1   INTRODUCTION

The MultiRAE Pro is a multi-gas meter that is commonly used in the environmental field. Information regarding the capabilities and uses of the MultiRAE Pro are briefly summarized below:

- Typical configuration includes sensors for:
    - Volatile organic compounds (VOC)
    - Oxygen (O_2)
    - Lower explosive limit (LEL)
    - Hydrogen sulfide (H_2S)
    - Carbon Monoxide (CO)
    - Gamma Radiation (available on multi-threat meter)
- Numerous other toxic gas sensors can be installed, including:
    - Ammonia (NH_3)
    - Chlorine (Cl_2)
    - Chlorine Dioxide (ClO_2)
    - Ethylene Oxide (ETO-A)
    - Formaldehyde (HCHO)
    - Hydrogen (H_2)
    - Hydrogen Cyanide (HCN)
    - Methyl Mercaptan (CH_3SH)
    - Nitrogen Dioxide (NO_2)
    - Nitric Oxide (NO)
    - Phosphene (PH_3)
    - Sulfur Dioxide (SO_2).
- Photoionization detector (PID) used for detecting VOCs based on their ionization potentials (IP):
    - Typical configurations include an ultraviolet lamp capable of ionizing organic (and some inorganic) compounds with IPs up to 10.6 eV. An 11.2 eV lamp is also available for purchase.
- Datalogging capabilities with the following options:
    - Local logging directly onto the instrument
    - Wireless access to real-time instrument readings through ProRAE Guardian using a RAELink3 mesh
    - Viper compatible for data transfer and remote viewing
- Important Rae Systems Technical Notes:
    - TN-106 – A Guideline for PID Instrument Response – displays ionization potentials and correction factors for many common industrial chemicals
    - TN-114 – Sensor Specifications and Cross-Sensitivities – displays warm up times, special instructions, and sensor cross sensitivities for the toxic gas sensors produced by Rae Systems
    - TN-123 – Special Diagnostic Modes for Rae Systems Instruments – provides raw sensor readings for instruments, used to determine if a sensor is properly responding to calibration gas

    A copy of the MultiRAE Pro Quick Start Guide (QSG) is provided on the following pages.
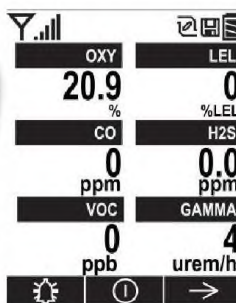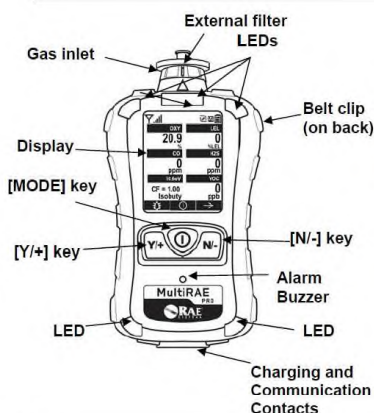
MultiRAE Pro

GENERAL INFORMATION	
Equipment Name:	MultiRAE Pro
Model:	PGM-6248
Manufacturer:	RAE Systems Inc.
National Manufacturer Contact:	Telephone: 408-952-8200 E-mail: tech@raesystems.com Website: http://www.raesystems.com

NOTE: Guides are to be used by trained personnel only and DO NOT replace the manufacturer's operations or technical manuals. These guides were developed by field personnel for utilization by EPA and their contractors and are helpful in quick start-up and operations. Various limitations have been identified through the experience of the development group. Different makes, models, and updates to this equipment may change the limitations. It is recommended that calibration, maintenance, and use be recorded in a logbook. Additional product information may be found in the accompanying Equipment Operating Guides.

