the pneumatic system is functioning properly, and that all the tubing runs are continuous and unblocked.

Open the unit door so that you can monitor the flowmeter mounted on the sensor bracket. Check the factory setting for the flowmeter noted on a decal on the inside of the door. Check for proper air flow with no tubing attached by using the Advance push-button, move to zone 1. Disconnect the tubing from that zone and compare the flow to the factory setting. The purpose of this test is to check that the flow setting did not get out of adjustment during shipping. The reading should be within 15% of the factory setting. Minor corrections can be made by adjusting the regulator (the black T shaped device after the fine filter). If any required corrections cannot be made with the regulator, turn to the Maintenance section of the manual for instructions on how to reset the flow.

Check for proper operation of the pressure switch. One of the safety features of the system is a pressure switch connected to the output of the vacuum pump. Failure of the pump or a blockage in the system will cause the pressure switch to deenergize. After a 10 second delay the Maintenance and Alarm relays will be energized and the pneumatic and sensor systems will shut down. Place your finger over the zone 1 opening to block air flow. The flowmeter reading will fall and after 15 or 20 seconds, the shut down should occur. The Maintenance light should be on and the alarms energized. If there are any problems, turn to the Maintenance section of the manual.

Check for proper flow in each zone. Reconnect the zone 1 tubing. Using the Advance push-button, step through all of the zones. The flow for each zone should not vary from the "no tube" reading by more than 20% of full scale. The shorter the tubing run the higher the flow. Observe each zone for a minute or two. If there is an obstruction at the far end of a particularly long run, it could take that long before the tubing is sufficiently evacuated for the flow to drop. The purpose of this test is to make certain that there are no obstructions in any of the tubing runs. If the flow in any of the zones drops excessively, disconnect the tubing from that zone. If the flow goes back to the "no tube" level, there is an obstruction somewhere in the tubing run. Before proceeding, check the tube run and clear the obstruction.

Check for no breaks in the tubing runs. The purpose of this test is to make certain that there are no discontinuities or leaks in any of the tubing runs. The test can be done most conveniently with two people one stationed at the monitor and the other at the tubing pickup points. All tubes should be connected to the monitor and the system in Manual. At the monitor end, set the system to zone 1. At the pickup point, unscrew the coarse filter from the tube. Place your finger over the end of the tube to block the 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 the pick up points in this manner. This test will confirm that there are no discontinuities, and that each zone tube is indeed connected to the correct zone inlet of the monitor.

Checking the Sensor System:
Reconnect any zone tube that may have been disconnected as part of your testing to this point. 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: Push the Auto/Manual push-button to set the system to Manual mode. Using the Advance push-button, slowly step through each zone, and make a note of the ppm meter readings. The readings should be leas than 5 ppm in each zone. If the reading is 10 ppm or higher in any zone or the system has gone into the Leak Wait Mode or Alarm Mode, there is a likelihood that there is a leak present in that zone. 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: Using the Advance push-button, select a zone to use for the set up procedures. Remove the inlet tubing from the selected zone so that you can introduce refrigerant into that zone for testing.

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 setting.

Step 4: To check for proper operation of the system, 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.

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 "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 from escaping.

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 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 to just under the 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 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 five (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 slowly be 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 the Manual Reset push-button to clear the alarm. Push the Advance push-button to move to another zone so that the refrigerant can be cleared from the unit during the warm-up period. Reconnect the tubing.

Step 8: Dispose of gas samples in an appropriate manner.

Step 9: Push Auto/Manual push-button to put the unit into Automatic mode.

Step 10: 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 INSTALLATION.

Step 11: 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.

PERIODIC PERFORMANCE CHECKS

Weekly:
Check that the system is sequencing through all selected zones. While it sequences, monitor the flowmeter to check that there are no obstructions in the tubing.
Momentarily depress the Maintenance push-button. Make certain that all Zone Alarm lights work, that any horns and strobes are actuated.

Quarterly:
Go through steps 2 through 9 of the start up instructions, to check proper functioning of the Leak Wait and Alarm modes.

PREVENTIVE MAINTENANCE CHECKS

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

Cooling Air Filters:
There are two air filters on the outside of the box, 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.

Tube End Coarse Filters:
Dirt and grease on the tube end filters will restrict air flow and increase the time for a sample to reach the monitor.

Optional In-line Filter Separators:
These filters should be installed in any zones that are particularly dirty and/or where there is a risk of moisture entering the system.

Pump Filters:
There are two filters on the inlet and outlet of the pump inside the System 2000 box. Dirt and moisture droplets will degrade the sensor and shorten its life.

Sensor Fine Filter:
In the sensor leg of the pneumatic system there is a final fine (5 micron) filter to protect the regulator, orifice, flowmeter, and sensor.

How often to clean the filters depends on how dirty the air is in the vicinity of the monitor and at the pickup points. The following recommendations are a starting point.

Filter Cleaning Recommendations:

1. For the first three months of operation, check all the filters at least monthly to determine how quickly each filter gets dirty, and establish a maintenance schedule based on that data.

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.

MAINTENANCE & TROUBLE SHOOTING

Maintenance:
The System 2000 can be partitioned into three major subsystems. These are the pneumatics or air sampling system; the sensor and sensor electronics; and the PLC or programmable logic controller. Note that the following discussion is based on a System 2038, or 8 zone system. All of the discussion is relevant to a 2034 system. The only difference in the pneumatic subsystem is that a 2034 has only one bank of inlet manifold/valve assemblies and the 2038 has 2 banks of inlet/manifold assemblies.

Pneumatic Subsystem (refer to Fig. 6):
The heart of the Pneumatic System is the vacuum pump which sequentially draws the air sample from each of the zones being monitored. The air is compressed to a pressure of 4 psig (pounds/square inch gauge). A small portion of the sample air is diverted to the sensor and the remainder is exhausted. The vacuum pump has been sized so that for the longest recommended tube run, 500 feet (120 meters), it will take 20 to 25 seconds for a new sample to reach the sensor.

Starting at the location to be sensed, the tubing is terminated with a coarse filter assembly. If the area to be sensed is particularly dirty and/or there is any risk of water entering the system, the optional filter/separator assembly should be in series with the tubing. This unit should be mounted at a convenient location near the pickup point. At the system 2000, the tubing is connected to the inlet port selected for that zone. Recall from the Zone Selection section of the manual, the tubing has to be installed starting with zone 1 (upper left hand inlet port) and continued in sequence.

In series with each inlet port, there is a solenoid valve that is controlled by the PLC. The valves are energized, one at a time, sequentially, starting with zone 1 and continuing until the last selected zone is energized, at which point the system returns to zone 1 and repeats the process. The manifolds are interconnected and the assembly is connected to the inlet filter of the pump.

