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**Spectrum RAL
Compressed Air Line
Carbon Monoxide Monitor
Instrument Manual**

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1.0 Introduction

The **SPECTRUM-RAL** carbon monoxide monitor is a small 110 VAC operated instrument for the detection of carbon monoxide gas in compressed air lines. An electrochemical cell detects the gas, and the gas concentration is displayed on an LCD. Audio and visual alarms occur when the gas concentration exceeds a preset alarm point. At relatively low concentrations of CO, an alarm can be acknowledged, which results in the temporary cessation of the audio alarm. Operation and maintenance procedures are managed with two pushbutton switches.

A description of the characteristics and toxic effects of carbon monoxide is given in Appendix A, and should be reviewed by the user.

NOTE: *All specifications stated in this manual may change without notice.*

1.1 Unpack

Unpack the **SPECTRUM-RAL** and examine it for shipping damage. If such damage is observed, notify both **ENMET** customer service personnel and the commercial carrier involved immediately.

Regarding Damaged Shipments

NOTE: It is your responsibility to follow these instructions. If they are not followed, the carrier will not honor any claims for damage.

- This shipment was carefully inspected, verified and properly packaged at our company and delivered to the carrier in good condition.
- When it was picked up by the carrier at **ENMET**, it legally became your company's property.
- If your shipment arrives damaged:
 - Keep the items, packing material, and carton "As Is." Within 5 days of receipt, notify the carrier's local office and request immediate inspection of the carton and the contents.
 - After the inspection and after you have received written acknowledgment of the damage from the carrier, contact **ENMET** Customer Service for return authorization and further instructions. Have your Purchase Order and Sales Order numbers available.
- ENMET** either repairs or replaces damaged equipment and invoices the carrier to the extent of the liability coverage, usually \$100.00. Repair or replacement charges above that value are your company's responsibility.
- The shipping company may offer optional insurance coverage. **ENMET** only insures shipments with the shipping company when asked to do so in writing by our customer. If you need your shipments insured, please forward a written request to **ENMET** Customer Service.

Regarding Shortages

If there are any shortages or questions regarding this shipment, please notify **ENMET** Customer Service within 5 days of receipt at the following address:

ENMET Corporation
680 Fairfield Court
Ann Arbor, MI 48108
734-761-1270 734-761-3220 Fax

1.2 Check Order

Check the contents of the shipment against the purchase order. Verify that the **SPECTRUM-RAL** is received as ordered. If there are accessories on the order, ascertain that they are present. Check the contents of calibration kits. Notify **ENMET** customer service personnel of any discrepancy immediately.

1.3 Serial Numbers

Each **SPECTRUM-RAL** is serialized. These numbers are on tags on the equipment and are on record in an **ENMET** database.

1.4 Check Instrument

Turn the instrument ON, by plugging into a standard 110 VAC wall outlet and attach to your compressed air line system. In uncontaminated air, the display should read 0000 within ten seconds of turn-on.

Check display operations by pressing the **OPTION** and **SELECT** switches as described in Figure 1.

The **SPECTRUM-RAL** instrument is calibrated prior to shipment. However, it is advisable to apply a known source of carbon monoxide to the instrument to verify the sensor has not been damaged during shipment.

If there is access to a source of CO in compressed air, such as in a calibration kit, expose the sensor to CO, and observe that the instrument is responsive.

If the concentration of CO is greater than 10 ppm, the instrument indicates an alarm condition. Acknowledge the alarm by pressing and releasing the right hand pushbutton, **SELECT**; this silences the audio alarm for four minutes unless the concentration of CO is greater than 50 PPM.

Remove source of CO. After the display reads zero or close to it, turn the instrument off, by removing the power adapter from the wall outlet.

If the instrument does not operate as described, contact **ENMET** customer service personnel immediately.

2.0 SPECTRUM-RAL Features and Installation

2.1 Features

The features of the **SPECTRUM-RAL** Carbon Monoxide monitor are shown in Figure 1. These are:

| | |
|-------------------------------------|---|
| DISPLAY | LCD indicates the gas concentration, or prompts for the operational and maintenance menus |
| PUSHBUTTON SWITCHES | These switches are used to access and utilize the operational and maintenance menus. There are two of these, as follows: OPTION , the left hand switch. SELECT , the right hand switch. |
| SENSOR HOUSING | A small cylindrical turret on the display surface; the membrane of the electrochemical sensor is exposed to the compressed air through the air supply line. |
| REGULATOR | A pressure regulator with a gauge. |
| FLOWMETER | Flowmeter with an adjustable valve, connected by tubing to the sensor housing. |
| VISUAL ALARM | A red LED, which is ON whenever, the CO concentration is above the alarm point. |
| AUDIO ALARM | A small horn, which is ON whenever, the gas concentration is above the alarm point, until the alarm is acknowledged. |
| COVER | Retained with four screws and removed to change the sensor and access the terminal strip. |
| RELAY CONTACT TERMINAL STRIP | A terminal strip inside the enclosure that enables access to the alarm relay contacts. See Figure 2. |