SPECIFICATIONS		
Uses:		The MultiRAE Pro uses standard gas detection sensors for detection of O_2, combustible gas (lower explosive limit [LEL]), volatile organic compounds (VOC), a combination CO and H_2S sensor; interchangeable specialty gas detection sensors including NH_3, Cl_2, HCN; and a gamma radiation-specific sensor. The integrated Photo Ionization Detector (PID) is used for broad-range toxic VOC gas detection. The default PID Lamp energy in the MR Pros shipped to EPA under the Blanket Purchase Agreement is 10.6 eV.
Limitations:	1.	Gas concentrations exceeding the upper limit of detection of the instrument (refer to table, manual pages 48-49) will not be properly detected. Any up-scale reading followed by a declining or erratic reading may indicate a gas concentration beyond the upper scale limit which may be hazardous.
	2.	Reliably operates in ambient conditions of -4° to 122°F (-20°C to 50°C) and 0-95% relative humidity (non-condensing).
	3.	The internal and external filters should be inspected and replaced as necessary.
	4.	Some sensors are cross-sensitive to many chemicals. Be aware that the LEL sensor can be "poisoned" by the following: silicone compounds, lead compounds, halogenated hydrocarbons, and reduced sulfur compounds. See Technical Note RAE TN-114 for more information.
	5.	PID calibrated to isobutylene. Sensor is not compound-specific, so VOCs are reported as lump sum. Other compounds have different response factors. See RAE TN-106.

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	6.	If the ionization potential of a compound is higher than the PID lamp energy (default lamp energy is 10.6 eV), the compound will not be detected. Verify your instrument PID lamp energy before use. See RAE TN-106.
	7.	LEL sensor calibrated to methane. For compound specific LEL reading, a correction factor must be applied. See RAE TN-156.
	8.	PID lamp requires periodic cleaning depending on operating conditions.
	9.	Detection of chemical warfare agents with the PID is unreliable, even if calibrated.
	10.	Make sure the instrument is updated with the latest firmware.
	11.	Periodic Fresh Air Calibration may be required.
	12.	When operating in Multi-Threat mode, the pump runs for 55 seconds and turns off for 5 seconds every minute under alarm-free conditions. During this 5 seconds period, Gamma readings are taken. Under alarm conditions this cycle changes to 0.7 seconds pumping and 0.3 seconds pump off for Gamma readings.
	13.	The CO/H2S combination sensor as well as the CO sensor no longer require charcoal filters to filter out for cross sensitivities as in the MultiRAE Plus or AreaRAEs.
Alarm Level and Response Range:		A 95 dB buzzer and five flashing red LEDs indicate when the specified limits were exceeded. HIGH: 3 beeps; LOW: 2 beeps; STEL and TWA: one beep and flash per second. Alarm latching with manual override or automatic reset. Additional diagnostic alarm and display message for low battery and pump stall.

ALARM LEVEL AND RESPONSE RANGE			
Compound	**Low Alarm**	**High Alarm**	**Response Range**
O_2	19.5%	23.5%	0 - 30% (volume)
LEL	10%	20%	0 - 100%
CO	35 ppm	200 ppm	0 - 500 ppm
H_2S	10 ppm	20 ppm	0 - 200 ppm
VOC	50 ppm	100 ppm	10 ppb - 2,000 ppm
Gamma	50 μrem/hr	250 μrem/hr	0 – 20,000 μrem/hr

Product Safety:	UL® Classified as Intrinsically Safe for use in Class 1, Division 1, Group A, B, C, D, & T4 Hazardous Locations
Battery:	The MultiRAE Pro operates by use of a lithium ion (Li-ion) battery pack, or 4 "AA" alkaline batteries via an optional removable adapter. To charge the instrument, connect the AC adapter to the DC jack on the MultiRAE Pro charging cradle or travel adapter with the instrument attached. The instrument should remain in charging status until ready for field use. The instrument should remain in charging status to ensure ready for field use. While charging, the display will indicate the charging status, battery voltage, and the instrument's LED will appear red until fully charged when it will change to green. The factory-supplied rechargeable Li-ion battery is designed to last for 12 hours of normal operation (no backlight, no alarms) under best conditions. As the battery lifespan increases, and/or under cold ambient temperatures, battery capacity may be noticeably reduced. Fresh alkaline batteries will provide approximately 6 hours of operation under ideal conditions.