The outlet filter is connected to a cross fitting. One arm of the cross is connected through a tee to the pressure gauge and then the pressure relief exhaust valve. Another arm is connected to the pressure switch which must be actuated for the system to operate. The third arm is connected to the subsystem which delivers the sample air to the sensor.

The air to the sensor first passes through a 5 micron filter, a pressure regulator, an orifice, a flowmeter and then the sensor. A decal on the inside of the front door of the unit shows the flow setting that was used in calibration and setup of the unit. The sensor electronics compensate for variations in flow through the sensor.

The flow rate is a function of the pressure at the inlet of the orifice and the orifice size. The pressure at the inlet of the orifice is a set by the pressure regulator. The regulator can control pressure from 0.1 to 10 psi. For the regulator to control its outlet pressure, the inlet pressure must be several psi higher than the desired outlet setting. The inlet pressure of the regulator is set by the adjustable pressure relief valve at the exhaust.

Resetting Sensor Air Flow:
Put the system in Manual mode and select a zone that will be convenient for disconnecting the tubing. Sensor flow adjustments should be done with no tubing connected. Disconnect the tubing from that zone. Make a note of the flow setting used when the unit was calibrated at the factory.

Correcting for relatively small variations in sensor air flow can be accomplished by adjusting the regulator.

A major readjustment that may become necessary because of a component change requires a two step process.

1. Loosen the locking nut on the pressure relief valve. Adjust the valve until the pressure gauge reads in the range of 4 psi. Retighten the lock nut making it as secure as you can.

2. Adjust the pressure regulator to achieve the required air flow.

Reconnect the tubing. Manually sequence through all the selected zones to double check that there are no problems in any of the tube runs.

Pressure Switch:
The purpose of the pressure switch is to shut down the system if there is a pump failure or a major blockage in one of the tube runs. It is a 0.5-10 psi switch that is normally set to actuate at approximately .5-1 psi. The normally closed contacts are used so that when there is insufficient pressure there is a 24 volt signal to the PLC. The signal is called FS1 and is input to the PLC main unit at position X6. (See the PLC section of this manual for a discussion of the PLC). There is a 10 second delay in the PLC logic so that when

the unit is first turned on, there is time for the pressure to build and actuate the switch before a shut down is executed. If there is a failure and the switch deactuates, the Maintenance relay is energized after the 10 second delay. When the relay is energized, power is removed from the pump and the sensor electronics.

Resetting the Pressure Switch:
The pressure switch is set at the factory, and is unlikely to need readjustment unless there is a failure and it has to be replaced.

1. Turn the pressure switch adjustment screw until approximately one (1) thread is showing.

2. Disconnect the tubing from one of the zones.

3. Switch to Manual mode and advance to the zone from which you disconnected the tubing.

4. Place your finger over the zone input to block air flow. The flowmeter reading will drop, and after 15-29 seconds shut down should occur.

5. Reconnect the tubing.

Checking for Pneumatic System Failures:
The first step in checking for a pneumatic system failure is to eliminate the other reasons for energizing the Maintenance relay.

The Maintenance relay will also be energized when all zones are in Alarm. If this is the case, all the selected zone Alarm lights will be flashing. Push Reset.

The system should come back on in Warm-up mode, with the pneumatic system operating normally. Proceed to solve the leak problem(s).

The second cause for actuating the Maintenance relay is a failure in the control board alarm circuitry. In this situation, at least one zone but not all should be in Alarm and the X4 LED on the PLC may be lit. If this is the case, turn to the sensor electronics portion of this section.

Assuming the other two reasons for energizing the Maintenance relay have been eliminated, the source of the problem is the pneumatic system.

