

QRAE PLUS

PGM-2000/2020

MULTI-GAS MONITOR



OPERATION & MAINTENANCE MANUAL


Document Number: 015-4001-001

Revision G-1, December 2002



ATTENTION!

For European Applications

- A. E 0575  II 2G
DEMKO 02 ATEX 04201X
EEx ia d IIC T4 (with Battery Pack P/N 015-3052)
EEx ia d IIC T3 (with Battery Pack P/N 015-3053)
- B. Recharge batteries only in non-hazardous locations
- C. Do not connect external cable to serial interface jack in hazardous locations.
- D. Use RAE Systems Adapter P/N 500-0072 for connection to communication port and charging jack only in a non-hazardous area.

- READ BEFORE OPERATING -

This manual must be carefully read by **all** individuals who have or will have the responsibility of using, maintaining, or servicing this product. The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions.

CAUTION!

To reduce the risk of electric shock, turn off power before removing the housing top or the sensor cover. Disconnect the battery before removing sensor modules for service. Never operate this monitor while the top or the cover is removed. Remove the top, the cover or sensor modules only in an area known to be non-hazardous.


SPECIAL NOTE

When the PGM-2000 or PGM-2020 multi-gas monitor is taken out from the transport case and is turned on for the first time, there may be some residual vapor trapped inside the detector chamber. The initial toxic sensor readings may indicate a few ppm. Make sure the area is free of toxic vapors before turning the monitor on. After running the monitor for several minutes, the residual vapor in the detector chamber should clear and readings should return to zero.

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NOTE: THE SYMBOL  MEANS “CAUTION-
RISK OF DANGER. CONSULT OPERATION AND
MAINTENANCE MANUAL”.

WARNINGS!

For safety reasons this equipment must be operated and serviced by qualified personnel only. Read and understand the instruction manual completely before operating or servicing.

Use only RAE Systems battery packs, part number 015-3051, 015-3052, or 015-3053. *Battery pack 015-3051 is approved for use in USA only. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous locations.

Do not connect external cable to serial interface jack in hazardous locations.

STATIC HAZARD

Clean only with a damp cloth.

CALIBRATION

The calibration of all newly purchased RAE Systems Instruments should be tested by exposing it to known concentration calibration gases before the instrument is put into service for the first time.

For safety, check the accuracy of the QRAE Plus by exposing the sensors to known concentration calibration gas before each day's use.

READINGS

Any rapid up-scale reading followed by a declining or erratic reading may indicate a gas concentration beyond upper scale limit, which may be hazardous.

AVERTISSEMENT!

Pour des raisons de sécurité, cet équipement doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d'instructions en entier avant d'utiliser, d'entretenir ou de réparer l'équipement.

Utiliser seulement l'ensemble de batterie RAE Systems avec numéro de série 015-3051, 015-3052, ou 015-3053. *Le batterie avec numéro de série 015-3051 est permit pour l'usage seulement aux Etats-Unis. Cet instrument n'a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d'oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsèque. Ne charger les batteries que dans l'emplacements désignés non-dangereux.

Connectez pas le cable externe au port parallel dans un environnement non-dangereux.

DANGER RISQUE D'ORIGINE ELECTROSTATIQUE

Nettoyer uniquement avec un chiffon humide.

LA CALIBRATION

La calibration de toute instruments de RAE Systems doivent être testé en exposant l'instrument a une concentration de gaz connue par une procédure dietalonnage avant de mettre en service l'instrument pour la première fois.

Pour une securite maximale, la sensibilité du QRAE PLUS doit être verifier en exposant l'instrument a une concentration de gaz connue par une procédure dietalonnage avant chaque utilisation journalière.

LES LECTURES

Toute lecture rapide et positive, suivie d'une baisse subite au erratique de la valeur, peut indiquer une concentration de gaz hors gamme de détection qui peut être dangereuse.

1. General Information

The QRAE Plus is a programmable multi-gas monitor designed to provide continuous exposure monitoring of toxic gases, oxygen and combustible gases for workers in hazardous environments.

There are two models available: the **PGM-2000**, a pump unit, and the **PGM-2020**, a diffusion unit. The figures and displays in this manual are primarily for the PGM-2000 model.

The QRAE Plus monitors inorganic toxic gases and oxygen concentrations with electrochemical sensors. It monitors combustible gases with a combination catalytic bead and thermal conductivity sensor.

The **QRAE Plus** includes:


- Calibration Adapter
- Quick Reference Guide
- Operation and Maintenance Manual
- Training Video
- Rubber Boot with Belt Clip
- 10 Water Trap Filters (PGM-2000 only)
- 3" Inlet Probe (PGM-2000 only)
- Water Trap and C-Filter Adapters (PGM-2000 only)
- Alkaline Battery Pack
- Lithium-Ion Battery Pack
- 120 V AC/DC Wall Adapter

Table 1. QRAE Plus Specifications

Dimensions:	3" L x 4.5" W x 1.8" H (7.6 cm x 11.4 cm x 4.3 cm)
Weight:	15 oz (525 g) with battery
Detectors:	2 Electrochemical toxic gases sensors 1 Electrochemical oxygen sensor 1 Catalytic/Thermal conductivity sensor for combustibles
Battery:	Rechargeable, Li-ion battery pack with built-in charger – 8 hours of charge time Alkaline battery adapter (3 AA's)
Operating Time:	Li-ion battery pack – up to 16 hours of continuous operation
Display:	Two-line, 16-character LCD with automatic LED backlight for dim lighting conditions
Keypad:	One operation key; two programming keys
Direct Readout:	Up to four instantaneous values, sensor name, high and low values for all detectors, TWA and STEL values for toxic, battery voltage and elapsed time
Sampling Pump:	Internal integrated pump with adjustable settings for low or high speed sampling
Alarms:	95 dB buzzer, flashing red LED, vibration alarm, LCD to indicate exceeded preset limits, low battery, or sensor failure
Alarm Settings:	Separate alarm limit settings for TWA, STEL, low and high alarms

(Continued)

GENERAL INFORMATION

- Calibration:** Two-point field calibration for fresh air and standard reference gas
Three-point optional oxygen calibration
- Attachments:** Rubber boot, belt clip, wrist strap
- Protection:** Password protected calibration settings, alarm limits, and data
- Intrinsic Safety:** UL Class I, Division I, Group A, B, C, D, and Class II, Division I, Group E, F, G
(Europe)
CE 0575  II 2G
DEMKO 02 ATEX 04201X
EEx ia d IIC T4 (with Battery P/N 015-3052)
EEx ia d IIC T3 (with Battery P/N 015-3053)
CSA Class I, Division 1, Group A,B,C,D
- EM Immunity:** No effect when exposed to 0.43mW/cm² RF interference (5 watts at 12")
- Data Storage:** 16,000 points of non-volatile memory (up to 67 hours of reading four sensors at one-minute intervals)
- Datalog Interval:** Programmable 1-second to 36,000-second intervals
- External Alarm:** Optional, plug-in, pen-size vibration alarm
- External Printer:** Optional, plug-in, thermal serial printer
- Communication:** Download data to PC
Upload monitor setup from PC through an RS-232 link to serial port on PC
- Temperature:** UL / ATEX
-20° C to 45° C (-4° F to 113° F)
CSA
0° C to 45° C (32° F to 113° F)
-20° C to 45° C (pending)
- Humidity:** 0% to 95% relative humidity

GENERAL INFORMATION

(non-condensing)

Table 2.
Range, Resolution & Response Time
(t₉₀ equipped with pump)

LEL	016-1171-000	0-100%	1%	15 seconds
O₂	008-1161-000	0-30%	0.1%	15 seconds
CO	008-1112-000	0-500 ppm	1.0 ppm	40 seconds
H₂S	008-1111-000	0-100 ppm	1.0 ppm	35 seconds
SO₂	008-1113-000	0-20 ppm	0.1 ppm	35 seconds
NO	008-1114-000	0-250 ppm	1.0 ppm	30 seconds
NO₂	008-1115-000	0-20 ppm	0.1 ppm	25 seconds
Cl₂	008-1116-000	0-10 ppm	0.1 ppm	60 seconds
HCN	008-1117-000	0-100 ppm	1.0 ppm	200 seconds
NH₃	008-1118-000	0-50 ppm	1.0 ppm	150 seconds
PH₃	008-1119-000	0-5 ppm	0.1 ppm	60 seconds

2. Operation

The QRAE PLUS Monitor is a compact multi-gas monitor. It gives real time gas measurements and alarms when gas levels exceed the preset limits. Before leaving the factory, default alarm limits are preset into the QRAE PLUS and the sensors are pre-calibrated with standard calibration gases. However, the user should calibrate the instrument before the first use to guard against changes during shipment. Once the monitor is fully charged and calibrated, it is ready for operation.

Calibration Frequency

The monitor should be calibrated before each day's use unless experience in the application shows that less frequent calibration meets the accuracy requirements for the job. In lieu of a full calibration, a "bump check" with calibration gas can be performed to ensure that the sensor(s) respond within the accuracy limits established by the user. If the bump check fails, a calibration must be performed. Frequent replacement of external filters may help extend the required calibration interval.

Sensor Cross-sensitivity and Deactivation

After calibration, all sensors will accurately read the gas for which they were designed and calibrated. However, all sensors can exhibit interferences or deactivation under more or less extreme conditions or concentrations. The user should always be aware of potential interfering compounds or deactivators and attempt to avoid such conditions. In particular, LEL sensors can be deactivated by silicones and compounds of chlorine, bromine, lead, phosphorus and sulfur. Percent levels of polar organic vapors (e.g., alcohols & acetone) reversibly affect some electrochemical sensors, particularly H₂S and CO. High levels of ammonia will shorten the life of the ammonia sensor.

Extremely low or high humidity may dry out or flood electrochemical sensors and should be avoided for extended periods. Indications that a sensor is nearing the end of its life are given by a) an expiration date warning on start-up, b) an error message during calibration or an inability to calibrate, and c) noisy readings in a clean atmosphere.