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Calibration and Maintenance:	Note: The calibration gas concentrations are different from that of the MultiRAE Plus and AreaRAE. The following are the default calibration gas settings from RAE for standard sensor configuration. Two-point calibration for zero and span gas calibration: CO 50 ppm, H_2S 10 ppm, LEL (methane) 50%, O_2 18%, and VOC 10 ppm Isobutylene. An optional three-point calibration for VOC sensor can be enabled, using 100 ppm Isobutylene.
Critical Operational Information:	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.

QUICK START GUIDE		
Prior to Starting:	1.	Check batteries by unplugging the MultiRAE unit from the charger and noting battery level on the display.
	2.	Make sure that the instrument is calibrated.
Start-up and Monitoring:	1.	Press and hold "**Mode**" key until monitor beeps once, monitor will go through a 90-second warm-up sequence.
	2.	Watch display screen for messages such as, sensor installed and the warranty expiration, alarm limits, last calibration date, and User/Alarm/Datalog modes.
	3.	After the warm-up period, the unit goes into monitoring mode, taking real-time readings.
	4.	When monitoring, the screen displays all instantaneous gas concentrations with the sensor name above the value and the value above the unit. In a non-hazardous environment the sensor readings should be similar to the following: (OXY=20.9%, LEL=0 %LEL, CO=0 ppm, H2S=0 ppm, VOC=0-200 ppb, and GAMMA=1-20 µrem/hr). Alarm Limits are set for High, Low, STEL, and TWA. When an alarm condition occurs, the monitor will provide audible and visual alarms to alert users of unsafe conditions.
	5.	Prior to deploying instrument for monitoring, a field bump test should be performed to ensure the monitor responds. If preferred a bump test can be performed through the calibration menu and procedures.
	6.	The instruments response time for different gases varies from 15 seconds to 150 seconds. Allow sufficient time before recording the reading.
	7.	To change monitoring mode between Multi-Threat, Gamma Radiation Only, and Gas Only modes, push "N-" button and then select the desired monitoring mode.
	8.	Pump speed should be operated on Low unless otherwise required to conserve battery and pump life. There is almost no difference in sampling accuracy according to the manual. Pump speed can be changed through the Programming Mode under Monitor. Pump speeds are approximately 200 cc/min on Low and 300 cc/min on High.
Calibration:	1.	Hold down "**Mode**" and "**N/-**" keys simultaneously for 5 sec to get in Programming Mode. A prompt may appear asking for the password to access this screen. Enter **** and press "**Mode**" enter Basic mode. To enter the Programming mode, the default password is 0000.
	2.	The Calibration icon will be highlighted. Press "Y/+" to enter the calibration menu or "**Mode**" to return to monitoring mode.