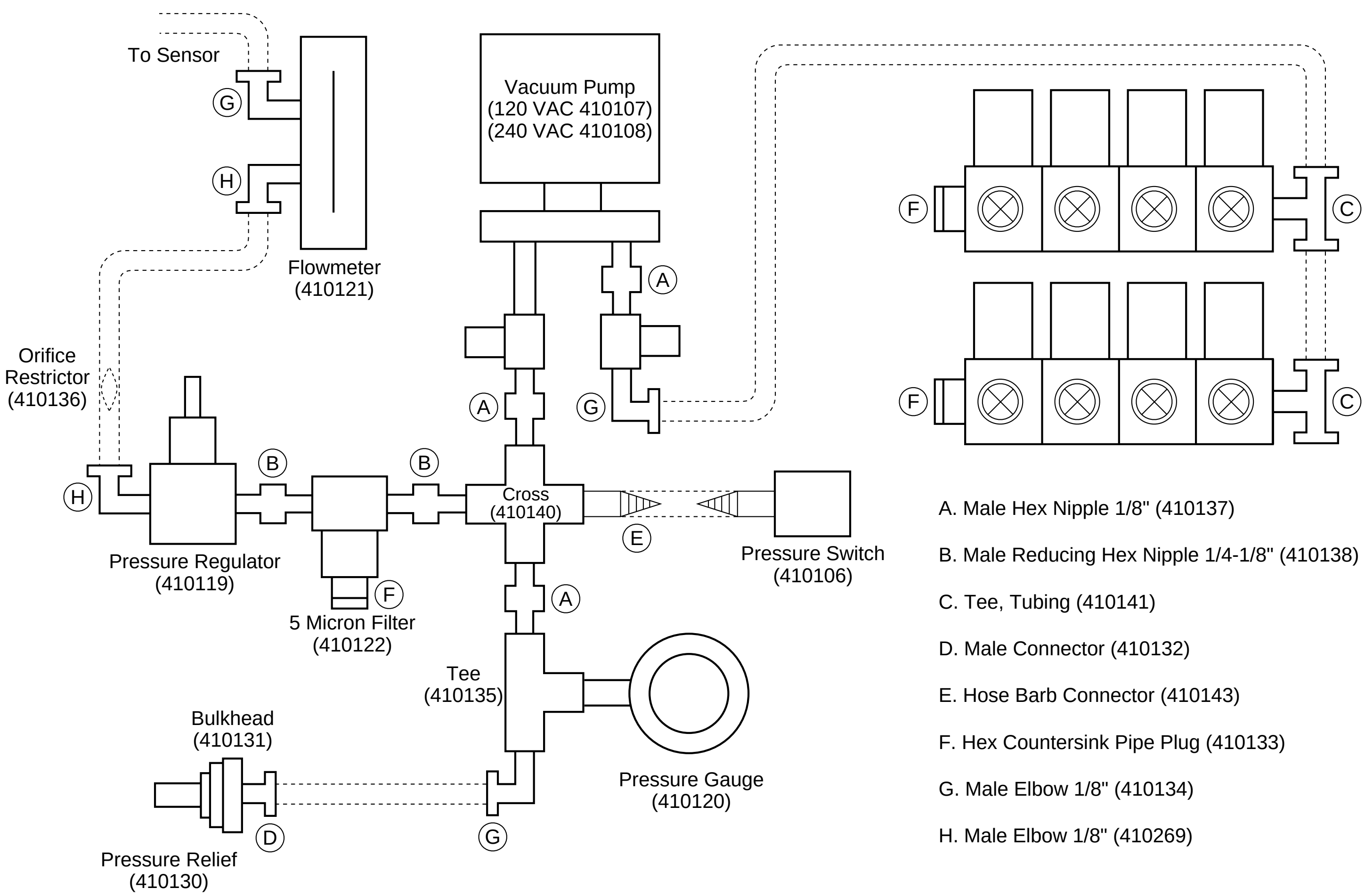


Fig. 6
Pneumatic Subsystem Schematic

Programmable Logic Control (PLC)

The System 2000 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. When Warm-up is completed, it proceeds to sequence through the selected zones monitoring for leaks. As with the pneumatic system, the following discussion will be based on a model 2038, 8 zone unit. The only difference between the models are that a 2034 has a single PLC base unit and one additional output block. The 2038 has two additional output blocks. 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, and the pressure switch signal. Outputs from the PLC control the lights, the zone valves, and 5 Relays. All the inputs and outputs are 24 Volts DC. 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 volts.

Input/Output Names and Locations:
The PLC Input/Output chart shows all the PLC inputs and outputs, their logic designations and descriptions. 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-Y3 means the Y3 connection on the lower set of terminal strips of unit 2 (the middle unit). 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 2000.

Logic Description:
All of the inputs except the Trigger signal are positive logic. That is a logic 1 or +24 Volts means something should happen or the signal is present or ON. The Trigger signal is the only reverse logic input. When the +24 is present, it is NOT Trigger, 0 Volts indicates that the system is Trigger. 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 Volts means the output is on.

Inputs

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

Trigger X1 and Enable X4 - The Trigger and Enable signals provide the communications between the control board/sensor electronics and the PLC. The Enable signal tells the PLC that a message is coming from the control board. When the PLC receives an Enable signal, it starts counting Trigger signals, which are 50 millisecond pulses. The number of Trigger pulses tell the PLC the current status of the sensor electronics. The following table describes each of the possible states and how the PLC reacts to each state.

Number of Pulses	Control Board Status	Meaning
0	Test or Warm-up	Sensor in Warm-up. (Test is used only for trouble shooting, see section on Sensor Electronics.
1	Monitoring	Monitoring mode, the system is waiting for a leak.
2	Low Alarm, no Main Alarm	Low Alarm trip point has been crossed.
3	Leak Wait	The Main Alarm trip point has been crossed, and the system is in Leak Wait mode.
4	Main Alarm	The Leak Wait has completed and the system has determined there is a Main Alarm condition.
5	Main Alarm, no Low Alarm	A Main Alarm has occurred and the signal has now dropped below the Low Alarm trip point. (This signal is used in single zone units.)
6	High Alarm	The High Alarm trip point has been crossed.
7	Malfunction	A sensor electronics malfunction has occurred.

A malfunction will be indicated for two possible problems. One potential problem is that the sensor output is below a minimum value, indicating a failure in the sensor system. This could be the result of a failure in the sensor, in the control board, or in the bridge board.

The second possibility is that there has been a communication failure between the control board and the PLC. Whenever the control board has a change in status, it reports that to the PLC through the Enable (X4) and the Trigger (X1) signals. Additionally, if there is no change in status for 30 minutes, the control board sends an update of the current status to the PLC. If the PLC does not get a signal from the control board for 45 minutes, the PLC assumes that there has been a communications failure and enters the Malfunction mode.