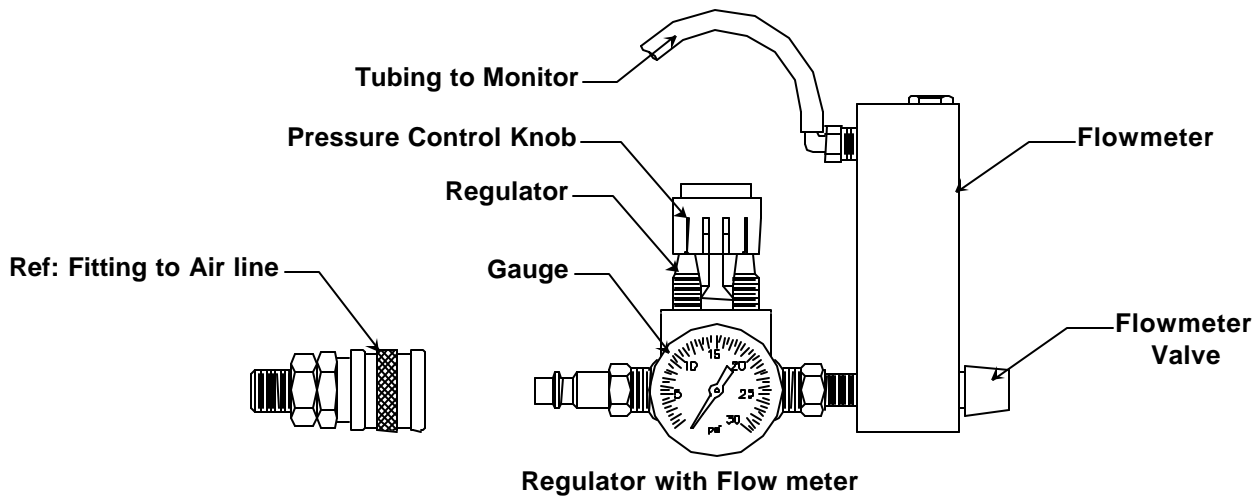
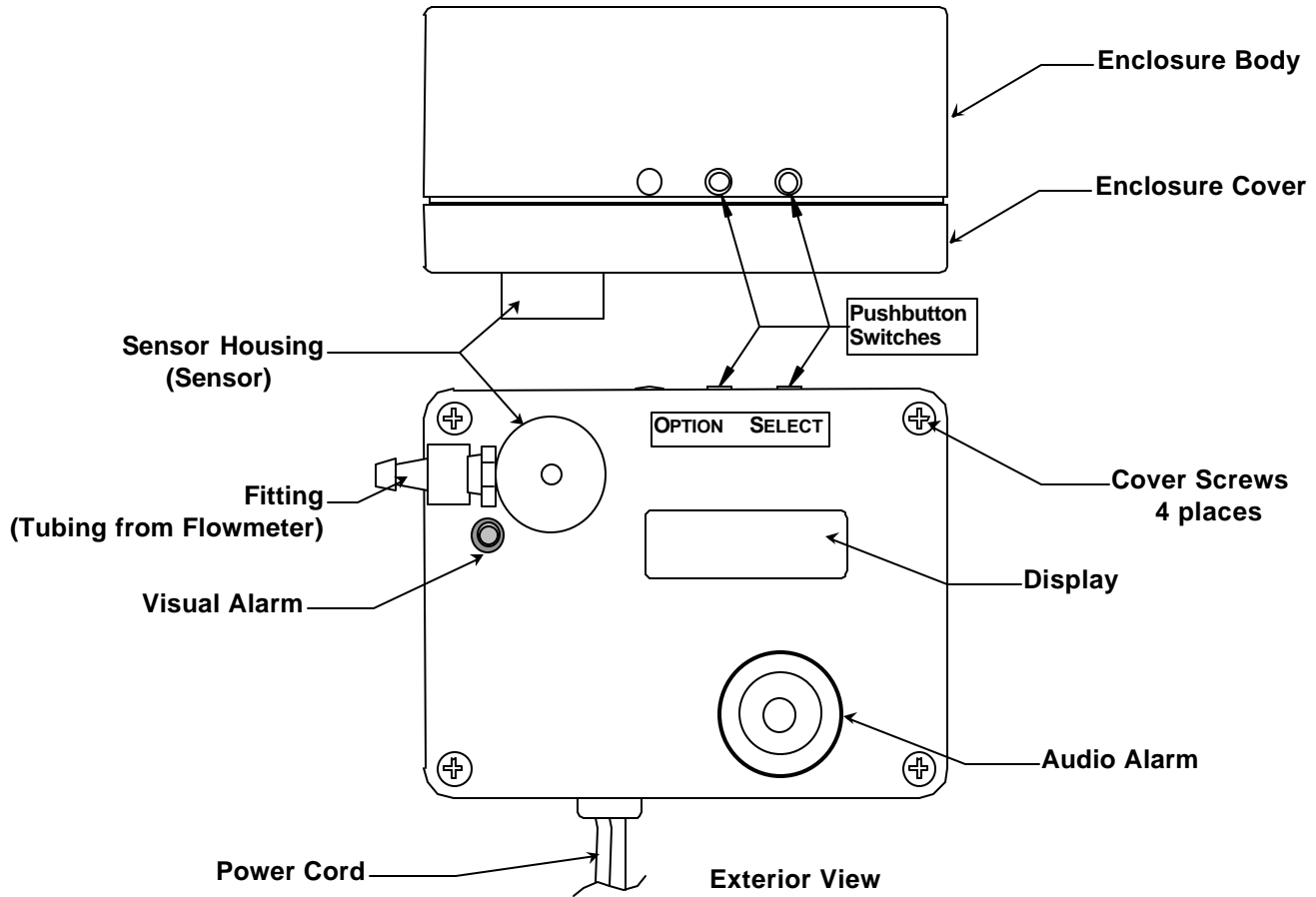