2.1. Physical Description

Main components of the QRAE PLUS multi-gas monitor:

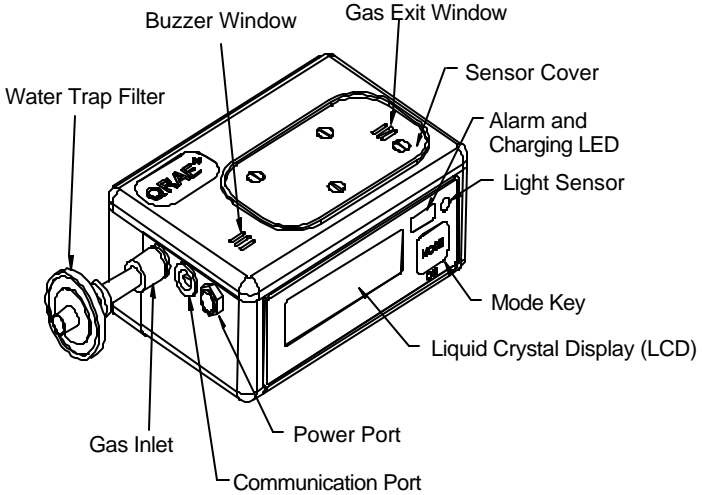


Figure 1. Front View of the QRAE PLUS

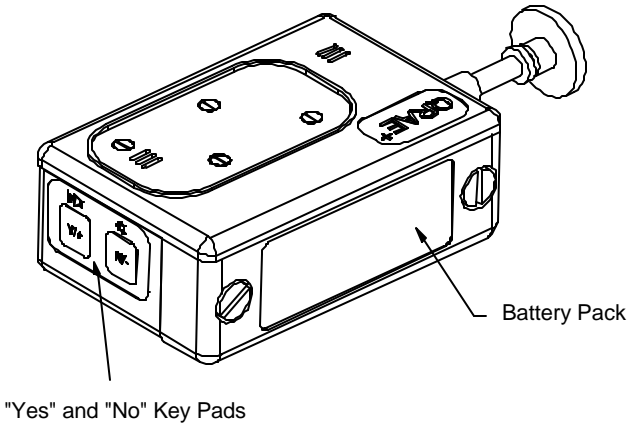


Figure 2. Back View of the QRAE PLUS

- 1) The **buzzer** provides an audible warning when an alarm situation exists.
- 2) The **water trap filter** prevents water and dust from being drawn into and damaging the unit.
- 3) The Li-ion **battery pack** provides up to 20 hours of the continuous operation.
- 4) A 12V DC power source plugged into the **power port** is required to charge the Li-ion battery pack.
- 5) The unit can communicate with a PC via the **communication port**.
- 6) Concentration readings and messages are shown on the **LCD**.
- 7) Use the **[MODE]** key to turn the power ON/OFF and cycle through the displays. Use the **[Y/+]** and **[N/-]** keys to enter data or respond to queries from the instrument.
- 8) The **light sensor** will detect ambient light levels and the Display's backlight will activate in low-light conditions.
- 9) **Alarm and indication LEDs** offer a visual warning if there is an alarm situation, and give the battery charging indication.
- 10) Sensors are under the **sensor cover** and can be easily changed.

2.2. Operation of Monitor

Figure 3 shows the LCD and the keypad on the front panel of the monitor. The functions of the three keys during normal operation are summarized in the next page.

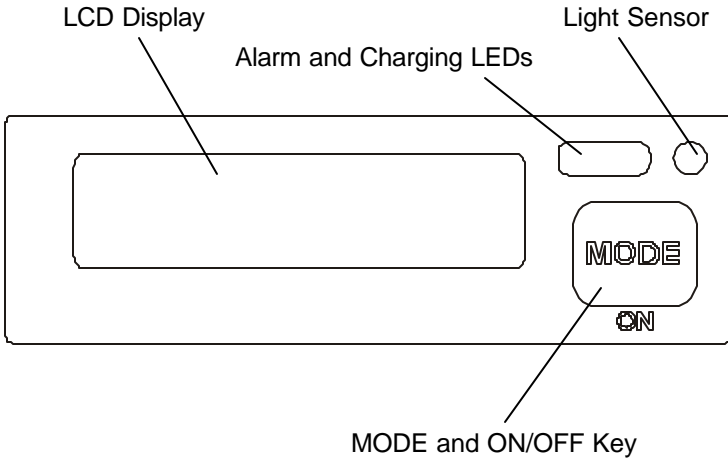


Figure 3. Front Keypad and Display

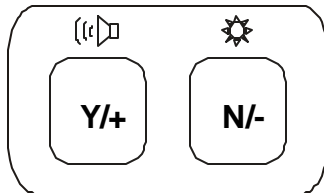


Figure 4. Side Keypad

Table 3.
Key Functions in Normal Operation Mode

[MODE] Hold for 1 second and release to turn ON the instrument.

Hold for 5 seconds to turn OFF the instrument.

Choose different displays.

[N/-] Answer “No” to a question.

Decrease a number.

Toggle ON/OFF the backlight.

[Y/+] Answer “Yes” to a question.

Increase a number.

Test Alarm.

Alarm Acknowledgment (turns off latched alarm/ turns on pump or LEL sensor after alarm conditions clear).

The QRAE PLUS multi-gas monitor offers two different user modes of operation:

1. Basic mode is the simplest mode of operation. The monitor alternately displays the instantaneous concentration readings and the sensor names after the monitor is turned on. The user can press the **[MODE]** key to see critical data, battery voltage or enter the PC communication mode. The displays in Basic mode are shown in Figure 5.

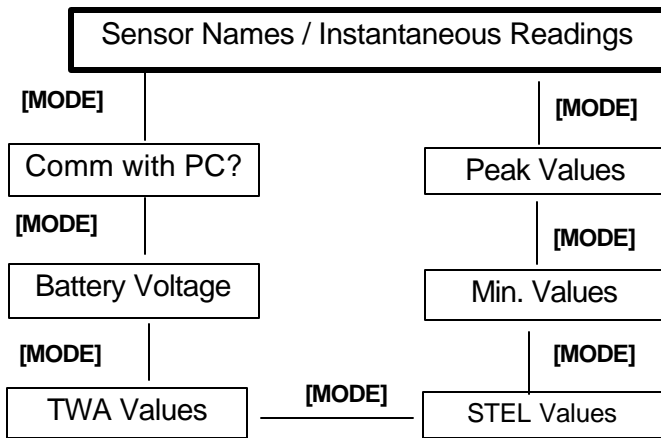
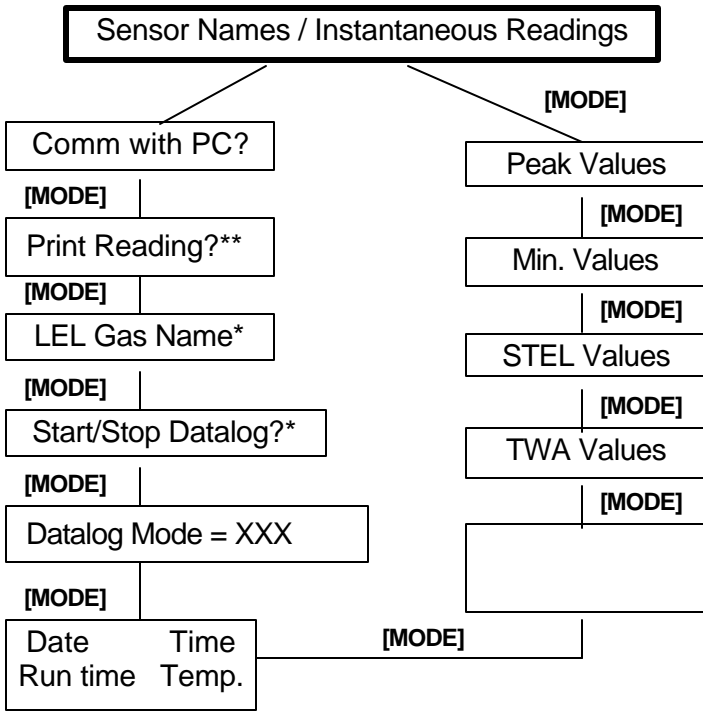


Figure 5. Displays in Basic Mode

2. Advanced mode, shown schematically in Figure 6, displays more information than the Basic mode and allows access to more programming functions. The Programming Mode is explained in detail in Chapter 4.



* Datalog appears only when unit has datalogging option and is programmed in manual datalog mode. LEL gas appears only when LEL sensor is installed.

** Appears only if the option is enabled through ProRAE Suite software.

Figure 6. Displays in Advanced Mode

OPERATION

To choose a specific display, press **[MODE]** one or more times until desired display appears. The following are brief explanations of each display.

- 1) The **Instantaneous Readings** are the actual gas concentrations in parts per million (ppm) for toxic gases, percent by volume of oxygen and percent of LEL or percent by volume for combustible gases. The readings are updated once per second.

Advanced mode display

0	0
0	20.9

Basic mode display

An "OK!" mark means the unit is in Basic mode and no alarm condition exists.

0	0
0	OK! 20.9

Both modes

A small "L" means the unit is logging data

0	0
0	L 20.9

- 2) The **Sensor Names** are displayed as:
LEL (Lower Explosive Limit): combustible gas sensor
OXY: oxygen sensor
CO, H₂S, etc: toxic gas sensors

OPERATION

- 3) The **PEAK** reading is the highest reading of each gas concentration since the monitor was turned on, and it is shown on the display with the label "PEAK".

5		3
10	PEAK	21.5

- 4) The **MINimum** reading is the lowest reading of each gas concentration since the monitor was turned on and it is shown on the display with the label "MIN".

0		0
0	MIN	19.9

- 5) The **STEL** reading is the average gas concentration over the most recent 15 minutes. The reading is updated once per minute and is shown in the display with a "STEL" message. For the first 14 minutes, "****" will be displayed. This reading applies to the toxic sensors only.

0		0
	STEL	

- 6) The **TWA** reading is the accumulated reading of the gas concentration divided by 8 hours since the monitor was turned on. The reading is updated once a minute and is shown in the display with a "TWA" label. This reading applies to toxic gases only.

0		0
	TWA	

- 7) The user can also choose to display "running average," instead of the TWA. See Section 4 for details on how to select running average or TWA. When "running average" is selected, the LCD will show "**AVG**," instead of "TWA."

0		0
	AVG	

- 8) The **Battery Voltage** screen displays the current battery voltage in volts. The shut down voltage is also shown.

<p>Battery = 4.0 V</p> <p>Shut off at 3.1 V</p>

Note: The battery pack will charge up to 4.0 volts when fully charged. When the battery voltage falls below a normal level, the word “Bat” flashes as a warning message, plus the buzzer beeps every minute. This means there are about 20-30 minutes run time left before the monitor automatically turns itself off.

- 9) The **Run Time** screen shows how long the monitor has been on, the current date, time and temperature. The readings are updated at one-minute intervals.