PLC INPUT/OUTPUT

PLC LOGIC DESIGNATION	PLC LOCATION	MNEMONIC	SIGNAL DESCRIPTION	2000 CONNECTION
X0	PLC1T-X0	AM	AUTO/MANUAL SELECTION	AUTO/MANUAL PB
X1	PLC1T-X1	$\overline{\text{TRIG}}$	TRIGGER SIGNAL FROM CONTROL BOARD	TBJ-1
X2	PLC1T-X2	MRES	MANUAL RESET	MANUAL RESET PB
X3	PLC1T-X3	ADV	ADVANCE	ADVANCE PB
X4	PLC1T-X4	E NBL	ENABLE SIGNAL FROM CONTROL BOARD	CONTROL BOARD J2-7
X5	PLC1T-X5	PTT	PUSH TO TEST	MAINTENANCE /PUST TO TEST PB
X6	PLC1T-X6	FSI	PRESSURE SWITCH	PRESSURE SWITCH N/C CONTACT
X7	PLC1T-X7	AZA	ALLOW ZONE A	TBDC-1
X10	PLC1T-X10	AZB	ALLOW ZONE B	TBDC-2
X11	PLC1T-X11	AZC	ALLOW ZONE C	TBDC-3
X12-X17	NOT USED	NOT USED	NOT USED	NOT USED
Y0	PLC1B-Y0	AUTO	AUTOMATIC MODE	AUTO/MAN PB, AUTO LIGHT
Y1	PLC1B-Y1	MAN	MANUAL MODE	AUTO/MAN PB, MANUAL LIGHT
Y2	PLC1B-Y2	RESR	MANUAL RESET	RESET RELAY COIL PIN 13
Y3	PLC1B-Y3	HALRMR	HIGH ALARM RELAY	HIGH ALARM RELAY COIL PIN 13
Y4	PLC1B-Y4	WUP	WARM UP MODE	WARM UP LIGHT
Y5	PLC1B-Y5	MNR	MAINTENANCE RELAY	MAINTENANCE RELAY COIL PIN 13
Y6	PLC1B-Y6	MNL	MAINTENANCE LIGHT	MAINTENANCE PB LIGHT
Y7	NOT USED	NOT USED	NOT USED	NOT USED
Y10	PLC1B-Y10	LWL	LEAK WAIT MODE	LEAK WAIT LIGHT
Y11	PLC1B-Y11	LALRMR	LOW ALARM RELAY	LOW ALARM RELAY COIL PIN 13
Y12	PLC1B-Y12	MLALRMR	MAIN ALARM RELAY	MAIN ALARM RELAY COIL PIN 13
Y13	PLC1B-Y13	WFL	MONITORING MODE	MONITOR LIGHT
Y14	PLC1B-Y14	Z1 ALRM	ZONE 1 ALARM	ZONE 1 ALARM LIGHT
Y15-X17	NOT USED	NOT USED	NOT USED	NOT USED
Y20	PLC2T-Y0	Z1 ON	ZONE 1 ON	TBB14 ZONE 1 ON LIGHT
Y21	PLC2T-Y1	Z2 ON	ZONE 2 ON	TBB1-5 ZONE 2 ON LIGHT
Y22	PLC2T-Y2	Z3 ON	ZONE 3 ON	TBB1-6 ZONE 3 ON LIGHT
Y23	PLC2T-Y3	Z4 ON	ZONE 4 ON	TBB1-7 ZONE 4 ON LIGHT
Y24	PLC2T-Y4	Z1HALRM	ZONE 1 HIGH ALARM	ZONE 1 HIGH ALARM LIGHT
Y25	PLC2T-Y5	Z2HALRM	ZONE 2 HIGH ALARM	ZONE 2 HIGH ALARM LIGHT
Y26	PLC2T-Y6	Z3HALRM	ZONE 3 HIGH ALARM	ZONE 3 HIGH ALARM LIGHT
Y27	PLC2T-Y7	Z4HALRM	ZONE 4 HIGH ALARM	ZONE 4 HIGH ALARM LIGHT
Y30	PLC2B-Y0	Z1MALRM	ZONE 1 MAIN ALARM	ZONE 1 MAIN ALARM LIGHT
Y31	PLC2B-Y1	Z2MALRM	ZONE 2 MAIN ALARM	ZONE 2 MAIN ALARM LIGHT
Y32	PLC2B-Y2	Z3MALRM	ZONE 3 MAIN ALARM	ZONE 3 MAIN ALARM LIGHT
Y33	PLC2B-Y3	Z4MALRM	ZONE 4 MAIN ALARM	ZONE 4 MAIN ALARM LIGHT
Y34	PLC2B-Y4	Z1LALRM	ZONE 1 LOW ALARM	ZONE 1 LOW ALARM LIGHT
Y35	PLC2B-Y5	Z2LALRM	ZONE 2 LOW ALARM	ZONE 2 LOW ALARM LIGHT
Y36	PLC2B-Y6	Z3LALRM	ZONE 3 LOW ALARM	ZONE 3 LOW ALARM LIGHT
Y37	PLC2B-Y7	Z4LALRM	ZONE 4 LOW ALARM	ZONE 4 LOW ALARM LIGHT
Y40	PLC3T-Y0	Z5 ON	ZONE 5 ON (USED ON 2038 ONLY)	TBB2-4, ZONE 5 LIGHT ON
Y41	PLC3T-Y1	Z6 ON	ZONE 6 ON (USED ON 2038 ONLY)	TBB2-5, ZONE 6 LIGHT ON
Y42	PLC3T-Y2	Z7 ON	ZONE 7 ON (USED ON 2038 ONLY)	TBB2-6, ZONE 7 LIGHT ON
Y43	PLC3T-Y3	Z8 ON	ZONE 8 ON (USED ON 2038 ONLY)	TBB2-7, ZONE 8 LIGHT ON
Y44	PLC3T-Y4	Z5HALRM	ZONE 5 HIGH ALARM (USED ON 2038 ONLY)	ZONE 5 HIGH ALARM LIGHT
Y45	PLC3T-Y5	Z6HALRM	ZONE 6 HIGH ALARM (USED ON 2038 ONLY)	ZONE 6 HIGH ALARM LIGHT
Y46	PLC3T-Y6	Z7HALRM	ZONE 7 HIGH ALARM (USED ON 2038 ONLY)	ZONE 7 HIGH ALARM LIGHT
Y47	PLC3T-Y7	Z8HALRM	ZONE 8 HIGH ALARM (USED ON 2038 ONLY)	ZONE 8 HIGH ALARM LIGHT
Y50	PLC3T-Y0	Z5 MALRM	ZONE 5 MAIN ALARM (USED ON 2038 ONLY)	ZONE 5 MAIN ALARM LIGHT
Y51	PLC3B-Y1	Z6 MALRM	ZONE 6 MAIN ALARM (USED ON 2038 ONLY)	ZONE 6 MAIN ALARM LIGHT
Y52	PLC3B-Y2	Z7 MALRM	ZONE 7 MAIN ALARM (USED ON 2038 ONLY)	ZONE 7 MAIN ALARM LIGHT
Y53	PLC3B-Y3	Z8 MALRM	ZONE 8 MAIN ALARM (USED ON 2038 ONLY)	ZONE 8 MAIN ALARM LIGHT
Y54	PLC3B-Y4	Z5LALRM	ZONE 5 LOW ALARM (USED ON 2038 ONLY)	ZONE 5 LOW ALARM LIGHT
Y55	PLC3B-Y5	Z6LALRM	ZONE 6 LOW ALARM (USED ON 2038 ONLY)	ZONE 6 LOW ALARM LIGHT
Y56	PLC3B-Y6	Z7LALRM	ZONE 7 LOW ALARM (USED ON 2038 ONLY)	ZONE 7 LOW ALARM LIGHT
Y57	PLC3B-Y7	Z8LALRM	ZONE 8 LOW ALARM (USED ON 2038 ONLY)	ZONE 8 LOW ALARM LIGHT

Pressure Switch X6 - When the X6 is high, it indicates that the pressure is below the pressure switch setting and there may be a problem with the pneumatic system.

Allow Zone X7-X11 - These signals are used to select the number of zones to be scanned. Refer to the Zone Selection section of this manual for a description of their functions.

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.

High Alarm Relay Y3 - The High Alarm Relay is energized by the PLC when a high alarm condition occurs. It is maintained until there is a Manual Reset. The High Alarm Relay contacts are available to the user for external signaling 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 and the sensor electronics.

Low Alarm Relay Y11 - The Low Alarm Relay is energized by the PLC when a Low Alarm condition occurs. It is maintained until there is a Manual Reset. The Low Alarm relay contacts are available to the user for external signalling devices.

Main Alarm Relay Y12 - The Main Alarm Relay is energized by the PLC when a Main Alarm condition occurs. It is maintained until there is a Manual Reset. The Main Alarm relay contacts are available to the user for external signalling devices.

Zone On Y20-Y23, Y40-Y43 - These outputs energize the zone solenoid valves.

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 24V to the run input, a jumper between SS and O V to define a +24 input as a logic 1, a connection between the PLC OV and the system 2000 common, jumpers to connect all the SG terminals, and the +24 volts to power the outputs.