Figure 1: SPECTRUM-RAL Features

2.2 SPECTRUM-RAL Installation

2.2.1 Mount Enclosure

Mount the enclosure at an appropriate location using the two mounting holes accessible inside the enclosure. See Figure 2. The location should be far enough upstream from the user that the sample air reaches the monitor before the air reaches the user.

Dimensions are in inches.

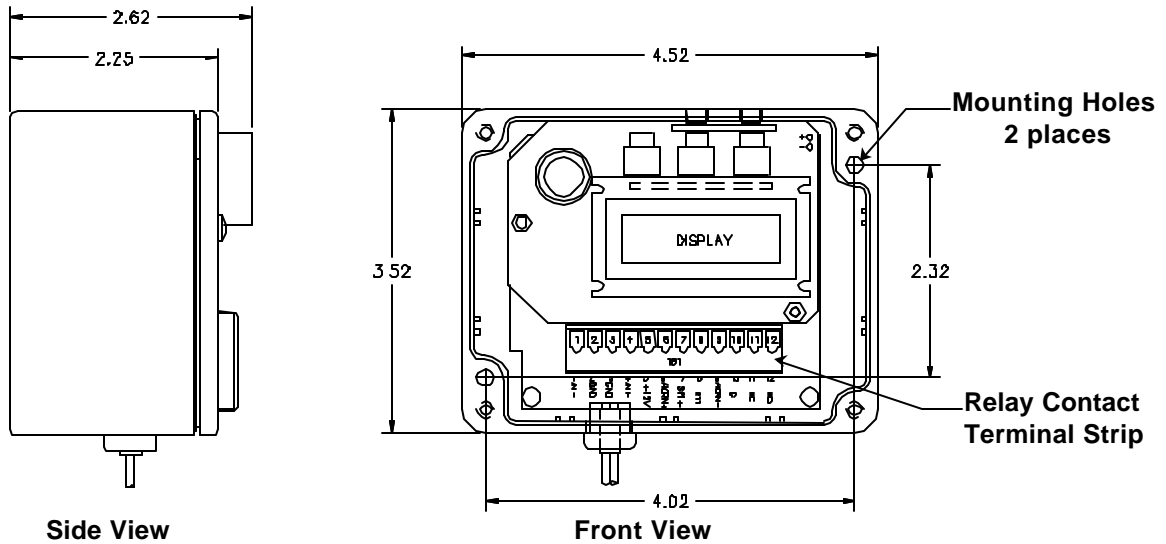


Figure 2: SPECTRUM-RAL Interior View

2.2.2 Air Supply

The male quick disconnect pneumatic connector on the regulator-flowmeter assembly is a Foster 3003 series. Plumb the associated female connector into the airline. See Figure 1.

Connect the regulator-flowmeter and set the pressure at approximately:

20 PSIG and the flow at 1.0 SCFH or 0.5 ℓ min.

2.2.3 Relay Contacts

Relay contacts are accessible on a spring-clamp terminal strip inside the enclosure after removing the cover. Terminal strip locations are listed in Table 1.

Table 1: Relay connections to terminal strip

| Relay contact | Terminal position |
|---------------|-------------------|
| C | 10 |
| NC | 11 |
| NO | 12 |

NOTE: Some versions of the **SPECTRUM-RAL** have two sets of relay contacts. If there is a second set of relay contacts there will be 13 – 15 positions on the terminal strip. If present position 13=C, 14=NC and 15=NO.

Contact position refers to the unpowered condition that is also the alarm condition. Relay contacts are rated at 2 amps @ 110V. Instrument ground is accessible at terminal strip locations 1, 2, and 3, and +12 VDC is available at locations 4, 5, and 6. When powering an auxiliary device with +12 VDC, do not overload the power supply (exceed 200 mA). To exit relay wires, drill a hole in the lower right surface of the enclosure, and use a strain relief.

3.0 SPECTRUM-RAL Operation

Plug the power supply into an 110 VAC outlet. The display should read "0000" within ten seconds when the monitor is supplied with uncontaminated air.