<p>Feb 07, '01</p> <p>ON = 03:50</p>	<p>11:05</p> <p>86° F</p>
--	---

- 10) The **Datalog** screen shows the current datalog mode. If your QRAE PLUS does not have datalogging enabled, the “Start Datalog?” screen will not show up. Instead, the screen will display “Datalog Mode = Automatic”.

Datalogging can be added to any instrument. Contact the Factory to learn how to add this powerful feature to your monitor.

If Manual datalogging is selected, this screen will prompt the user to turn on or off datalogging. When “Start Datalog?” appears, pressing the **[Y/+]** key will turn datalogging on. Likewise, datalogging is turned off by pressing the **[Y/+]** key when “Stop Datalog?” appears on the screen.

<p>Start Datalog?</p>

- 11) The **LEL Gas** screen displays the name of the gas for which the combustible sensor (if installed) will calculate gas concentrations. These calculations are based on the built-in correction factors for the specific gases.

LEL gas = Methane

- 12) If the Serial Printer option is enabled through the Pro-RAE Suite, a screen called "**Print Reading?**" is shown. Connect the RAE Serial Printer to the serial port of the monitor.

The RAE Serial Printer is an optional, hand-held, thermal printer capable of immediately printing current readings of a location when attached to your QRAE PLUS. Contact the Factory for more information on this time saving addition.

By pressing the "Y" key, the current instantaneous readings of the monitor will be printed out from the serial printer.

Print Reading?

- 13) The **Communicate with PC?** screen allows the user to send data from the QRAE PLUS to a Personal Computer (PC) or download configuration information from a PC to the QRAE PLUS.

Communicate With PC?

Note: When the monitor is in communication standby mode, it stops monitoring the gas concentrations and stops logging data. Datalogging must be manually restarted when exiting the communication standby mode if it is not in automatic datalogging mode.

2.3. Alarm Signals

The built-in microcomputer constantly monitors and updates gas concentrations and compares them with the programmed alarm limits (TWA, STEL, Low and High). Whenever a gas concentration exceeds any of the preset limits, the buzzer, red flashing LED, vibration alarm and the backlit LCD are activated immediately to warn the user of a potentially hazardous condition.

In addition, the QRAE PLUS will alarm if any of the following condition occurs: battery voltage falls below a pre-set voltage level (3.3V), LEL sensor turns off, pump shuts off, datalog memory error or datalog memory is full, etc.



The QRAE Plus, portable gas detector has been designed for the detection of oxygen deficiencies, flammable gas, and toxic vapor levels. An alarm condition indicating the presence of one or more of these potentially life-threatening hazards should be taken very seriously.

In the event of an alarm condition it is important to follow established procedures. The safest course of action is to immediately leave the affected area, and return only after further testing together with other appropriate safety procedures to determine that the area is once again safe for entry.

See Table 4 for the summary of the alarm signals. Some of these error messages will also be discussed in Chapter 7.

When the low battery alarm occurs, there will be approximately 20-30 minutes of operating time remaining. When the battery voltage falls below 3.1V, the monitor will shut down automatically.

Alarm Signal Disable Situation: It is extremely important to note that during the following conditions, the alarm signals are disabled while:

- 1) PC communication is in standby mode.
- 2) In calibration mode.
- 3) Viewing data during datalog.
- 4) Printing data to a serial printer.



The alarm signals are disabled during PC communication, calibration, and datalog review or when printing data to the serial printer. To reduce the risk of exposure to hazardous atmospheres, perform PC communication, calibration, datalog review or data printing only in areas known to be non-hazardous.

During these modes of operation, real time monitoring of the gas concentration stops. None of the gas concentrations will be calculated, including Peak, STEL or TWA.

Alarm Signal Latching

It is possible to setup the QRAE PLUS from a PC or in programming mode so that when an alarm condition occurs, the alarm signals stay on even after the alarm condition is no longer present. This is called the “latching alarm” mode. The default mode is to automatically reset the alarm signal when the alarm condition is cleared (see Chapter 4 for details on how to set the alarm mode).

**Table 4.
Alarm Signals and Reset**

Condition	Alarm Signal	Message on the LCD	Alarm Reset by
Gas exceeds "High Alarm" limit	3 beeps/flashes per second / Vibration	Sensor name and "High"	Move away from the gas.
Gas exceeds "Low Alarm" limit	2 beeps/flashes per second / Vibration	Sensor name and "Low"	Move away from the gas.
Gas exceeds STEL	1 beep/flash per second / Vibration	Sensor name and "STEL"	Move away from the gas and wait 15 minutes.
Gas exceeds TWA	1 beep/flash per second / Vibration	Sensor name and "TWA"	Move away from the gas, turn the unit OFF and then back ON.
Gas exceeds the sensor range	3 beeps/flashes per second / Vibration	Sensor name and "OVR"	Move away from the gas.
Water sucked in, unit short circuit or reading out of the maximum range	3 beeps/flashes per second / Vibration	Sensor name and "MAX"	Move away from the gas.
Excessive sensor negative drifting	1 beep/flash per second / Vibration	Sensor name and "NEG"	Perform a fresh-air zero calibration.
Blocked inlet or pump failure	3 beeps/flashes per second	"Pump"	Unblock the inlet and press the [Y/+] key, adjust pump threshold.
Excessive LEL gas or LEL sensor OFF	3 beeps/flashes per second / Vibration	LEL sensor name and "Off"	Move away from the gas and turn the LEL sensor back ON.
Low battery	1 flash per second, 1 beep per minute	"Bat"	Charge the battery.
Memory full	1 flash per second	"Mem"	Clear the datalog.
Datalog memory write error	1 flash per second	"Emm"	Turn the unit OFF and then back ON.

Alarm Signal Testing: Under normal non-alarm conditions, it's possible to test the QRAE PLUS buzzer, vibration alarm, LED, and backlight by pressing [Y/+] momentarily. The buzzer, vibration alarm, LED and backlight will activate once to indicate that these alarm signals are functioning correctly.

2.4. Backlight

The display is equipped with an LED backlight to assist in reading the display under poor lighting conditions. In Manual mode, this backlight can be turned on **manually** by holding the **[N/-]** key for one second in normal operation. The backlight can be turned off by pressing **[N/-]** a second time. If the **[N/-]** key is not pressed, the backlight will turn off automatically after a pre-programmed time-out period to save power.

In Automatic mode, the ambient light is sensed and the backlight will turn on **automatically** if the ambient light is below a threshold level. The backlight will then turn off automatically when the ambient light exceeds the threshold level.

See Chapter 4 for details on how to set the backlight mode and time out period from either the monitor or from a PC. See Chapter 8 for details on how to set the ambient light threshold level.

Note: The LED backlight consumes a higher amount of power from the battery and shortens the operating time of the monitor by 10 - 20%.

2.5. Preset Alarm Limits & Calibration

The QRAE PLUS Multi gas monitor is factory calibrated with standard calibration gas, and is programmed with default alarm limits as listed below. Refer to Section 4 for programming procedures if new calibrations or alarm limits are required.

**Table 5.
Factory Calibration and Preset Alarm Limits**

Gas	Cal Gas / Balance	Units	TWA	STEL	Low	High
CO	50 / Air	ppm	35	100	35	200
H ₂ S	10 / N ₂	ppm	10	15	10	20
SO ₂	5 / N ₂	ppm	2	5	2	10
NO	25 / N ₂	ppm	25	25	25	50
NO ₂	5 / Air	ppm	1	1	1	10
Cl ₂	10 / N ₂	ppm	0.5	1	0.5	5
O ₂	0 / N ₂	%Vol	-	-	19.5	23.5
CH ₄	50 / Air	%LEL	-	-	10	20
CH ₄	20 / N ₂	%Vol	-	-	10	20
HCN	10 / N ₂	ppm	5	5	5	50
NH ₃	50 / N ₂	ppm	25	35	25	50
PH ₃	5 / N ₂	ppm	0.3	1	1	2

2.6. Datalogging

This function applies only to datalogging monitors.

The QRAE PLUS multi-gas monitor calculates and stores the gas readings based on a user-specified datalogging period and the type of measurement. Two types of gas measurements, average or peak concentration, can be stored for each sensor during each datalogging interval. The datalogging interval can be programmed from one second to 60 minutes. In addition, time stamp, user ID, site ID, serial number, last calibration date, and alarm limits are also stored. All data are retained in non-volatile memory so they can later be downloaded to a PC. There are four options to start/stop datalog operation:

- **Automatic:** start and stop datalogging automatically when the monitor is turned on or off.
- **Manual:** start and stop datalogging in user mode manually.
- **Periodic:** start and stop datalogging daily, based on a preset start and stop time (hour and minute).
- **Scheduled:** start and stop datalogging one time per year at a preset start and stop date and time.

See Chapter 4 for setting up the datalog options.

If manual datalog mode has been selected, toggle through the menu using the **[MODE]** key until the “**Start Datalog?**” prompt is displayed. Pressing the **[Y/+]** key turns on datalogging. Likewise, pressing the **[Y/+]** key on “**Stop Datalog?**” turns off datalogging. The other three datalog options will start and stop automatically without any user intervention.

Datalogging pause

Under the following conditions, the datalogging pauses automatically:

1. When entering programming mode.
2. When entering PC Communication mode.
3. When printing data to a serial printer.

OPERATION

A new datalog event is created when the datalogging is resumed.

3. Operation of Accessories

The accessories for the QRAE PLUS monitor include:

- Li-Ion Battery & AC-DC Adapter (RAE 500-0036-000, CSA/UL approved)
- Alkaline Battery Adapter
- Water Trap and C-Filters



WARNING!



To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in area known to be non-hazardous.

Ne charger les batteries que dans l'emplacements désignés non-dangereux.

3.1. Battery Charging Operation

The charging circuit of the QRAE PLUS is built into the monitor. It only needs a 120 VAC to 12 VDC adapter (RAE 500-0036-000, CSA/UL approved) to charge the monitor.

Note: For European markets, Adapter P/N 500-0072 is required.

Connect the AC adapter (or the optional automotive charging adapter) to the DC jack on the QRAE PLUS monitor. The charging function will begin. For example, the display will show:

Charging...	3.9V
Time used=	0 min

The charging LED should be red in color when charging. If the battery is fully charged, the LED will change from red to green. The red color indicates that the battery is being fast charged. The green color indicates that the battery is fully charged. The display will also indicate "Fully charged." It takes about 8 hours to fully charge the batteries.

Fully charged.