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 effect 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.

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 (Fig. 7):
Figure 7 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 circuit. 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 (Fig. 8):
Figure 8 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 various trip point thresholds. As the sensor level exceeds the trip points, the system goes through the Low Alarm, Leak Wait, Main Alarm, and finally High Alarm modes.

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.

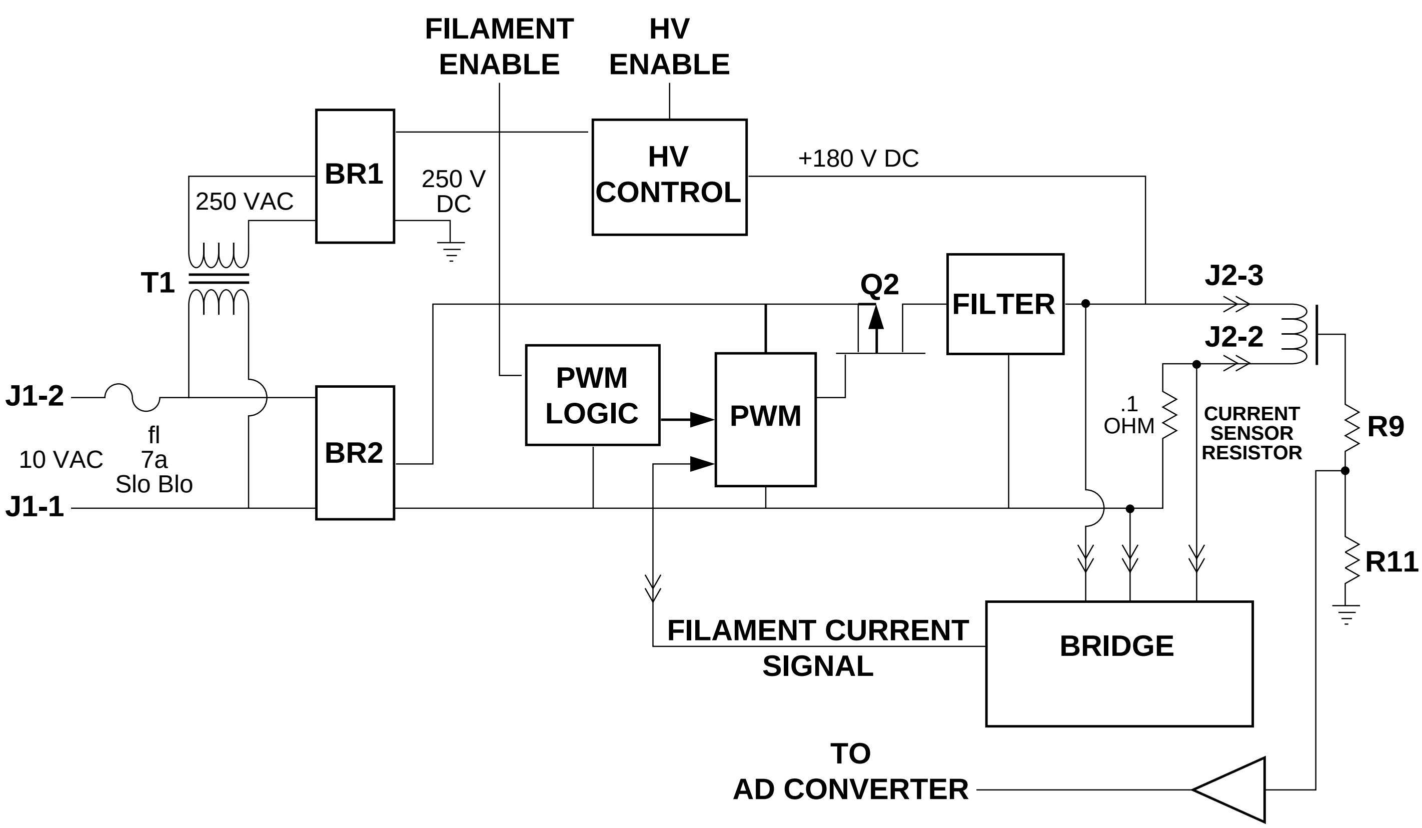


Fig. 7
Sensor Power Circuit

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 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 (to the right) for normal operation.