3.1 Operational Menu

The operational menu flow diagram is shown in Figure 3. This menu is accessed with the **OPTION** pushbutton switch, the left hand switch as viewed from the front of the instrument. Successive displays are achieved by repeatedly pushing the **OPTION** switch, as indicated by "O" in the menu flow diagram. The alarm acknowledgement function, and displays and function in the "see DATA" area, are accessed with **SELECT** pushbutton, indicated by "S" in the menu flow diagram.

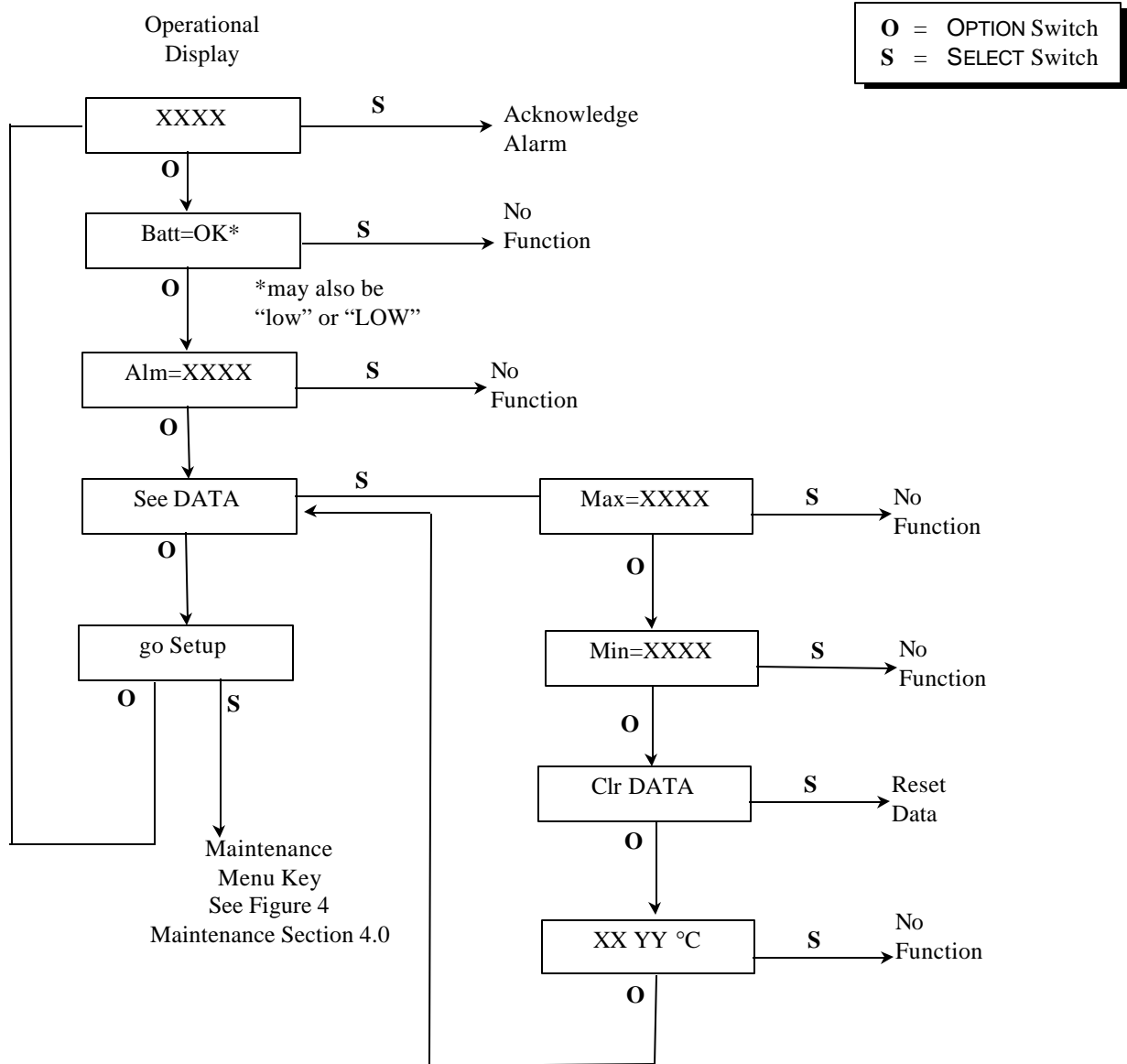


Figure 3: Operation Menu Diagram

3.2 Gas Concentration Display and Alarms

The LCD furnishes a numerical display of CO concentration from 0000 to 100 PPM. If the CO concentration exceeds 100 ppm, the display reads "100+." When the concentration of CO exceeds the preset alarm point, the audio and visual alarms are activated. The gas concentration continues to be displayed during alarm. The alarm point is adjustable between 5 and 100 ppm CO by accessing the maintenance menu; the factory setting of the alarm point is 10 ppm CO, the value recognized by OSHA as the acceptable exposure limit for compressed air lines. A user should have a justifiable application-based reason for setting the alarm point higher than 10 PPM. When the CO concentration drops below the alarm point, the audio and visual alarms cease operation. The alarm point setting can be observed on the display by pushing the OPTION switch twice.