The smart charging circuitry in the QRAE PLUS will protect the battery from overcharge or over discharge, so removing the charger is not required.

The battery of the QRAE PLUS monitor will be drained slowly even if the monitor is turned off. If the monitor is not charged for 25 days, the battery voltage will be low.

Note: The monitor draws power from the battery pack even when the power is turned off. It is very important to disconnect the battery pack before servicing or replacing sensors or any other components inside the monitor. Severe damage to the circuit board may occur if the battery pack is not disconnected before servicing the unit.

3.2. Alkaline Battery Adapter

The AA Alkaline battery adapter supplied by RAE Systems is intrinsically safe!

An alkaline battery adapter is supplied with each QRAE PLUS kit. It accepts three AA alkaline batteries (Duracell MN1500 or Energizer E-91 only) and can be used in place of the Li-ion battery pack, as shown below, to provide approximately 6 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Li-ion battery pack.

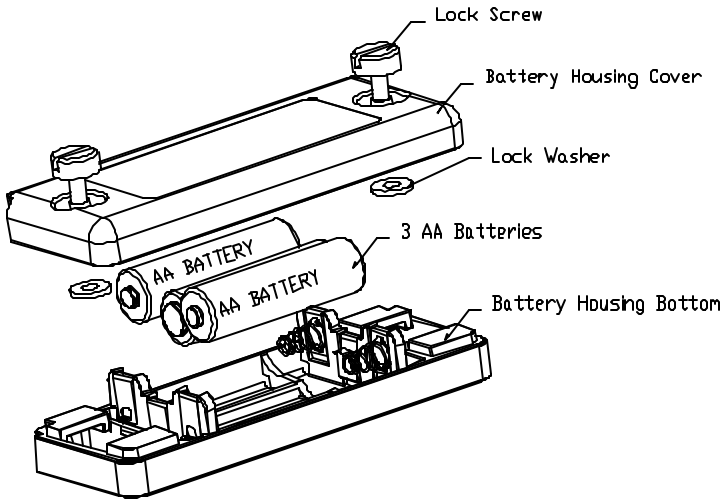


Figure 7. Alkaline Battery Adapter

The internal charging circuit of QRAE PLUS will automatically detect the alkaline battery adapter and prevent the charging of alkaline batteries.

NOTE: The monitor draws power from the battery pack even when the power is turned off. It is very important to disconnect the battery pack before servicing or replacing sensors or any other components inside the monitor. Severe damage to the circuit board may occur if the battery pack is not disconnected before servicing the unit.

3.3. Water Trap and C-Filters

The water trap filter is made of PTFE (Teflon[®]) membrane with a 0.2 micron pore size to prevent water from being sucked into the sensor manifold, which would cause extensive damage to the monitor. It will also prevent dust and other particles from entering the monitor. The C-filter is a cellulose filter that helps remove coarse dust and water mist and reduces high humidity. Both can be used together to prolong the operating life of the sensors and pump. Either or both filters should be changed if they change color, become clogged with particulates, or if liquid water has been sucked in.

To install the water trap filter, twist the threaded end tightly into the Luer connector on the inlet probe. Install the C-filter into its plastic housing and twist the threaded end tightly into the Luer connector in front of the water trap filter.

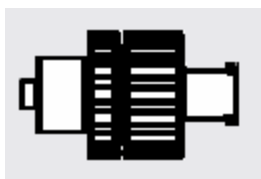


Figure 8. C-Filter housing

For faster response, the user may consider removing the water trap for some reactive gases including Cl_2 , PH_3 , NH_3 , and HCN . However, the procedure may shorten the pump and sensor lives.

4. Programming

The QRAE PLUS monitor is built with a microcomputer to provide programming flexibility for a variety of users. Authorized users can re-calibrate the monitor, change the alarm limits, change site ID, user ID, datalogging period, real time clock, etc.

Menu-driven programming provides intuitive end-user operation. The display shows the menu options, and the keypad is used for menu selection and data entry.

Note: The real time monitoring of gas concentrations continues while in the programming mode. However, during the calibration or review datalog procedures, the real time monitoring will pause until the procedures are completed. In addition, entering programming mode pauses the datalogging operation automatically. After exiting programming mode, datalogging operation will resume.

4.1. Programming Mode

The QRAE PLUS has two user modes: Basic and Advanced mode. Advanced mode offers complete accessibility to the programming menus.

There are also three security levels to control the access of the QRAE PLUS programming mode. They are security levels 0, 1, and 2.

- “Level 2” security offers complete access to the programming menus without a password. This is the Factory default security setting.
- “Level 1” security requires a 4-digit password to enter programming menus. The Factory default password is “0000”.
- “Level 0” security does not require a password, but offers only limited access to the programming menus.

In Basic mode, calibration is available but modification of the other monitor settings is limited. Refer to Appendix A for the detailed accessibility to the programming functions.

The programming menus allow you to change the setup of the monitor, calibrate the monitor, modify the sensor configuration and enter user information, etc. The programming functions are organized in a multiple tier menu structure. The main menu of the programming mode in advanced mode:

Calibrate Monitor?
Change Alarm Limits?
Change Datalog?
Change Monitor Setup?
Change Sensor Configuration?

To enter the programming mode, hold down the **[MODE]** and **[N/-]** keys simultaneously for three seconds. Depending on the **security level**, the display will be different according to Appendix A.

- Security “Level 0” - “Display Only! Cannot enter....”
- Security “Level 1” - “Enter Password = 0000”
- Security “Level 2” - Enters the programming menus

In security “Level 1”, after holding down the two keys for three seconds, the display will show “Enter Password = 0000” with the left-most digit flashing. Starting from this flashing digit, the user should enter a password using the **[Y/+]** and **[N/-]** keys.

To exit the programming mode and return to the normal operation, press the **[MODE]** key at any of the first tier menu displays.

Note 1: Prior to factory shipment, the QRAE PLUS monitor was installed with “0000” as the default password.

Note 2: For added security, “0000” is always displayed instead of the actual password at this step.

4.2. Keys for Programming Mode

The three keys perform a different set of functions during the programming mode as summarized below.

Table 6.
Key Functions in Programming Menu

[MODE]	Exit one tier of the menus when pressed momentarily or exit data entry mode when pressed and held for 1 second
[Y/+]	Increase an alphanumerical value for data entry Answer “yes”
[N/-]	Decrease an alphanumerical value for data entry Answer “no”

4.3. Calibration



The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas(es) before the instrument is put into service the first time.

For maximum safety, the accuracy of the QRAE PLUS should be checked by exposing the sensor(s) to known concentration calibration gas(es) before each day's use.

In programming mode, the user may re-calibrate the sensors in the QRAE PLUS monitor. This is a two-point calibration process using "fresh air" and the standard reference gas. First, "fresh air" containing 20.9% oxygen and no detectable toxic or combustible gases is used to set the zero point for each sensor and span the oxygen sensor. Then a standard reference gas, which contains a known concentration of a given gas, is used to set the second point of reference (also known as span gas). The two-point calibration procedure is detailed below. The sub-menus for calibration operations (advanced mode) are:

Fresh Air Calibration?
Multiple Sensor Calibration?
Single Sensor Calibration?
Modify Span Gas Value?
Change LEL Span Gas?
OXY Calibration Type?

Pumped Instruments

The preferred calibration methods for monitors with pumps are ones that maintain the gas at atmospheric pressure. Such methods include the open cup, open tube, or “Tee” methods, in which the calibration gas flow is higher than the pump draw, and excess gas flows out freely beside the inlet probe. Suggested calibration connections are indicated below.

Alternately, to save gas, connect the monitor directly to the gas cylinder using a demand-flow regulator. Calibration through such a regulator will produce similar results to the open tube methods, but special corrosion-resistant demand-flow regulators are recommended for reactive gases such as Cl_2 and H_2S . The monitor can also be calibrated from a gas sample bag (Tedlar® bag), or directly from a cylinder through a fixed-flow regulator with a flow rate between 0.5 and 1.0 liters per minute, although the latter method is less accurate than the other methods by a few percent.

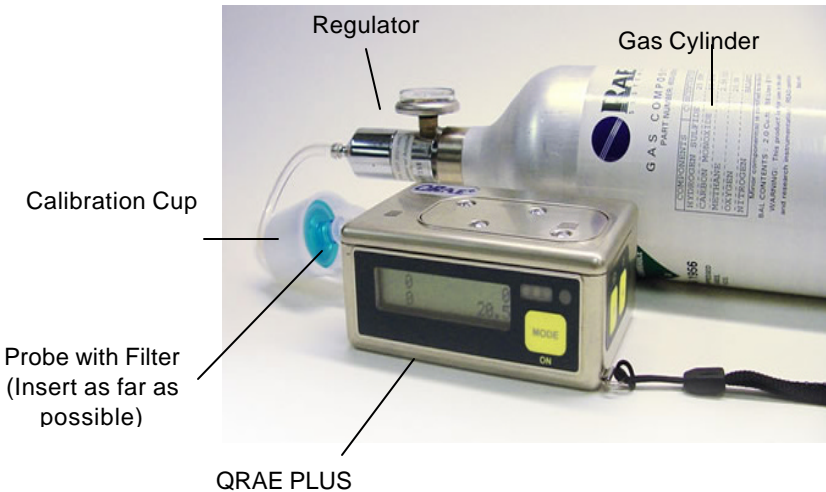


Figure 9. Calibration Connection

Diffusion Instruments

QRAE PLUS diffusion monitors must be calibrated using a fixed flow regulator with a flow rate between 0.5 and 1.0 liters per minute. Diffusion monitors are supplied with a special calibration adapter that covers the gas diffusion port.

Sensor Calibration Time

Slowly responding sensors listed in the table below may require pre-exposure of the sensor to the gas immediately before initiating the calibration sequence. Some firmware versions use a fixed 60-second calibration time; some newer versions automatically apply the full calibration time. After completing the zero calibration, expose the unit to the gas for the pre-exposure time listed below if a 60-second countdown time is programmed in the unit.

If the firmware has the full calibration time programmed in, the sensors must be calibrated in the Single Sensor mode to take advantage of this feature. The calibration time is set at 60 seconds in the Multiple Sensor mode and may not be changed.

Sensor	Response Time t_{90} (seconds)	Total Cal Time (seconds)	Pre-exposure Time for 1-min Cal Time
HCN	200	230	170
ClO ₂ , NH ₃ , COCl ₂	150	150	90
Cl ₂ , PH ₃	60	120	60
CO, H ₂ S, SO ₂ , NO, NO ₂ , O ₂ , LEL, VOL	=40	60	0

Calibration Time Stamp

When a single or multiple sensor span calibration is performed, a time stamp will be stored in the non-volatile memory. This information will be included in the datalogging report.