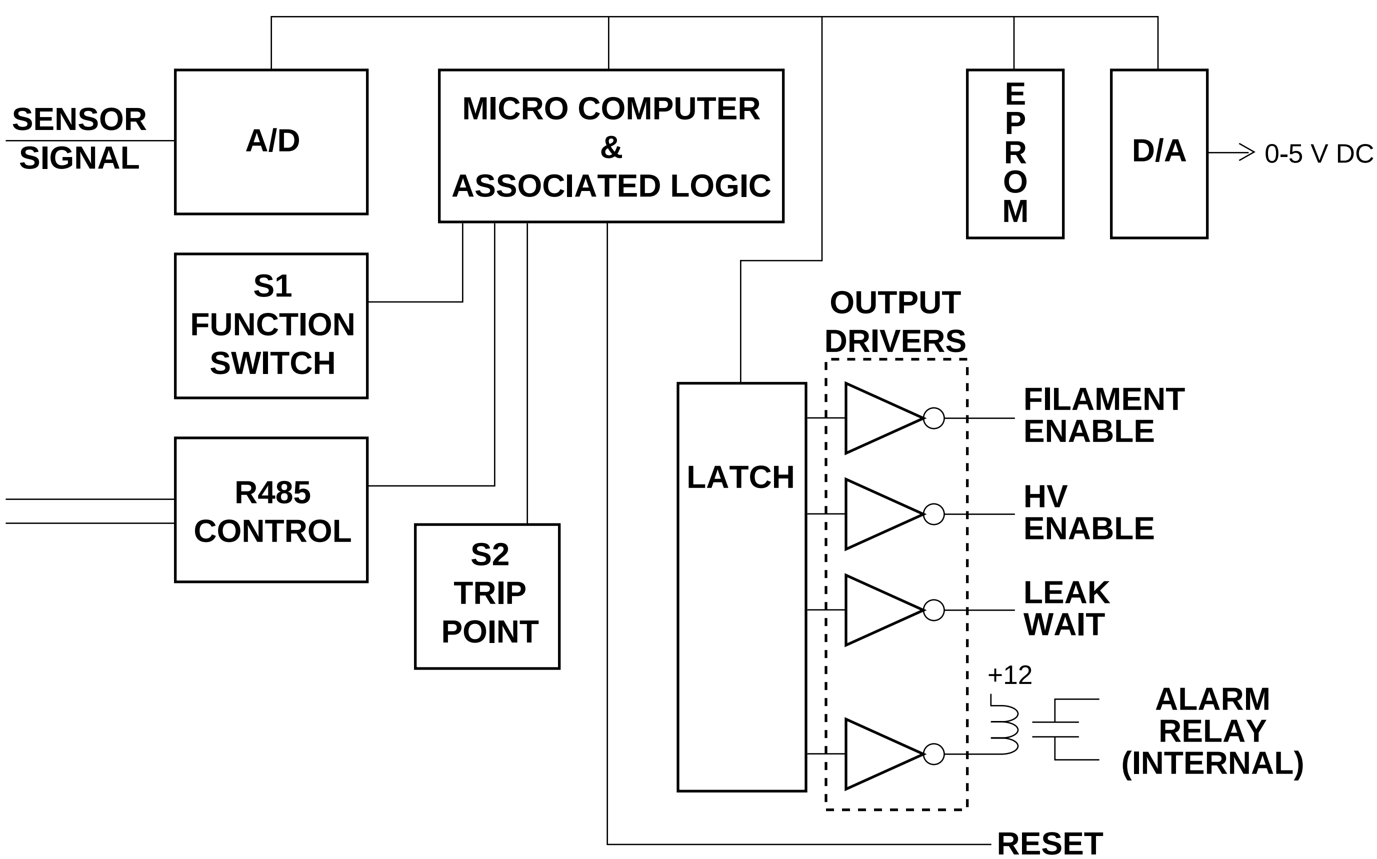


Fig. 8
Electronics Digital Control

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". 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

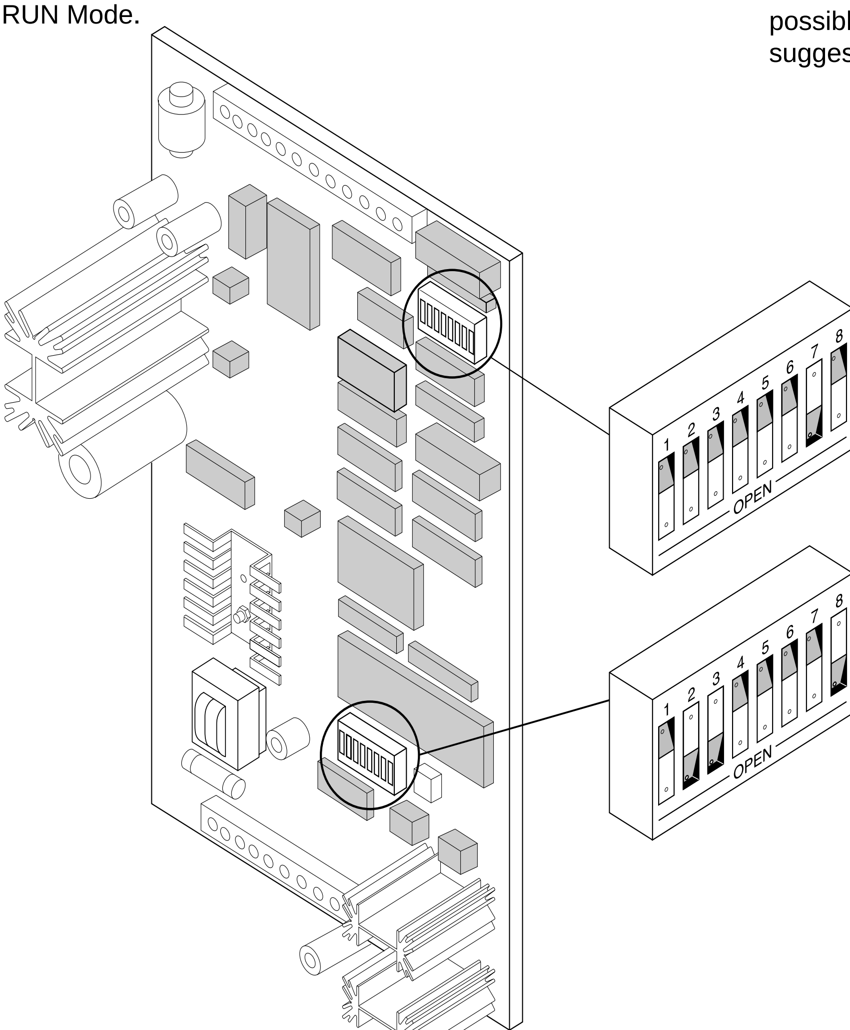
Position 8 determines whether the unit is in Run Mode or Test Mode. Test Mode is used for trouble shooting and maintenance. For normal operation position 8 must be in RUN Mode.

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.



S2 MAIN ALARM TRIP POINT
(See trip point calibration)

S1 LOW ALARM TRIP POINT FUNCTION
Position 1-4 Low Alarm
Position 5-7 Reserved
Position 8 Run/Test shown in run mode

Diagram "A"

TRIP POINT SETTINGS: 100 PPM FULL SCALE CALIBRATION †

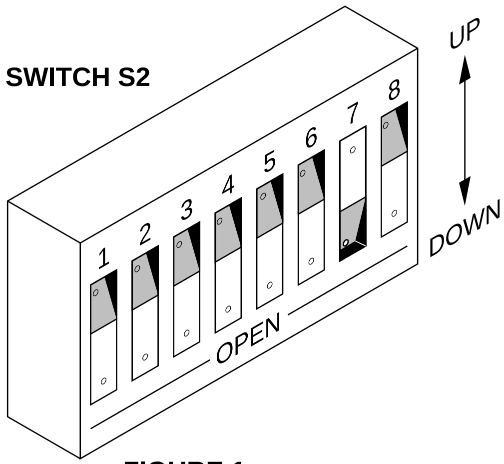


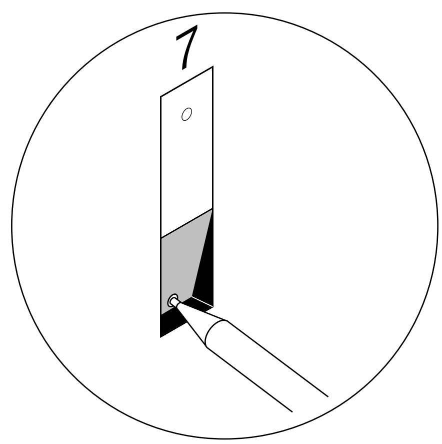
FIGURE 1
MAIN ALARM TRIP POINT SETTING
@ PPM - 25
(DIP SWITCH - 7)

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 (40–90)