If an alarm concentration is encountered when the display is at a location in the operational menu other than the concentration numerical display, the audio and visual alarms are activated and the alarm cannot be acknowledged.

If the display is left idle at a location other than the concentration numerical display for 45 seconds it automatically transfers to the concentration numerical display.

3.3 Alarm Acknowledge

When the instrument is in alarm, and the CO concentration is below 50 PPM, the alarm can be acknowledged by pressing and releasing the SELECT pushbutton, but only when the instrument is in the numerical concentration location of the operational menu. The acknowledgement causes the temporary cessation of the audio alarm; the red LED continues to be ON. The audio alarm is OFF for a period of four minutes, after which it is reactivated, if the gas concentration is still above the alarm point. The alarm can again be acknowledged. However, acknowledgement of the alarm at gas concentrations above 50 PPM, does not result in audio alarm cessation, and if the gas concentration rises above 50 PPM during an alarm condition which has been acknowledged, the audio alarm resumes operation.

3.4 Data

The **SPECTRUM-RAL** monitor retains the maximum and minimum gas concentration values encountered since turn-on, or since the data was cleared and reset. There is a one minute delay from the time the instrument is turned on until when it starts storing the information. To access this press the OPTION switch three times; "see DATA" is displayed. Press the SELECT switch; the maximum concentration since turn-on or last reset is displayed. Press the OPTION switch again; the minimum concentration since turn-on or last reset is displayed. Press the OPTION switch again; "clr DATA" is displayed. Pushing the SELECT switch clears the data and resets it to the current concentration.

Pushing the OPTION switch once more results in a display of both the countdown to the confidence beep and the internal temperature of the instrument in degrees centigrade. Push the OPTION switch three more times to return to the gas concentration numerical display.

3.5 Interference Gases

Some gases other than CO cause a sensor response, and thus are termed "interference gases".

Known interference gases are shown in Table 2.

Table 2: Known Interference Gases

| Gas | Concentration in PPM | Reading in ppm |
|--------------|----------------------|----------------|
| Hydrogen | 1,000 | 100+ |
| Nitric oxide | 100 | 25 |

Table 3 shows levels of gases that are known to cause no sensor response.

Table 3: Known gases with no response

| Gas | Concentration |
|-------------------|---------------|
| Ammonia | 100 ppm |
| Carbon dioxide | 5,000 ppm |
| Chlorine | 5 ppm |
| Ethylene* | 2 % |
| Gasoline vapor* | saturated |
| Hydrogen cyanide | 10 ppm |
| Hydrogen sulfide* | 10 ppm |
| Isopropanol* | 1,025 ppm |
| Methane | 10,000 ppm |
| Nitrogen dioxide* | 10 ppm |
| Sulfur dioxide* | 10 ppm |

*For indicated gases or vapors, prolonged exposure may reduce the efficiency of the sensor filter.

4.0 Maintenance

4.1 Maintenance Menu

From the gas concentration numerical display, push the OPTION button four times; "go SETUP" is displayed. This is the entrance to the maintenance menu. The maintenance menu flow diagram is shown in Figure 4.