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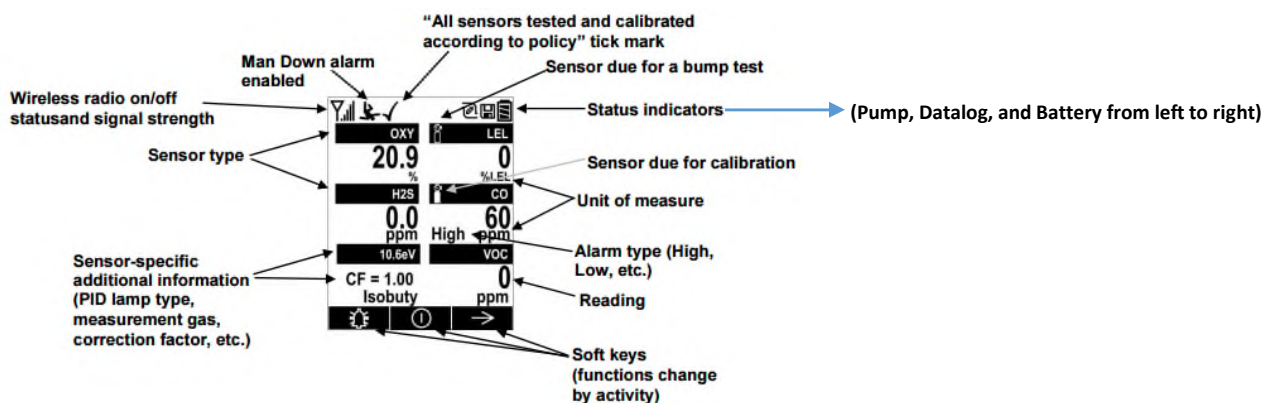|		
Calibration Required Symbol ↓	3.	A list of calibration options will be displayed. Press "**Y/+**" to select the highlighted option, "**Mode**" to return to Programming/Basic mode, or "**N/-**" to cycle down through the list of options.
	4.	When using the calibration adapter the gas flow rate should be set between 500 and 1000 cc/min, or the use of a Demand-Flow regulator can be employed without the use of the calibration adapter.
	5.	**Fresh Air** -Clean ambient air, "Zero Air" from a cylinder, or ambient air purified through a charcoal filter can be used. This procedure should **always** be performed prior to any sensor calibration. -When display shows "Fresh Air Calibration?" press "**Y/+**" key. When successful, the display should show a reading of "20.9" for oxygen sensor and "0.0", or a very small number for all other sensors.
	6.	**Multi Sensor Span** If you are using a multiple gas cylinder, press "**Y/+**" at "Multiple Sensor Span". Ensure the appropriate sensors and concentrations correspond to the calibration gas cylinder. If this is not the case it will be necessary to change the span value or select/deselect the sensors for multi cal. **Note**: These changes can only be made through Programming mode. After ensuring the sensors to be calibrated are correct, attach calibration gas to the unit using a regulator and calibration adaptor. Press the "**Y/+**" key to start the calibration process, and follow instructions on screen. Disconnect regulator from gas cylinder when calibration is complete. Multiple Sensor Bump calibration also follows this procedure.
	7.	**Single Sensor Zero** This option allows for zero calibration of individual sensors, rather than the all-or-nothing option of the Fresh Air option.
	8.	**Single Sensor Span** If you are calibrating a single sensor, press "**Y/+**" at "Single Sensor Span", then press "**Mode**" in the menu to toggle to the desired sensor. Attach the calibration gas cylinder to the unit using a regulator and calibration adaptor. Press "**Y/+**" and follow instructions on screen. Disconnect the regulator from the gas cylinder when calibration is complete. Single Sensor Bump calibration also follows this procedure.
Turn Off:	1.	Press the "**Mode**" key for 5 seconds to power down the instrument. A countdown sequence on-screen will verify when the unit is off.
Connectivity and Telemetry:	1.	Wireless functionality is dependent upon both hardware and software capabilities. Wireless capability is installed in the units; however they are enabled/disabled dependent upon what was ordered from the manufacturer. Wireless capability may have been disabled in order to allow a "P2P interface" program to be able to communicate with VIPER. If the wireless capability has been enabled, then ProRAE Guardian software will be required for communication. This program is different from ProRAE Remote which is used in conjunction with the AreaRAEs. Interfacing with ProRAE Guardian and VIPER cannot be done at the same time. Additional hardware may be necessary to communicate with the respective programs.
	2.	There are also two different Travel Chargers associated with the units, a green and a white one. These Travel Chargers will affect which wireless capability can be utilized, and procedures for connecting to ProRAE Studio II to download data.

2   GETTING THE MULTIRAE PRO UP AND RUNNING

The diagrams below provide an example of the MultiRAE Pro's display screen during operation, including identification of some symbols observed, and a table summarizing the menus and submenus available on the instrument.