*** DO NOT USE**

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



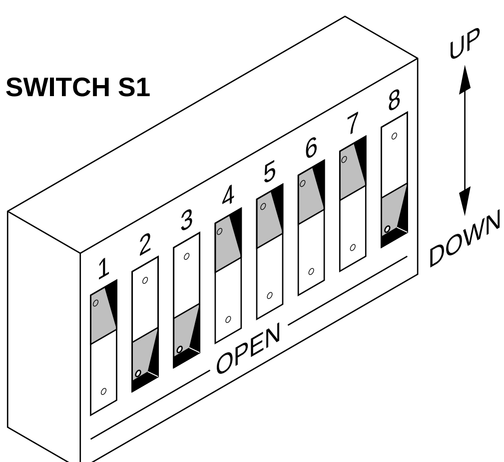


FIGURE 3
LOW ALARM TRIP POINT
SHOWN IN RUN MODE (6 PPM)

PPM	DIP SWITCH DOWN
*0	NONE
1	1
2	2
4	3
6	2,3
8	4
10	2,4
12	3,4
15	1,2,3,4

Not recommended unless normal ambient very low (1–4)

*** DO NOT USE**

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.

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

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 ?

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

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

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 ?

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

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

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/m³	0.28 m³/kg
R-12	4.96 kg/m³	0.20 m³/kg
R-11	5.76 kg/m³	0.17 m³/kg
R-502	4.64 kg/m³	0.21 m³/kg
R-123	6.56 kg/m³	0.15 m³/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 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

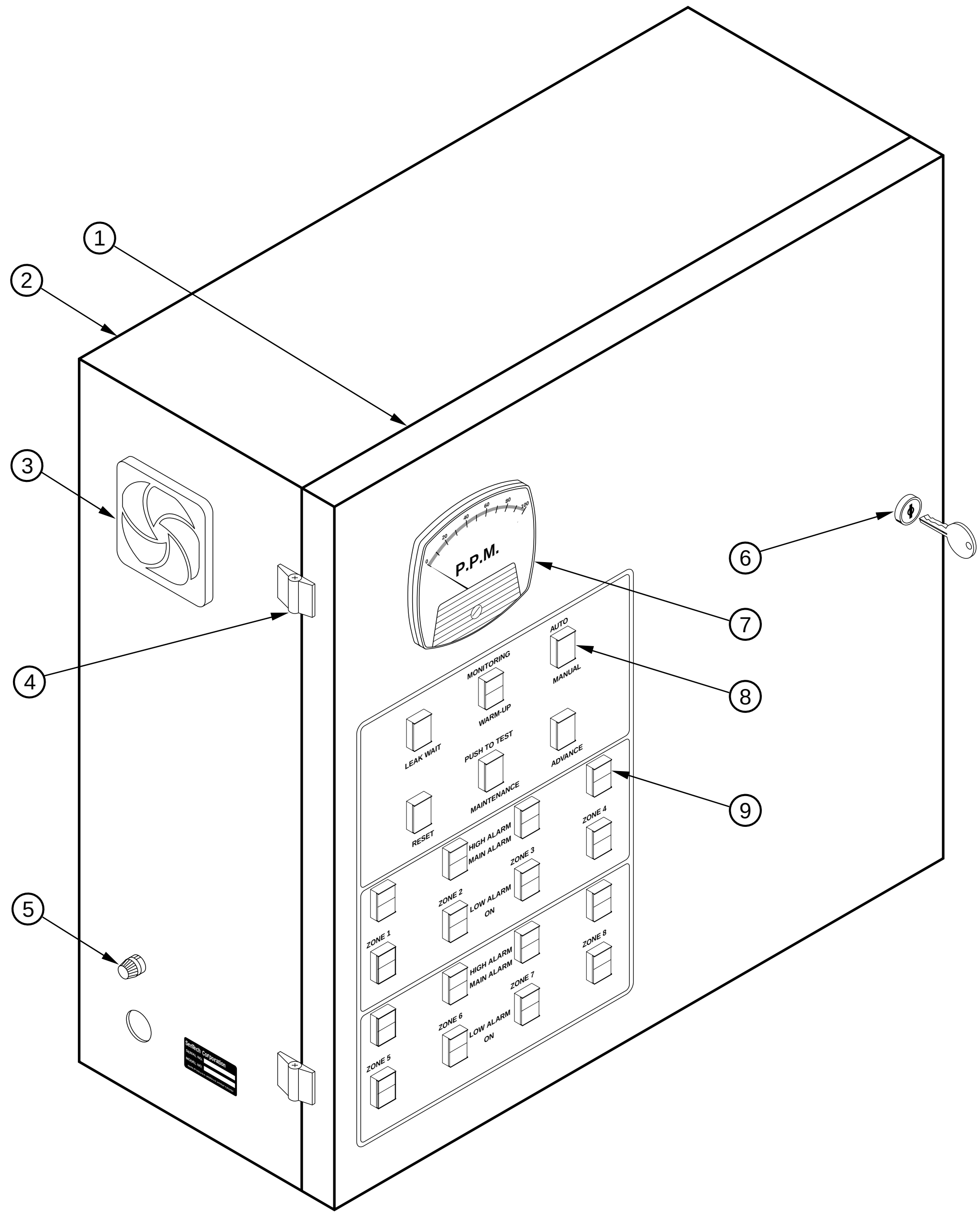
4. How long will it take to detect a leak of 150 kg/yr of R-123 ?