4.3.1. Fresh Air Calibration

This procedure determines the zero point of the sensor calibration curve. To perform a fresh air calibration, the calibration adapter and a cylinder of “fresh” air (optional) are required. The “fresh” air is clean dry air with 20.9% oxygen concentration and without any organic, toxic or combustible gases or impurities. If such an air cylinder is not available, any clean ambient air without detectable contaminants can also be used. A charcoal filter should be used if one is not sure of the ambient air’s purity.

After pressing the **[Y/+]** key at “Calibrate Monitor?”, the “Fresh Air Calibration?” screen will appear. Press **[Y/+]** to perform zero calibration.

When the zero calibration is successful, the display should show a reading of “20.9” for the oxygen sensor and “0.0,” or a very small number, for all other sensors.

4.3.2. Multiple Sensor Calibration

This function simultaneously determines the second point of the calibration curve for multiple sensors in the monitor.

A cylinder of mixed standard reference gases is needed to perform this procedure. The user can choose several gas mixtures* to be used in multiple-sensor calibration.

1. When the display shows “Multiple Sensor Calibration?” Press the **[Y/+]** key. The display shows all the pre-selected gases for the mixed gas cylinder and the question “OK?”

Press the **[Y/+]** key to accept the multiple sensor selection and start the calibration, or press the **[N/-]** key to modify the sensor selection and go on to Step 4.

CO	H₂S
LEL	OK? - - -

2. Turn on the valve of the mixed gas cylinder to start the flow of the span gas when the display shows "Apply Mixed Gas." When the calibration gas has reached the sensor the display will show "calibration in progress... 60" with the countdown timer shows the number of remaining seconds while the monitor performs calibration. When the countdown timer reaches 0, the display shows the name of each sensor, the message "cal'ed!" and the calibrated value for each gas.

Note: The readings should be very close to the span gas values.

3. After showing the concentrations of the calibration gases, the display will show "Span Cal Done! Turn Off Gas." Follow the instructions on the LCD and the multiple sensor calibration is finished.
4. From Step 1, if the **[N/-]** key is pressed, the display shows all the sensor names selected for multiple sensor calibration with the cursor blinking at the first sensor location.

CO*	- - - -	H₂S*
LEL*	pick	OXY

Press the **[Y/+]** key to select the sensor and the **[N/-]** key to de-select the sensor. A previously selected sensor will show an "*" next to the sensor name. A previously de-selected sensor will not have an "*".

Note: The oxygen span calibration is normally done when fresh air calibration is finished, so the oxygen is not selected in this multi-gas calibration. Pure nitrogen and single gas

calibration option is needed for 0% oxygen calibration. See next section for single gas calibration.

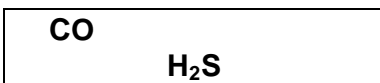
5. Press the **[MODE]** key momentarily to move from one sensor location to the next one. Repeat Step 4 until all of the sensors that need to be calibrated during multiple sensor calibration are selected. Press and hold the **[MODE]** key for 1 second to exit.
6. The display shows “Save?” right after exit from the sensor pick-up menu. To confirm the new selection, press the **[Y/+]** key to accept the change and continue on with Step 2. Press the **[N/-]** key or the **[MODE]** key to discard the change and to continue on with Step 2.

* **Cross Sensitivity:** some sensors may show cross sensitivity to other gases; therefore, it is important to choose the gas mixture carefully to avoid erroneous calibration due to cross sensitivity. For example, some organic gases are known to cause a response on the CO sensor, and H₂S responds on the NH₃ sensor. In general, it is recommended to calibrate the CO, H₂S, and combustible and oxygen sensors with a cylinder of mixed gas using the multiple sensor calibration and to calibrate other toxic gas sensors with a separate cylinder of toxic gas using the single sensor calibration.

4.3.3. Single Sensor Calibration

This procedure determines the second point of the sensor calibration curve for a single sensor. A cylinder of standard reference gas (span gas) is needed to perform this procedure. Table 5 shows the standard calibration gases typically used as span gases in the factory. Below is an example of single gas calibration.

1. Choose “Single Sensor Calibration?” and press the **[Y/+]** key. The display shows all the installed sensors in the monitor with the cursor blinking at the first sensor location.



LEL	pick	OXY
------------	-------------	------------

2. Oxygen Calibration:

a) Press the **[MODE]** key twice to move to OXY, then press **[Y/+]** to select the highlighted OXY sensor and start the calibration.

b) If the oxygen calibration type is **3-point calibration** (see Section 4.3.6 on oxygen calibration type), that is 20.9% (air), 0% (99.9% N₂), and 19.5% calibration, the display shows:

Apply Oxygen?	
Y - 0%	N - 19.5%

c) If the oxygen calibration type is **2-point calibration** that is 20.9% (air), and 0% (99.9% N₂) calibration, the display shows:

Apply Oxygen?	
Y - 0%	

d) If the **[Y/+]** key is pressed, the display shows “Apply 0% oxygen...” turn on the flow of the 99.9% nitrogen or other inert gas. After a count-down on the calibration timer, the display shows:

O₂ cal'ed	
Reading = 0%	

e) Press the **[N/-]** key for the 19.5% oxygen calibration in 3-point calibration mode.

2. Follow the instructions on the display and turn off the gas when finished.

4.3.4. Modify Span Gas Value

This function allows the user to change the span values of the standard calibration gases.

1. If “Modify Span Gas Value?” is chosen in the calibration sub-menu, the display will show:

50		10
50	span	19.5

- A cursor is blinking at the first digit of the first Span value. If the user wants to modify any one of the span gas values, go to Step 3. Otherwise, press and hold the **[MODE]** key for 1 second to accept the previously stored span gas value and move to the next calibration sub-menu.
2. Starting from the left-most digit of the span gas value, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to next digit, the cursor will move one digit to the right. Repeat this process until all span gas values are entered. Press and hold the **[MODE]** for one second to exit and choose whether or not to save the new value.
 3. The span value for oxygen is 19.5% and can be changed between 19.0% to 20.0%. This value is only used if the monitor is set to 3-point oxygen calibration (see Section 4.3.6 and Section 4.3.3 for more details).

4.3.5. Change LEL Span Gas

This function allows selection of the gas to be used for span calibration of the LEL sensor. The correction factor for the measurement gas (Appendix B) is automatically divided by the correction factor for the span gas selected here, to obtain a new factor for the combination of gases. The new factor will be applied to the readings to display a true concentration.

1. "Change LEL Span Gas?" is the next sub-menu item in the Calibrate/Select Gas Menu.
2. Press the **[Y/+]** key. If the combination LEL/VOL sensor is installed and the sensor is set to "LEL mode", the display shows:

<p style="text-align: center;">LEL span =? Methane</p>
--

Otherwise, the message "No LEL selected" will appear.

3. If the user does not want to change the LEL span gas, press the **[Y/+]** key to accept the current selection and exit this sub-menu.
4. If the user wants to select a different LEL span gas, press the **[N/-]** key. Then use the **[Y/+]** or **[N/-]** key to scroll through a list of gas names until a desired gas name appears in the Display, then press the **[MODE]** key to select the new gas name.
5. The display now shows "Save?" To confirm the new gas selection, press the **[Y/+]** key to accept the change. Press the **[N/-]** key or **[MODE]** key to discard the change and return to the first display.

4.3.6. OXY Calibration Type

The QRAE PLUS allows both 2-point and 3-point O₂ sensor calibrations (99.9% nitrogen or other inert gas).

The 2-point calibration is at 20.9% during “fresh air zero” and 0% in single sensor calibration. The 3-point calibration is at 20.9% during “fresh air zero”, and at both 19.5% and 0% in sub-menus of the single sensor calibration. The 3-point calibration gives greater accuracy for oxygen near 19.5%, a common alarm limit for warning of oxygen depletion.

Only the 19.5% calibration point can be modified, from 19.0% to 20.0% as described in Section 4.3.4.

For more details, see Section 4.3.3 for oxygen calibration and Section 4.3.4 for span value modification.

When the display shows “OXY Calibration Type?”, answer the question on the LCD will get the desired calibration type.

1. “OXY Calibration Type?” is the next sub-menu item in the Calibration /Select Gas submenu.
2. Press the **[Y/+]** key to enter the sub-menu. The display shows “OXY Cal type = 2-Pt” or “OXY Cal type = 3-Pt”.
3. Press **[N/-]** to toggle between the options, **[MODE]** to skip to the next menu, or **[Y/+]** to accept the current Cal type.

4.4. Change Alarm Limits

In the programming mode, the users may change alarm limits of each sensor for the QRAE PLUS Monitor. The Change Alarm Limit Sub-Menu in advanced mode:

Change High alarm limit?
Change Low alarm limit?
Change STEL alarm limit?
Change Average alarm limit?

1. The sub-menu items allow the user to change the alarm limits: high, low, STEL or average.

Note: The average type can be set to either “Running Average” or “Time Weight Average” (TWA) under the “Change Averaging Method?” sub-menu of the “Change Monitor Setup?” menu (see Table 10). Press the **[N/-]** key to cycle through the sub-menus. Press the **[Y/+]** key to enter a sub-menu and the display will show “HIGH,” “LOW,” “STEL,” “TWA” or “AVG” with a flashing cursor on the upper, left-most digit of the previously stored alarm limits.

200		20
20	HIGH	23.5

35		10
10	LOW	19.5

100		15
	STEL	

35		10
	TWA	

OR

1.0		10
	AVG	

Depending on the selected averaging type from the "Change Averaging Method?" menu (see Step 1)

2. To modify these alarm limits, start at the left-most digit. Use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance the cursor one digit to the right. Repeat this process until all the new Alarm limits are entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode. If there is any change to the existing value, the display shows "Save?" Press the **[Y/+]** key to accept the new value and move to the next sub-menu. Press the **[N/-]** key to discard the changes.
3. To preserve the previously stored alarm limit, press and hold the **[MODE]** key for 1 second and the monitor will exit data entry mode and move to the next sub-menu.

4.5. Change Datalog

The QRAE PLUS monitor calculates and stores the gas readings at specified intervals. The user can change the datalog setup in the programming mode. Users can also program additional datalog options using a PC and download them to the monitor (see ProRAE Suite Manual for details). The sub-menus for datalog options:

Clear All Data? Change Datalog Period? Select Data Type? Enable / Disable Datalog? Select Memory Full Type?