Calibration	Measurement	Alarms	Datalog	Wireless*	Monitor
Fresh Air	Sensor On/Off	Alarm Limits	Clear Datalog	Radio ON/OFF	LCD Contrast
Multi Sensor Span	Change Meas. Gas	Alarm Mode	Datalog Interval	Roaming	Pump Speed**
Single Sensor Zero	Measurement Units	Alarm Settings	Sensor Selection	PAN ID	Zero At Start
Single Sensor Span		Comfort Beep	Data Selection	Channel	Fast Startup
Multi Sensor Bump		Man Down Alarm	Datalog Type	Join Network	Temperature Units
Single Sensor Bump			Memory Full Action	Interval	Language
Cal. Reference				Off Network Alarm	Site ID
Change Cal. Gas				Factory Reset	User ID
Multi Cal. Select					Date Format
Change Span Value					Date
Change Span2 Value***					Time Format
					Time
					User Mode
					Backlight
					LCD Flip

The following subsections provide discussions of tasks to be completed prior to operating the instrument.

2.1 Equipment Checks

Prior to using the MultiRAE Pro, there are certain equipment checks that should be completed to ensure that the instrument is set up properly for the task at hand. The following list briefly highlights these:

- **Battery Check:** When removing the instrument from the charger, check that the battery status indicator located on the instrument display screen shows a fully charged battery.
- **Moisture/Particulate Filter:** Check to ensure that the moisture/particulate filter attached to the inlet is clean, and change as necessary.
- **Pump Status:** Upon startup, listen for the sound of the pump running and check the pump status indicator located on the instrument display for proper operation.
- **Sensor Status:** During startup, observe the instrument display for messages regarding any necessary calibration or expiration dates associated with the individual sensors; evaluate sensors prior to field use and change as necessary.
- **Alarm Levels:** Check the status of alarm levels and update accordingly.
- **Datalogging:** Ensure that datalogging parameters are set appropriately.
- **Time/Date:** Ensure that the date and time are set correctly.

2.2 Calibration

As described in the QSG, periodic calibration of the MultiRAE Pro should be conducted to keep the instrument in proper working order. The following list highlights some tips for performing calibration, as well as typical frequency of calibrations.

- **Frequency of Calibration**:
    - o **During Storage:** A full calibration is typically performed once per month when the instrument is not actively being used (i.e. on charge at the warehouse).
    - o **During Field Use:**
        - ▪ **Fresh Air Calibration:** Should be performed daily, during a shift change, or when errant readings are suspected. Includes all sensors, except O_2.
        - ▪ **Bump Test:** Should be performed daily, during a shift change, or when errant readings are suspected. Can be performed on a single sensor or on multiple sensors at one time.
        - ▪ **Full Calibration:** If the bump test indicates any problems with the instrument such as an out-of-range sensor, then a full calibration should be performed.
- **Full Calibration:**
    - o **Span Values:**
        - ▪ Verify that the span value concentrations for the MultiRAE Pro match those of the calibration gases being used.
        - ▪ Multiple span value concentrations can be assigned to provide a better calibration curve and improve the dynamic range of the VOC sensor.
    - o **Sensor Selection:**
        - ▪ Full calibration can be performed on a single sensor or on multiple sensors at one time. Typically, the standard sensors (O_2, LEL, H_2S, and CO) are calibrated at the same time.
        - ▪ When installing a new sensor, ensure that the appropriate calibration gas is used and that calibration provides sufficient saturation time as specified for certain sensors (i.e. Cl_2)

- See section 9.3.2 of the MultiRAE Pro User's Guide and RAE Systems Technical Note-148 for additional options and information regarding calibration.

2.3 Measurement

After completing the Equipment Checks and Calibrations, the MultiRAE Pro is ready for use. The following list highlights some measurement information:

- **Operation Mode**
  - o **Hygiene Operation Mode:** Typical mode of operation, which provides continuous monitoring.
  - o **Search Operation Mode:** Provides monitoring only while the MultiRAE Pro is "sampling", and can be useful when it is desired to sample specific areas and keep data separate.
- **Sensor On/Off:** If desired, specific sensors can be turned on or off.
- **Correction Factors:** Can be applied to allow the instrument to read VOC concentrations in units of specific gases of interest, while the instrument is calibrated to a single calibration gas, typically isobutylene. Sometimes used in environments when a known compound is suspected to be present. See RAE Systems Technical Note TN-106 for additional information.

3   DATALOGGING

The following subsections discuss datalog capabilities and options for the MultiRAE Pro.