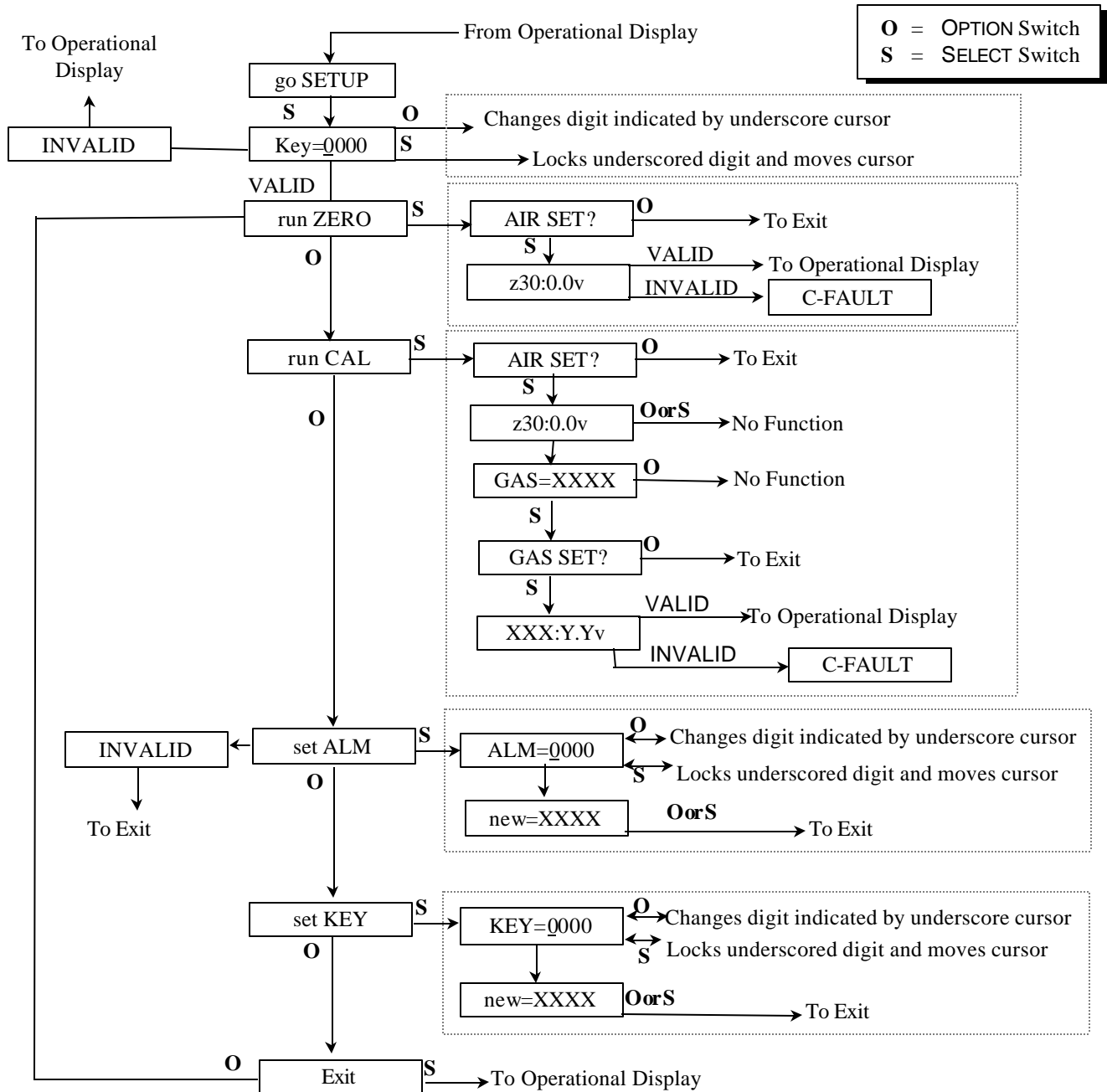


Figure 4: Maintenance Menu Diagram

4.2 Key

Entrance to the maintenance menu is guarded with a four digit numerical key. The factory default setting of the key is 1270. When the valid numerical key is inserted, the user is allowed to enter the maintenance menu.

When in the "go SETUP" location, press the **SELECT** pushbutton; "Key=0000" is displayed. The underscore cursor is under the left hand digit. To insert the key, press the **OPTION** pushbutton to index the left hand digit, and choose the correct digit; then press the **SELECT** pushbutton, which locks in the chosen left hand digit and moves the underscore cursor one space to the right. Continue this process until the four digit key is complete. When the valid key is inserted in this manner, the display is transferred to the "run ZERO" portion of the maintenance menu. When an invalid key is inserted, "INVALID" is briefly displayed, and the instrument returns to the operations menu.

The process that a different key is set is given in section 4.6.

4.3 Zero

A valid key entry sets the instrument at the "run ZERO" location, of the maintenance menu, which enables the setting of the zero gas concentration point. This is desirable if the zero reference of the gas sensor has drifted over a period of time, indicated by a persistent gas concentration reading in a clean environment. Note that the calibration sequence given below also includes setting the zero point. If a full calibration is required, instead of setting just the zero point, push the **OPTION** button once; "run CAL" is displayed. See section 4.4.

To set the zero point without performing full calibration, from the "run ZERO" location press the **SELECT** button; "AIR SET?" is displayed. Be certain that the instrument is supplied with clean air, uncontaminated by carbon monoxide. If uncertain of the environment, use pure compressed air from a pressurized cylinder, and flow it over the sensor at a flow rate of 1 SCFH.

With the instrument in zero air, press the **SELECT** button again. "ZERO=30" is displayed; this is a counter that counts down in seconds from 30 to 0. The validity of the new zero setting is then examined; if it is reasonable, the display is transferred to the concentration numerical display in the operations menu.

If the new zero setting is not between reasonable parameters, "C-FAULT" is displayed. Turn the instrument OFF, the ON again. This re-boots the system with the most recent valid zero setting.

4.4 Calibration

NOTE: Calibration should be performed at normal room temperature (20-25°C) for optimal performance. If the instrument is exposed to temperature extremes just prior to calibration, it should be allowed to stabilize to room temperature. The internal temperature of the instrument can be verified by cycling through the "see DATA" menu.

In order to calibrate the instrument, it is first zeroed as described above. Then the sensor is exposed to a known concentration of the target gas, in air or an inert gas such as nitrogen, called the "span gas". After an appropriate interval, which is timed, the new span setting is examined for validity.

A valid key entry sets the instrument at the "run ZERO" location of the maintenance menu. Press the **OPTION** pushbutton once to access the "run CAL" display, then press the **SELECT** pushbutton; "AIR SET" is displayed. Zero the instrument as described in section 4.3. When the zero timer is complete, the display indicates "SPAN=XXX", where the numbers indicate the correct span gas concentration for the instrument. The span gas value for this instrument is 20 PPM CO.