1. “Clear All Data?” will clear all the data in the datalog.
2. “Change Datalog Period?” allows the user to log the concentration readings every 1 to 3,600 seconds.
3. “Select Data Type?” allows the user to choose if the peak or the average reading in the datalog period will be stored.

Note: The QRAE PLUS monitor generates one concentration reading every second. If the datalog period is 900 second (15 minute) and the data type is average, the QRAE PLUS will calculate the average of 900 readings and store it to the memory every 15 minutes.

4. “Enable / Disable Datalog?” will activate or suspend the datalog function. The asterisk (*) next to the sensor’s name means that the datalog function is enabled for that sensor. By pressing the [Y/+] or [N/-] key, it will activate or deactivate that sensor’s datalog function.
5. “Select memory full type?” allows the user to decide how the data are stored. Two options are available when the memory becomes full, either the memory begins to “wrap around,” overwriting the oldest data, or it can “Stop” storing any more data. Follow instructions on the display and use [Y/+] , [N/-] and [MODE] to perform desired functions.

4.6. Change Monitor Setup

Users may change the monitor setup, as shown below, or enter personal information into the QRAE PLUS:

Change Site ID?
Change User ID?
Change Alarm Mode?
Change User Mode?
Change Real Time Clock?
Change Backlight Mode?
Change Password?
Change Pump Speed?
Change Averaging Method?
Change Display Language?
Set Temperature Units?
Enable/Disable Vibrator?

Monitor Setup Options

- 1) **Site ID** – the location information that will be stored into the datalog with the concentration readings, an 8 digit alphanumeric character.
- 2) **User ID** – The user information that will be stored into the datalog with the concentration readings, an 8 digit alphanumeric character.
- 3) **Alarm Mode** – determines whether the alarm will latch or automatically reset after an alarm situation occurs.
- 4) **User Mode** – Basic or Advanced Mode controls access to programming menus, information and security levels as discussed in Section 4.1.
- 5) **Real Time Clock** – a clock with the date: “Feb 07, ‘00” and time: “hh:mm.” If the time or date on the clock is not accurate, the user can adjust it.

- 6) **Backlight Mode** – manual or automatic. If manual mode is chosen, pressing the **[N/-]** key will turn on the LCD backlight. Automatic mode allows the backlight to turn on when the ambient light falls below a threshold level preset in the monitor.
- 7) **Password** – a 4-digit numeric character which allows the user to enter the programming mode when needed. The manufacturer’s default password is “0000.”
- 8) **Pump Speed** – low or high. The factory default setting is low, which reduces the flow rate by 30%, but increases the battery run time by 10%, and increases the lifetime of the LEL sensor. Setting the pump speed to high (see Section 4.7), offers quicker response time. A high pump speed is required to measure reactive and slowly-responding gases such as Cl_2 , PH_3 , NH_3 , and HCN .
- 9) **Averaging Method** – (TWA) Time Weighted Average (*default*) or (AVG) a running Average. These two averaging methods are alternate ways to evaluate gas exposure over time.
- 10) **Change Display Language** – allows the user to choose either Spanish or English screen text.
- 11) **Temperature Units** – allows the user to display the temperature in either degrees Centigrade or Fahrenheit.
- 12) **Enable/Disable Vibrator** – will activate or deactivate the vibration alarm.

4.7. Change Sensor Configuration

This sub-menu allows the user to change the following sensor related options on the QRAE PLUS monitor:

Change LEL/VOL Sensor Type? *
Enable / Disable Sensor?
Change LEL Gas Selection? **

Note: Combination LEL/VOL Sensor is not available in North America.

**This menu is applicable only if the combination LEL/VOL sensor is installed*

***This menu is applicable if the LEL sensor or combination LEL/VOL sensor is installed and the sensor is set to LEL mode.*

Correction Factors

The LEL sensor used in QRAE Plus responds to a broad range of gases having different sensitivities. A correction factor can be multiplied by the apparent reading to give the true gas concentration:

True Concentration = Correction Factor x Monitor Reading

Correction factors allow measurement of a specific gas while using a different gas for calibration.

The QRAE PLUS stores several different correction factors for the LEL sensor. The user can choose one gas from the list to be the calibration gas (Change LEL Span Gas) and another gas to be the measurement gas (LEL Gas Selection). For example, one can choose propane as the calibration gas and pentane as the measurement gas. The QRAE PLUS will calculate the correction factor between these two gases and convert the

measured value of the LEL sensor into equivalent concentration of the pentane gas.

Note 1: Using the correction factor provides an estimate the target measurement gas. For greatest accuracy, it is necessary to calibrate the LEL sensor directly with the target gas.

Note 2: Using the correction factor does not make the sensor specific to that gas. It still responds to all gases, but the readings or on a scale of equivalent units of the specified gas.

4.7.1. Change LEL/VOL Sensor Type

Note: Combination LEL / VOL Sensor is not available in North America.

This programming sub-menu applies only to monitors with the combination LEL/VOL sensor installed. This sensor can be setup to measure combustible gases by percentage of the Lower Explosive Limit (LEL), or it can be set up to measure combustible gases in percent by volume (VOL) levels up to 100%. It can also be set to switch automatically from %LEL to %VOL when combustible gases go beyond the lower explosive range. This auto-ranging feature only works for methane gas.

The user can select one of these sensor modes from the first sub-menu item, “**Change LEL/VOL Sensor Type?**”

1. Press the **[Y/+]** key and the display will ask if you wish to “Switch to %VOL?”
2. Press the **[Y/+]** key to accept the new sensor mode. Press the **[N/-]** key to cycle through to another mode. Press the **[MODE]** key to exit and return to the first sub-menu.
3. Once you select your desired mode of operation for your LEL/VOL sensor, press the **[Y/+]** key and the display will show “Save?” Then, press the **[Y/+]** key again to accept or the **[N/-]** key to discard and advance to the next sub-menu.



CAUTION!

Auto-range should be selected only when the methane is used as the calibration and target gas.

4.7.2. Enable / Disable Sensor

This function allows the user to selectively enable or disable individual sensors in the QRAE PLUS monitor. When a sensor is disabled, the unit will not measure or display gas concentrations of that type.

1. “Enable / Disable Sensors?” is the second sub-menu item.
2. Pressing the **[Y/+]** key causes the QRAE PLUS to display all the sensors installed in the monitor. A previously enabled sensor is marked with an “*” next to the sensor name. The cursor will blink at the first sensor location. Press the **[Y/+]** key to enable the sensor or the **[N/-]** key to disable the sensor. A previously disabled sensor will show “----” instead of the sensor name.

CO*		H ₂ S*
LEL*	pick	OXY*

3. Press the **[MODE]** key momentarily to move to the next sensor location. Repeat Step 2 until all the appropriate sensors are enabled.
4. Press and hold the **[MODE]** key for one second to save your changes. The display will show “Save?” To confirm the new selection, press the **[Y/+]** key. Press the **[N/-]** or **[MODE]** key to discard the change and move to the next sub-menu.

4.7.3. Change LEL Gas Selection

This function allows selection of the measurement gas for the LEL sensor from the on-board compound library. The correction factor for this gas is automatically divided by the correction factor for the span gas selected previously, to obtain a new factor for the combination of gases. The new factor is applied to the readings to display a true concentration. The user can also create a custom correction factor for a non-standard gas or mixture of gases.

1. If a combination LEL/VOL sensor is installed, pressing the **[Y/+]** key will cause the display to show:

<p style="text-align: center;">LEL Gas =?</p> <p style="text-align: center;">Methane</p>
--

Otherwise, the message “No LEL installed” will be displayed and you will return to the first sub-menu.

2. If the user does not want to change the LEL measurement gas, press the **[Y/+]** key to accept the current gas and skip to Step 5.
3. To modify the LEL measurement gas, press the **[N/-]** key first, then use the **[Y/+]** and **[N/-]** keys to scroll through a list of gas names until the desired gas name appears in the Display, then press the **[MODE]** key to select the new gas. The display will read “Save new gas?” To confirm the new gas, press the **[Y/+]** key. Press the **[N/-]** or **[MODE]** key to discard the change and move to the next step.

4. The display will now show:

<p style="text-align: center;">Methane LEL factor = 1.00?</p>

“1.00” is the calculated correction factor of the selected gas in Step 4. If you do not want to modify the LEL correction factor, press the **[MODE]** key and go to Exit. To modify this factor, press **[N/-]** key first. Then starting from the left-most digit, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until all 4 digits of the new factor are entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode. If there is any change to the existing value, the display shows “Save?” Press the **[Y/+]** key to accept the new value and exit the gas selection sub-menu. Press the **[N/-]** key to discard the changes.

4.8. Exit Programming Mode

1. To exit programming mode from the first tier of menus, press the **[MODE]** key once. The display will return to the instantaneous readings of normal operation.
2. To exit programming mode from the second tier of menus press the **[MODE]** key twice.
3. To re-enter programming mode, press and hold the **[N/-]** and **[MODE]** for 3-5 seconds as described in Section 4.1

5. Computer Interface

Every QRAE PLUS that is ordered with datalogging enabled additionally includes a ProRAE Suite software package and a serial computer-interface cable. Please refer to the ProRAE Suite Manual for installation instructions.

6.Theory of Operation

The QRAE PLUS monitor uses up to four different sensors to measure a variety of gases. A newly developed thermal conductivity sensor is combined with a catalytic gas sensor to measure combustible gases. Several different types of toxic gas sensors are offered. They can be plugged into the two toxic sensor sockets and are interchangeable.