3.1 Datalog Parameters

The MultiRAE Pro is equipped with a datalog feature that will store sensor readings while the instrument is operating. The MultiRAE Pro will display a 💾 icon in the top, right corner when the datalog feature is enabled. Considerations for the datalogging feature are highlighted below.

- **Datalog Interval:** Select the desired datalog interval prior to monitoring; a typical interval is 60 seconds, but intervals can range from 1 second to 3,600 seconds.
- **Sensor Selection:** Specify which sensors will be included in datalogging.
- **Data Selection:** Specify which types of data are logged, such as minimum, average, maximum, and real-time concentrations.
- **Clear Datalog:** Once the data has been downloaded and verified, the datalog should be cleared to prevent confusion during future monitoring activities.
- Section 9.3.6 of the MultiRAE User's Guide provides further details regarding datalogging capabilities.

3.2 Wireless Programming

Some MultiRAE Pros are capable of using a 900 megahertz (Mhz) signal to send data from the instrument to a host computer (through a RAELink3 mesh radio) running ProRAE Guardian Software. The following list briefly summarizes parameters involved in this process.

- **Radio On/Off:** The first step to transmitting the data via radio telemetry is to turn on the radio on the MultiRAE Pro.

- **PAN ID:** The MultiRAE Pro and any other devices, including the RAELink3 mesh radio that you wish to connect via radio telemetry must have the same PAN ID in order to connect with the ProRAE Guardian Software. Refer to the RAELink 3 Mesh Radio QSG to learn how to identify the PAN ID for the wireless network.
- **Channel:** The MultiRAE Pro and RAELink 3 mesh radio must have matching channels in order to connect wirelessly. Refer to the RAELink 3 Mesh Radio QSG to learn how to identify the channel on the RAELink 3 mesh radio.
- **Join Network:** Once the PAN ID and Channel on the MultiRAE Pro and RAELink 3 Mesh Radio match, the operator can then join the wireless network.
- **Interval:** Select the desired interval between wireless transmissions. The default setting is 30 seconds, but the interval can also be set to 10, 60, 120, or 240 seconds.
- **Factory Reset:** Restores the instrument's wireless settings to the factory defaults.

3.3 Viper

Some MultiRAE Pros are compatible with the Viper telemetry system. The following list briefly summarizes parameters involved in this process.

- **Peer-to-Peer Mode (P2P):** The MultiRae Pro must be put into P2P mode prior to connecting to Viper. A quick check for P2P mode is to enter the programming menu and attempt to access the wirelss menu selection. If the wireless menu selection cannot be highlighted the instrument is in P2P mode. If it is accessible, the unit must be connected to a computer to switch from wireless mode to P2P mode.
- **RS-232 Adaptor:** The RS-232 adaptor (it has a green sticker on the bottom instead of a silver sticker) must be used to connect a MultiRae Pro to a Viper Linc.
- **5-Pin Connector:** The connector to the Linc should be a 5-pin connection, not a 3-pin connection used for AreaRaes.
- **Baud Rate:** The Linc should be set to a Baud rate of 9600 instead of 19200 for AreaRaes.

4 MAINTENANCE AND TROUBLESHOOTING

The MultiRAE Pro requires little maintenance to be performed by the operator. Basic maintenance that would be expected to be completed by the operator include calibration (see Section 3.3), replacing sensors, replacing filters, and changing the battery.

- **Replacing Filters and Gas Inlet Adapter:** If the filter is dirty or clogged, it can be simply unscrewed from the gas inlet adapter, and replace with a new filter. The black gas inlet adapter can also be simply unscrewed from the inlet and replaced with a new one.
- **Replacing Toxic Gas Sensors:** The MultiRAE Pro can be outfitted with over 25 different sensors. The instrument should be turned off when changing sensors, and sensor compartments should not be left empty. In the case where one is not being used, a 'dummy' sensor should be installed.
- **PID Sensor and Lamp:** The PID sensor and can be replaced or cleaned, but care must be taken not to damage the items.
- See Section 14 of the MultiRAE Pro User's Guide for detailed information regarding maintenance.