150 kg/yr of R-123 = .0026 m³/hr

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

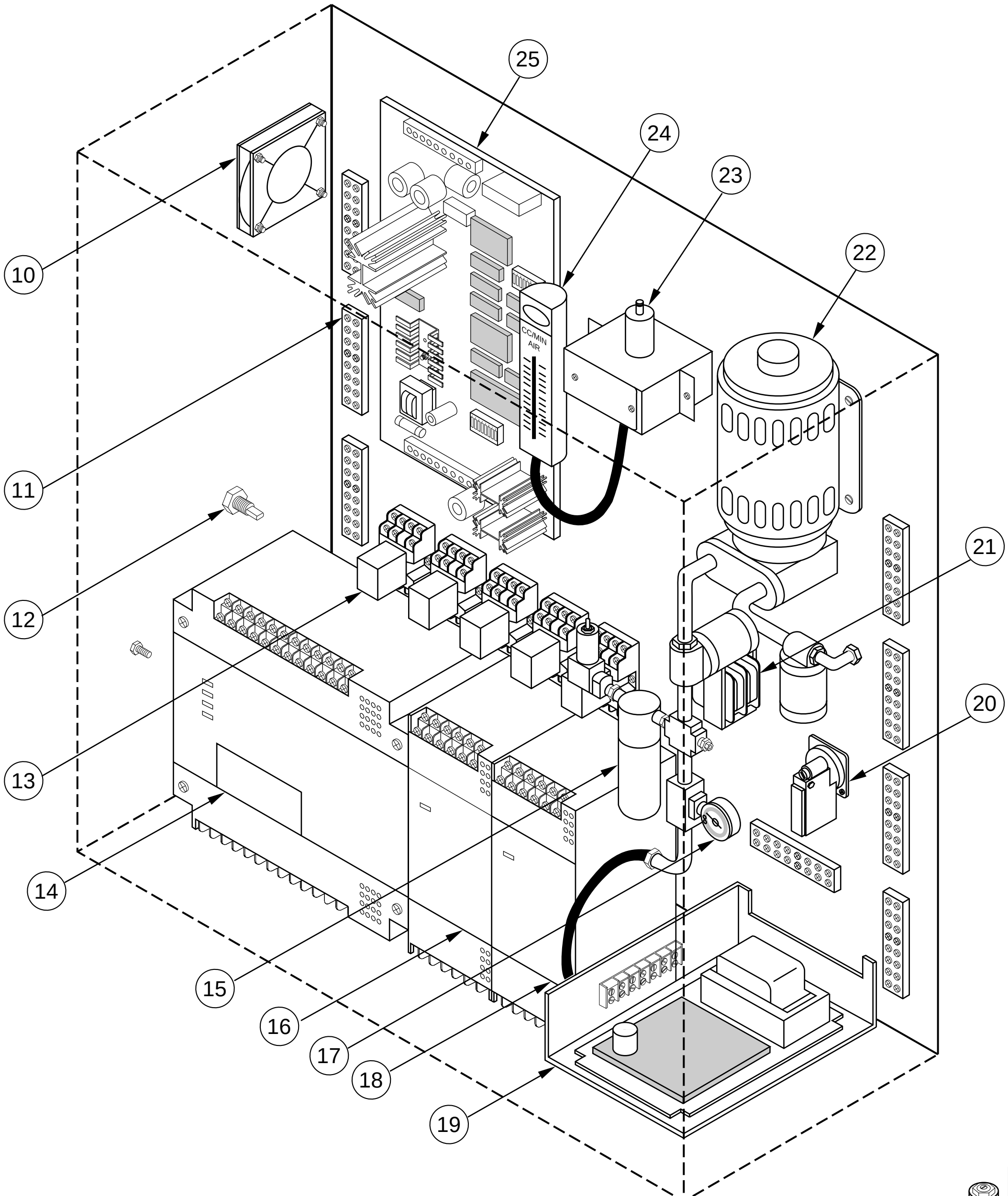
These numbers represent worst case conditions. With the monitor placed close to the potential leak points and on the "downwind" side of the air flow, the trip points are likely to be activated sooner.

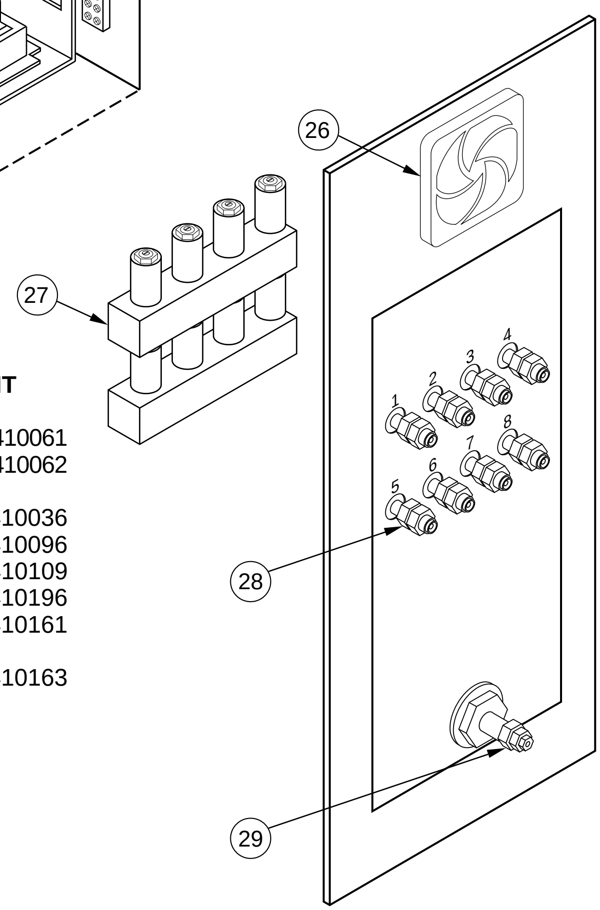
SenTech System 2000
Exploded View & Parts List



1. Lid, Finished 400005
2. Box, Finished 400006
3. Fan Guard/Filter 410017
   Filter Replacement 410018
4. Hinge (2) 410050
5. Main Power Fuse 410095
   Main Power
   Fuse Holder 410033
6. Key Lock Assembly 410006
7. Meter, Analog 410010
8. Push Button
   Switch (6) 410153
9. Panel Light (16) 410154
   Replacement Lamp
   (24VDC) 410159
10. Exhaust Fan 410016
11. Terminal Strip,
    7 position 410041
12. Main Power Fuse 410095
    Main Power
    Fuse Holder 410033
13. Relay, 24 VDC (5) 410087
    Relay Socket (5) 410040
14. PLC Base Unit 410092
15. 5 Micron Filter 410122
    5 Micron
    Replacement Element 410162
16. PLC Extension Unit 410093
17. Pressure Gauge 410120
18. PLC Extension Unit 410093
19. Power Supply
    (24 VDC) 410103
20. Pressure Switch 410106
21. Transformer 410039
22. Vacuum Pump
    Assemby (115 VAC) 410107
    Vacuum Pump
    Assemby (240 VAC) 410108
23. Sensor*
    Sensor Bracket 400056
24. Flowmeter 410121
    Flowmeter Bracket 400057
25. Control Board*
26. Fan Guard/Filter 410017
    Filter Replacement 410018
27. Manifold Assy. (4) 410114
28. Male Connector (16) 410123
29. Pressure Relief 410130

** Replacement of the sensor or control board requires recalibration. Return to the factory for repair.*





ITEMS NOT ILLUSTRATED

Course Tube Filter 410144
Female Hose Barb 1/4" 410151
Vacuum Pump Replacement
Filter 410353
Vacuum Pump Replacement
Vanes 410409

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 Assembly 410161
20 Micron
Replacement Element 410163

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 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
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.

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

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. 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 Rd.
Indianapolis, Indiana 46241

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

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

SenTech

P/N 400204
Rev. 091195