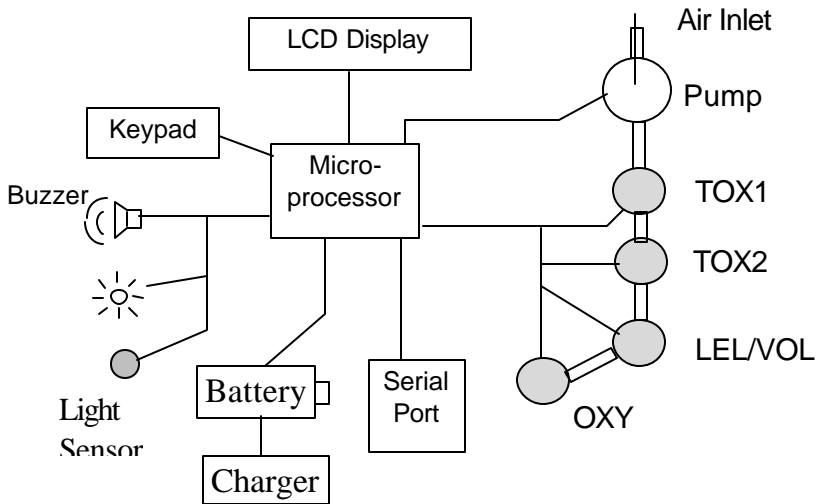


Figure 10. Block Diagram of QRAE PLUS Monitor

The sensors are mounted next to the gas inlet probe. A diaphragm pump can be installed inside the monitor to draw an air sample into the sensor manifold and then be distributed to all the sensors. A single microcomputer chip is used to control the operation of the alarm buzzer, LED, pump and light sensor. It measures the sensor readings and calculates the gas concentrations based on calibration to standard, known gases. The data are stored in non-volatile memory so that they can be sent to a PC for record keeping. RS-232 transceivers provide a serial interface between the monitor and the serial port of a PC. A 2-line by 16-character LCD is used to display the readings. The user interacts with the monitor through the three keys on the front and right side keypads.

For portability, a rechargeable Li-Ion or an alkaline battery pack powers the monitor.

NOTE: The monitor draws power from the battery pack even when the power is turned off. It is very important to disconnect the battery pack before servicing or replacing sensors or any other components inside the monitor. Severe damage to the circuit board may occur if the battery pack is not disconnected before servicing the unit.

7. Maintenance

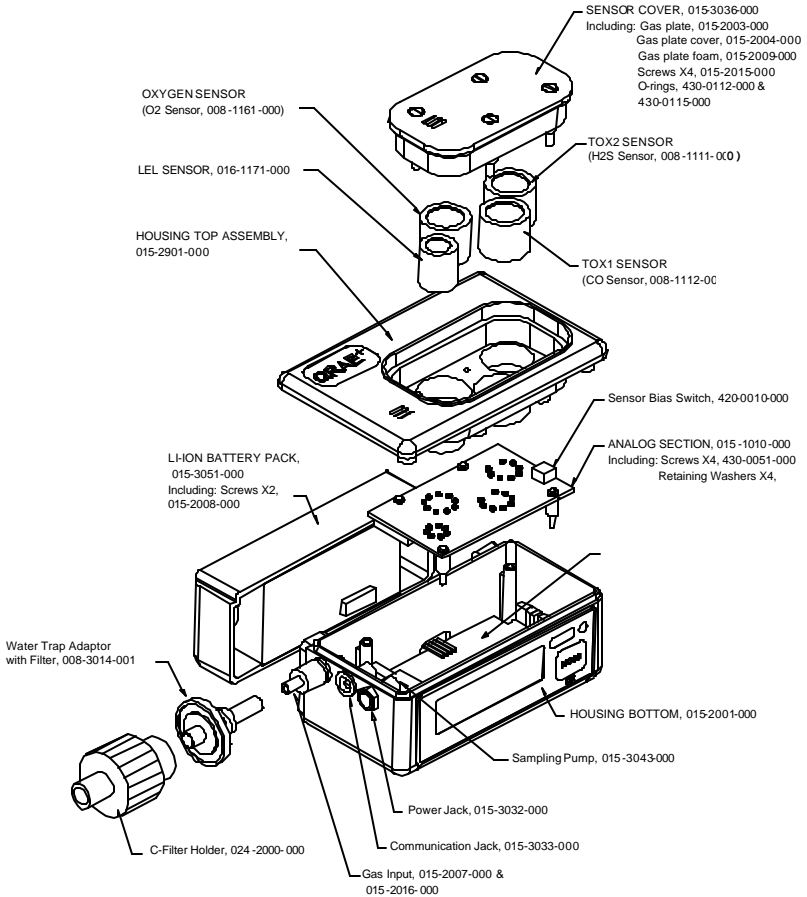


Figure 11. Main Components of QRAE PLUS



Maintenance should be performed only by a qualified person who has proper training and fully understands the contents of this manual.

The QRAE PLUS is basically a maintenance free unit. By taking care of the battery properly and changing the water trap filter frequently as described in Chapter 3, the unit will provide a longer period of service.

The possible maintenance/replacement items are:

- Water trap filter
- Battery
- Sensors
- Sampling pump
- AC/DC adapter (RAE 500-0036-000, CSA/UL approved)

Refer to Table 2 & Figure 11 for assembly and part number information when ordering new components.

Cleaning: Use only a cloth dampened with water to wipe the unit. Apply gently while cleaning the display area.

The following guidelines should be followed when changing components:

1. Do not change the sensors or sampling pump, unless the related information in Chapters 2, 4, and 8 are fully understood and the diagnostic procedure is performed.
2. Turn off the unit and unplug the charger before changing a battery. The battery pack screws can be tighten or loosen with a quarter.
3. The unit continuously draws power from the battery pack, even when off, so the battery back must be detached before trying to change sensors or the pump.
4. When changing the sensor or the dip switch setting, detach the battery first and then open the sensor cover only, do not open the housing top (refer to Figure 11.)
5. The four screws that tighten the housing top are under the unit (refer to Figure 11.) Remove the housing top only when changing pump is necessary. Before closing the housing top, do not forget to reconnect the tubing and the buzzer wire. A pair of needle nose pliers is helpful to reconnect the tubing and wire.
6. Identify the location of a specific sensor and pay attention to the sensor pin orientation when removing and plugging in sensors.
7. The NO and NH₃ toxic sensors require a special 300 mV bias voltage to operate. There is a “dip switch” located on the PCB next to the Tox 1 and 2 sensor positions. When either an NO or NH₃ toxic sensor is plugged into a toxic sensor socket, it is necessary to turn “OFF” the “dip switch” for enabling the bias voltage. It is very important to set the bias switch to the correct position when installing the toxic sensors. The default setting of bias off (switch on) meets the requirements of most sensors.

8. Troubleshooting

To aid diagnosis of the monitor, it has a diagnostic mode that displays critical, low level parameters. Section 8.1 describes the diagnostic mode. Section 8.2 summarizes the frequently encountered problems and suggested solutions.

Turning the QRAE PLUS monitor on in diagnostic mode, and using the troubleshooting table in section 8.2, the user can narrow problems down to one or two areas and often correct the problem without having to return the monitor for repair.



The diagnostic mode allows the user to set several low-level parameters that are critical to monitor operation. Extra care should be taken when setting these low-level parameters. If the user is not familiar with these parameters and sets them incorrectly, it may cause the monitor to malfunction.

8.1. Diagnostic Mode

To place the monitor in diagnostic mode, first turn the monitor off. Next push and hold the **[Y/+]** and the **[MODE]** keys for at least two seconds. After the unit “beeps”, release both keys and the monitor will turn on in diagnostic mode. The monitor will display a “Diagnostic mode” message and then start going through the normal start-up procedure. After the unit starts up, the standard display will show 1 to 4 numbers with a message “Raw”. These numbers are the raw sensor readings without calculation.

Other critical parameters of the monitor are available to be viewed. They can be reached by pressing the **[MODE]** key repeatedly until the desired parameters are displayed.

**Table 7.
Displays in Diagnostic Mode**

Key Action	Display
	Show raw readings
[MODE]	Show sensor name
[MODE]	Show battery voltage, and charge raw count
[MODE]	Adjust LCD contrast
[MODE]	Adjust Buzzer Frequency
[MODE]	Show LEL or VOL sensor raw readings
[MODE]	Show date, clock, battery voltage and temperature
[MODE]	Show LEL&OXY sensor expiration date
[MODE]	Show Tox1&Tox2 sensor expiration date
[MODE]	Adjust pump stall threshold
[MODE]	Show serial number
[MODE]	Show battery duration time
[MODE]	Communicate with PC?

Diagnostic displays:

1) Raw Sensor Readings

The raw sensor readings provide a quick diagnosis for sensor response and sensitivity. If the raw reading is outside the normal ranges, the sensor or the unit may be defective.

When a specific gas is applied to the monitor, the corresponding sensor's raw reading should increase or decrease. If the reading of the corresponding sensor does not change when the target gas is applied, then the sensor may be defective.

165	160	173
2051	RAW	1100

2) Sensor Names

All the combustible, oxygen and toxic sensors have a non-volatile memory which contains the sensor identification and other vital information, such as manufacturing date, expected operating life, etc. If a sensor is programmed and installed properly in the monitor, the sensor name should be displayed. If the sensor name does not show up in the display, then the sensor may not be programmed properly or may be defective.

3) Show Battery and Charging Raw Count

The battery voltage, charge input sampling and charging current in raw count are displayed to provide a greater understanding of how your battery is functioning.

4) Adjust LCD Contrast

This display allows the user to adjust the LCD contrast. Press the **[Y/+]** key to increase the contrast and the **[N/-]** key to decrease the contrast. The bar graph shows the current LCD contrast setting.

5) Adjust Buzzer Frequency

The buzzer frequency can be adjusted for the best output sound volume.

6) Display LEL or VOL Raw Reading

This display shows the present raw reading of the LEL or of the combination LEL/VOL sensor. The top display shows the mode of the combustible sensor. The bottom line shows the instantaneous reading of raw counts from the LEL or VOL sensor. By pressing the **[N/-]** key, the sensor mode can be switched from %LEL to %VOL and vice-versa.

7) Show Date, Clock, Battery and Temperature

This display shows the real time clock, battery voltage in raw count and temperature sensor reading.

8) Sensor Expiration Date

This display shows the expiration date (month and year) of all the installed sensors in the QRAE PLUS monitor. If the current date exceeds the expiration date of any sensor, the performance of the given sensor can no longer be guaranteed. It is strongly recommended that the user replace the sensor immediately to ensure proper and safe operation of the instrument.

9) Adjust Pump Stall Threshold

This display can be used to set the pump stall threshold.

The firmware compares the pump's current raw count to the threshold raw count set by the customer. When the current raw count is higher than the threshold, the firmware stops the pump to prevent damage to the unit.

If the gas inlet is blocked but the pump does not shut down, the raw count of the pump stall threshold is set too high. If the pump shuts down too easily with a slight blockage to the gas inlet, the raw count of the pump stall threshold may be set too low. The pump stall feature is disabled in diagnostic mode.