Assure that the correct span gas is available, connect the calibration adapter to the cylinder, then press the **SELECT** button; "GAS SET" is displayed. Unplug the regulator-flowmeter assembly from the airline, connect it to the calibration adapter and set the flow at 1.0 SCFH. Then press the **SELECT** button; "XXX:0.Yv" is displayed. The XXX is a counter which counts down in seconds to zero from 120 to provide the proper time interval for calibration. The 0.Yv indicates a sensor signal which is used during the sensor replacement procedure. When the timer reaches zero, the new calibration and zero gas settings are examined for validity. If the values are reasonable, the display is transferred to the gas concentration numerical display in the operations menu. Return the regulator-flowmeter assembly to the airline.

If the new zero and calibration settings are not reasonable, "C-FAULT" is displayed. Turn the instrument OFF, then ON again. This re-boots the system with the most recent valid zero and calibration settings.

4.5 Changing the Alarm Level

A valid key entry sets the instrument at the "run ZERO" location of the maintenance menu. Press the **OPTION** push button twice to access the "set ALM" display, then press the **SELECT** button; "ALM=0000" is displayed. This is called the alarm update window, and the value displayed is the present alarm setpoint. The underscore cursor is under the far left digit. Press the **OPTION** button to index the underscored digit; press the **SELECT** button to index the underscore cursor one position to the right. When the desired new alarm point is set, press either the **OPTION** or **SELECT** button to return to the alarm update window. If the new alarm setting is valid, "set ALM" is again displayed. Press the **OPTION** button four times to return to the operations menu.

For the safety of the user, there is an upper limit past which the alarm setting is invalid, and the instrument does not accept it. If an invalid alarm setting is attempted, after the numerical value is inserted in the "ALM=0000" window, pressing the **OPTION** or **SELECT** button results in a momentary display of "INVALID" after which the display returns to the alarm update window. Exiting the alarm update window at this point results in an alarm point setting unchanged from the value present when the procedure was begun.

For the **SPECTRUM-RAL**, the factory default alarm setpoint is 10 PPM, and the upper alarm limit is 50 PPM.

4.6 Setting a New Key

A valid key entry sets the instrument at the "run ZERO" location of the maintenance menu. Press the **OPTION** button four times to access the "set KEY" display. Press the **SELECT** pushbutton once; "KEY=0000" is displayed. A new key can be set by indexing the underscored number with the **OPTION** button and indexing the underscore cursor with the **SELECT** button. Four digit key numbers should be selected carefully and recorded. Without the correct key, the maintenance menu cannot be accessed. If a four digit key number is lost, call **ENMET** customer service personnel.

4.7 Changing Components

Changing the sensor requires that the front of the instrument be removed; remove the four phillips head cover retaining screws, and then the cover.

A sensor must be replaced when it no longer responds adequately to the target gas. This is indicated by a low gas concentration reading when exposed to a known concentration of the target gas, and the inability to calibrate the instrument, with a "C-FAULT" display after calibration. The expected sensor lifetime in normal environments is one to two years.

CAUTION: New sensors come with a shorting clip that must be removed for proper operation.

Remove the front cover of the instrument enclosure. Unplug the sensor from the circuit board. Remove the shorting clip from the new sensor and plug it in place. Allow the sensor to stabilize in the instrument with the power on for one hour before recalibrating.

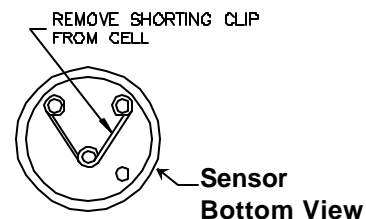


Figure 5: Remove Shorting Clip

The initial calibration of a new sensor must be performed with the front cover of the enclosure removed. A calibration cup is provided with the calibration kit. Follow the procedure for calibrating the instrument as outlined in Section 4.4 of this manual with the following modification.

NOTE: During this procedure make sure the RED calibration cup, 02552-008, stays centered over the sensor.

During the application of the span gas, the counter counts down from 120. When the counter gets down to 30, adjust the potentiometer next to the display module on the instrument PC board, so that the display to the right of the counter reads 0.65v. This is a one-time adjustment to align the sensor output with the instrument electronics. It should only be performed upon sensor replacement. All future calibrations should follow the procedure in Section 4.4.

Replace the front cover on the instrument enclosure. Calibrate the instrument according to the procedure in section 4.4.