The pump current draw is higher when the pump is running at the high speed than when it is running at the low speed, so both thresholds need to be set separately. Press the **[Y/+]** key to adjust the low speed, press the **[N/-]** key to adjust the high speed. Calculate and adjust the threshold as follows:

1. The maximum “xxx” and minimum “zzz” raw counts of the pump are displayed on the first row: “Pump = xxx/zzz”. The pump stall count is displayed on the second row: “Stall = yyy +/-.” The user can block the gas inlet and watch the raw count reading. Note: the firmware will hold the reading for a moment after the blockage to allow a user read the raw count. If the reading does not increase significantly (i.e. more than 3–5 counts), then there may be a leak in the gas inlet or the pump might be weak or defective.
2. Use the **[Y/+]** or the **[N/-]** key to increase or decrease the stall value until it is the average of the idle and the blocked counts of the maximum “xxx”. That is: “yyy” *stall value* = (“xxx” *idle* + “xxx” *block*) / 2.
3. Press the **[MODE]** key to exit this display. If the threshold value is changed, a message “Save new stall threshold?” will appear. Press **[Y/+]** to confirm the change. Press **[N/-]** or **[MODE]** to abandon the change.

Note: The pump threshold may also need to be adjusted after the pump speed or the water trap filter has been changed, or as the pump ages.

10) Serial Number

This displays the unit’s serial number.

11) Display Battery Duration Time

This display shows how long the unit has been on.

12) Communicate with a PC?

This display allows the user to transfer data between the unit and a PC.

8.2. Troubleshooting Tips

Problem	Possible Cause	Possible Solution
Cannot turn on power after charging battery	Defective battery. Microcomputer hang-up.	Charge or replace battery. Disconnect then connect battery to reset computer.
No LED or LCD backlight	Wrong mode setting. Defective LED or LCD backlight.	Check and see if the backlight is in automatic or manual mode. Call service center.
Lost password	Forgot.	Use ProRAE Suite to reset the password.
Buzzer inoperative	Bad buzzer	Call authorized service center.
Calibration error message	No standard gas input Low sensitivity to cal gas	Check standard gas flow path or cylinder pressure Change cal gas or sensor
“Voltage too high” message	Battery fuse blown or wrong AC adapter	Check battery and adapter.
“Bat”message	Battery Low	Recharge battery.
High pump noise or no inlet suction	Leaky inlet path Defective pump	Check inlet connection. Replace pump.
Abnormally low reading	Incorrect calibration or calibration error	Make sure the span gas value matches the calibration gas, then re-calibrate.
Reading jumping around	Incorrect gas calibration Low sensitivity to cal gas	Calibrate the sensor. Use different cal gas. Change sensor.
Cannot turn off monitor or corrupted characters	Microprocessor hang-up	Disconnect and re-connect battery to reset computer. Reload the firmware.
Read a small background value	There is actually a small background gas level Sensor zero drift	Do fresh air calibration

TROUBLESHOOTING

Programming Functions

1. Accessibility of calibration and programming functions

Mode	BASIC			ADVANCED		
	0	1	2	0	1	2
Security Level						
Calibrate Monitor?						
Fresh Air Calibration?	x	√*	✓	✓	√*	✓
Multiple Sensor Calibration?	x	√*	✓	✓	√*	✓
Single Sensor Calibration?	x	√*	✓	✓	√*	✓
Modify Span Gas Value?	x	x	x	x	√*	✓
Change LEL Span Gas?	x	x	x	x	√*	✓
OXY Calibration Type?	x	x	x	x	√*	✓
Change Alarm?						
Change High Alarm Limit?	x	x	x	x	√*	✓
Change Low Alarm Limit?	x	x	x	x	√*	✓
Change STEL Alarm Limit?	x	x	x	x	√*	✓
Change TWA Alarm Limit?	x	x	x	x	√*	✓
Change Datalog?						
Clear All Data?	x	x	x	x	√*	✓
Change Datalog Period?	x	x	x	x	√*	✓
Select Data Type?	x	x	x	x	√*	✓
Enable/Disable Datalog?	x	x	x	x	√*	✓
Select memory full type?	x	x	x	x	√*	✓
Change Monitor Setup?						
Change ID? (Site & User)	x	x	x	x	√*	✓
Change Alarm Mode?	x	x	x	x	√*	✓
Change User Mode?	x	√*	✓	✓	√*	✓
Change Real Time Clock?	x	√*	✓	✓	√*	✓
Change Backlight Mode?	x	x	x	x	√*	✓
Change Password?	x	x	x	x	√*	✓
Change Pump Speed?	x	x	x	x	√*	✓
Change Average Method?	x	x	x	x	√*	✓
Change Display Language?	x	x	x	x	√*	✓
Set Temperature Unit?	x	x	x	x	√*	✓
Enable/Disable Vibrator?	x	x	x	x	√*	✓
Change Sensor Configuration?						
Change LEL/VOL Sensor Type?	x	x	x	x	√*	✓
Enable/Disable Sensor?	x	x	x	x	√*	✓
Change LEL Gas Selection?	x	x	x	x	√*	✓

x - Function not allowed

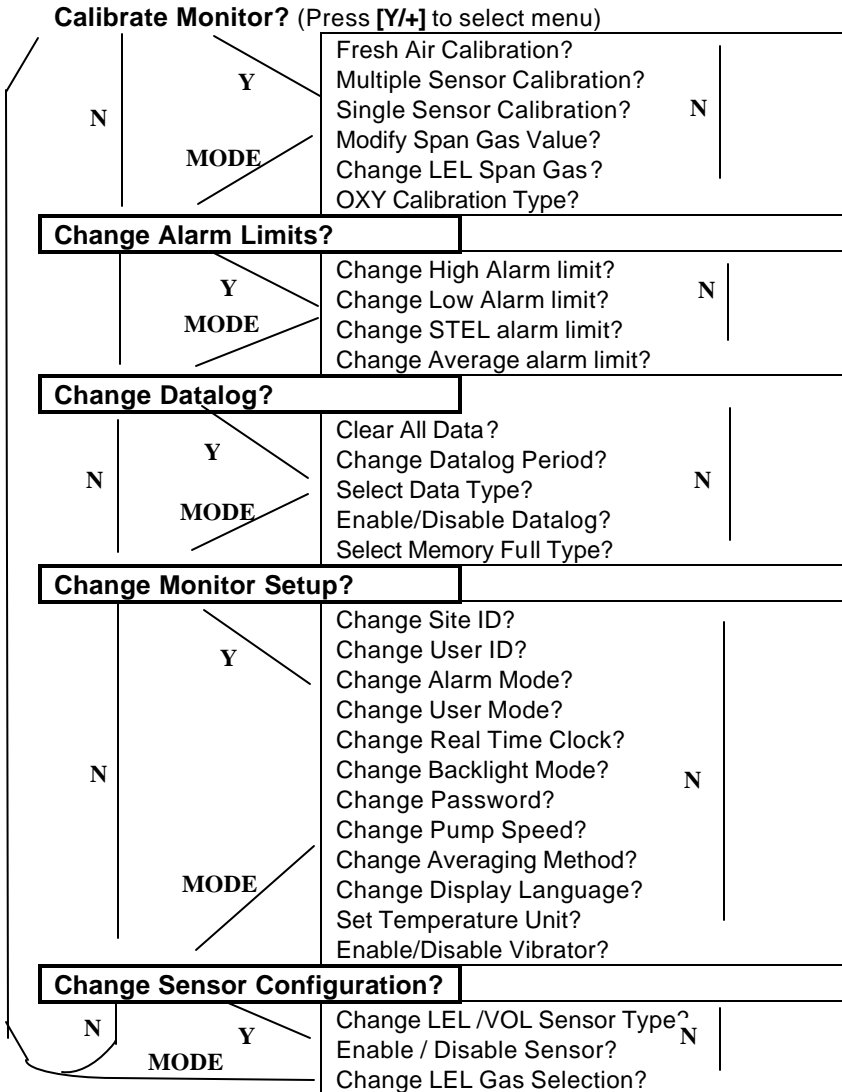
APPENDIX A

- ✓ - Function allowed
- * - Password required

2. Full Programming Menu versus Key Operation

To enter, press [N/-] and [MODE] together for 3 seconds.

To return, press [MODE].



LEL Correction Factors

Correction factors (CFs) for a number of commonly used compounds for the LEL sensor are on the facing page. The factors are measured relative to methane. After calibration to methane, multiply the reading by the factor to obtain the actual % LEL of the gas. If the CF of a gas is <1.0, then the sensitivity to the gas is higher than that of methane. The factors are typically measured at 50% LEL, less than 5% relative humidity and 77°F (25°C). The CFs may change at other concentrations, but temperature and humidity variations usually have little effect on the sensor response. The CFs are for new sensors and may change with age.



The LEL CFs listed in Table 14 should not be confused with CFs for volume % measurements using the thermal conductivity (TC) function of the sensor. See Technical Note 153 at www.raesystems.com for CFs for Vol% measurements. The CF's are subject to change; check Technical Note 156 for the latest LEL CF updates.

LEL CFs may change as the sensor ages. Typically the CFs decrease, therefore use of the values above will err on the safe side.

APPENDIX B

Correction Factors for LEL Sensors		
Compound	CF	LEL (Vol%)*
Acetaldehyde	1.8	4.0
Acetic acid	3.4	4.0
Acetone	2.2	2.5
Ammonia	0.8	15.0
Benzene	2.2	1.2
Butadiene, 1-3-	2.5	2.0
Butane, n-	2.0	1.9
Butene, 1-	2.1	1.6
Carbon monoxide	1.2	12.5
Cyclohexane	2.5	1.3
Dichloromethane	1.0	13.0
Ethanol	1.7	3.3
Ethene	1.4	2.7
Ethyl acetate	2.2	2.0
Ethylbenzene	2.8	0.8
Ethyl ether	2.3	1.9
Gasoline, whole	2.1	1.3
Heptane, n-	2.4	1.1
Hexane, n-	2.3	1.1
Hydrogen	1.1	4.0
Isobutane	1.8	1.8
Isobutene	1.5	1.8
Isopropanol	2.6	2.0
Methane	1.0	5.0
Methanol	1.5	6.0
Methyl ethyl ketone	2.6	1.4
Octane, n-	2.9	1.0
Pentane	2.3	1.5
Propane	1.6	2.1
Propene	1.5	2.0
Toluene	2.6	1.1
Turpentine	2.9	0.8
Vinyl chloride	1.8	3.6
Xylene, m-	2.7	1.1
Xylene, o-	3.0	0.9

APPENDIX B

Xylene, p-	2.8	1.1
* Lower Explosion Limit of the gas in volume percent		

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