5.0 Replacement Part Numbers

ENMET replacement part numbers:

| Description | Part Number |
|--|-------------|
| Calibration Kit | 03412-001 |
| Calibration Cup | 02552-008 |
| Calibration Gas, 20 ppm CO | 03219-020 |
| Zero Gas, 20.9 % Oxygen | 03296-209 |
| Replacement CO Sensor <i>for instrument S/N 43-8099 and below</i> | 67020-1200 |
| Replacement CO Sensor <i>for instrument S/N 43-8100 and above</i> | 67016-1204 |
| Display Assembly | 62022-007 |
| PC Board Assembly | 05215-002 |
| Relay | 60004-000 |
| Power Supply | 67052-004 |
| | |

6.0 WARRANTY

ENMET warrants new instruments to be free from defects in workmanship and material under normal use for a period of one year from date of shipment from **ENMET**. The warranty covers both parts and labor excluding instrument calibration and expendable parts such as calibration gas, filters, batteries, etc... Equipment believed to be defective should be returned to **ENMET** within the warranty period (transportation prepaid) for inspection. If the evaluation by **ENMET** confirms that the product is defective, it will be repaired or replaced at no charge, within the stated limitations, and returned prepaid to any location in the United States by the most economical means, e.g. Surface UPS/RPS. If an expedient means of transportation is requested during the warranty period, the customer is responsible for the difference between the most economical means and the expedient mode. **ENMET** shall not be liable for any loss or damage caused by the improper use of the product. The purchaser indemnifies and saves harmless the company with respect to any loss or damages that may arise through the use by the purchaser or others of this equipment.

This warranty is expressly given in lieu of all other warranties, either expressed or implied, including that of merchantability, and all other obligations or liabilities of **ENMET** which may arise in connection with this equipment. **ENMET** neither assumes nor authorizes any representative or other person to assume for it any obligation or liability other than that which is set forth herein.

NOTE: When returning an instrument to the factory for service:

- Be sure to include paperwork.
- A purchase order, return address and telephone number will assist in the expedient repair and return of your unit.
- Include any specific instructions.
- For warranty service, include date of purchase
- If you require an estimate, please contact **ENMET** Corporation.

Appendix A

The Characteristics and Effects of Carbon Monoxide

Carbon monoxide is a colorless odorless toxic gas generated by incomplete combustion of a hydrocarbon fuel in air. It may be present where internal combustion engines, furnaces, boilers, and other combustion devices are present. It is toxic when inhaled because of its great affinity to hemoglobin, the oxygen carriers in the red cells of the blood. CO replaces the oxygen normally carried by the hemoglobin, and thus inhibits the delivery of oxygen throughout the body; the victim suffers from oxygen deficiency, and may die from asphyxiation. The symptoms and degree of danger resulting from exposure to CO depend upon the concentration of the gas and the length of exposure; this is shown in Figure 6. The **ENMET SPECTRUM-RAL** carbon monoxide monitor is employed to warn the user of the presence of CO, and to facilitate the assessment of the degree of danger that he or she is exposed to.

Based upon knowledge of the effects of CO, the Occupational Safety and Health Authority (OSHA) has set limits on exposure to CO in the workplace. For ambient air conditions, these are 35 PPM (parts CO per million parts air) as an time weighted average for an eight hour day, and a maximum exposure of 200 PPM. For compressed air line applications, 10 PPM is the maximum acceptable limit. The **SPECTRUM-RAL** monitor is shipped with the adjustable alarm set at 10 PPM; this alarm cannot be adjusted above 50 PPM.

The curves below are for percent carboxalhemoglobin with 50% being the top curve, 5% the bottom. % COHb is a measure of the amount of hemoglobin occupied by CO rather than oxygen. CO effects upon children, adults engaging in physical activity, and smokers, are more pronounced.

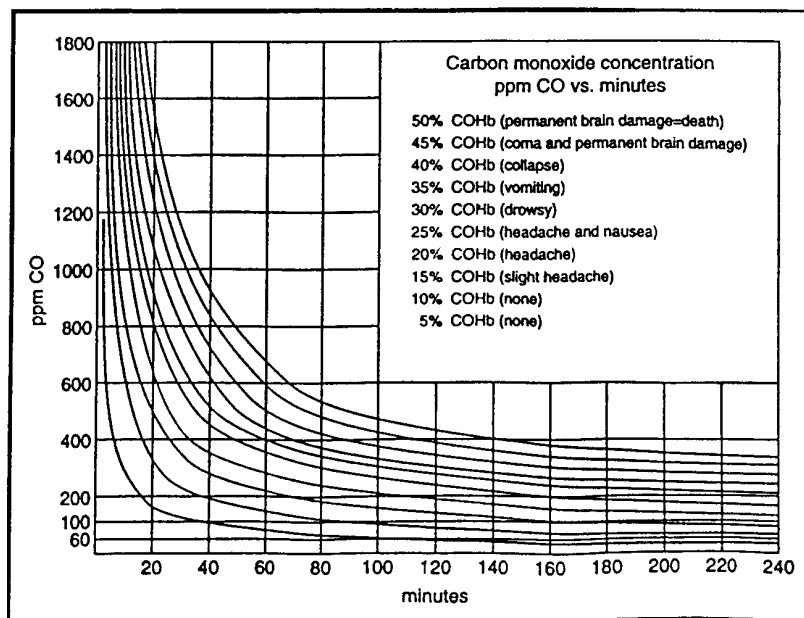


Figure 6: % COHb vs Time