



RAEGuard LEL

Lower Explosion Limit Transmitter

FGM-1100 Series



User's Guide



- 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. The user should understand how to set the correct parameters and interpret the obtained results.

CAUTION!

To reduce the risk of electric shock, turn the power off before removing the instrument cover. Disconnect the power before removing the sensor module for service. Never operate the instrument when the cover is removed. Remove instrument cover and sensor module only in an area known to be non-hazardous.

WARNING!

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is used or put into service. For maximum safety, the accuracy of the RAEGuard should be checked by exposing the sensor(s) to known concentration calibration gas before each day's use.

AVERTISSEMENT!

La calibration de toute instruments de RAE Systems doivent être teste 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 sécurité maximale, la sensibilité du RAEGuard doit être verfier en exposant l'instrument à une concentration de gaz connue par une procédure dietalonnage avant chaque utilisation journalière.

RAEGuard LEL User's Guide

Contents

Contents	1
1. General Information	2
1.1 General Specifications	3
2. Operation	4
2.1 Physical Description	5
2.2 Installation and Access Instructions	6
Mounting	6
Electrical Wiring	8
Instrument Assembly Installation	8
2.3 Display And User Interface	9
User Interface	9
Magnet Key	9
Using The Magnet Key	10
System Initialization	10
Reading Display	10
Alarm Contacts	12
2.4 Calibration	13
Zero Calibration	14
Span Calibration	15
2.5 Calibrating With Other Gases	17
2.6 Advanced Menu	17
3. Theory of Operation	18
4. Maintenance	19
5. Troubleshooting	20
6. Appendix A: Common Correction Factors For Other Gases	21

1. General Information

The RAEGuard LEL is a fixed lower explosion limit (LEL) transmitter that operates from a 9 to 36 VDC power source and provides a 4-20mA analog output in the range of 100% LEL. The microprocessor-based circuit is housed in an explosion-proof enclosure, and the RAEGuard LEL is equipped with a local digital display of the gas concentration, unit of measurement and function keys for performing calibration.

Key features:

- 4-20mA analog output for product ranges of 100% LEL equivalent
- Explosion-proof enclosure for hazardous environment application
- Magnetic key interface eliminates need to open explosion proof housing when making operation parameter adjustments
- Long life poison resistance 7R sensor
- LCD plus status/error LEDS
- Operation at 9 to 36VDC
- Two dry contact (<30V,2A)

Applications:

- Waste water treatment plants
- Marine and off-shore oil wells
- Refineries and petrochemical plants
- Power plants
- Colliery
- Solvent recovery systems
- Painting and coating operations

Hazardous Location Classification:

- UL: Class I, Division 1, Groups B, C and D, Temperature Code T6
- ATEX: Ex II 2 G EEx d II B T6

1.1 General Specifications

Detector Specifications

Size	12.7cmx12.7cmx11.5cm (5.0"Lx5.0"Wx4.5"H)
Weight	2.5kg (5.5 lbs)
Detector	7R-sized protected catalytic bead combustible gas sensor
Range	0-100% LEL
Resolution	1% LEL
Accuracy	+/- 2% LEL or +/-10% of reading
Hazardous Location Classifications	UL: Class I, Division 1, Group B,C,D,T6 ATEX: Ex II 2 G EEx d II B T6
Power	9-36 VDC max 160mA at 24V
Signal Output	4-20mA with 12V compliance at 24V power
Sampling	Internal diffusion
Display	7-segment, 4-digit LCD with 4 color- coded fault LEDs
Response Time (t₉₀)	15 seconds to 90% of reading to 50%LEL methane
User Interface	Magnetically accessed keys for calibration
Calibration	Two point field calibration
Temperature	-20 to +55° C (-4 to +131° F)
Humidity	0-95% relatively humidity (non- condensing)

2. Operation

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to a known concentration calibration gas before the instrument is used or put into service. For maximum safety, the accuracy of the RAEGuard LEL should be checked by exposing the sensor(s) to a known concentration calibration gas, after a period of time.

Calibration should be verified daily during the period of initial use in the intended atmosphere to ensure nothing is poisoning the sensor(s). The period of initial use must be of sufficient duration to ensure that the sensors are exposed to all conditions that might have an adverse effect on the sensors.

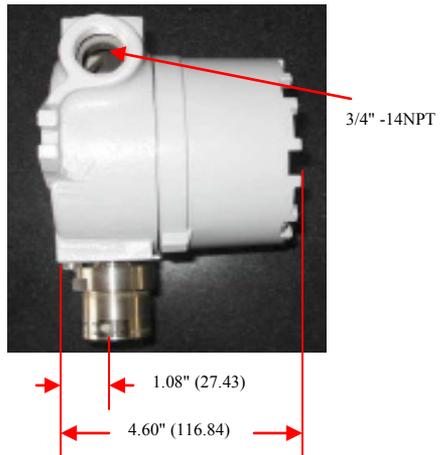
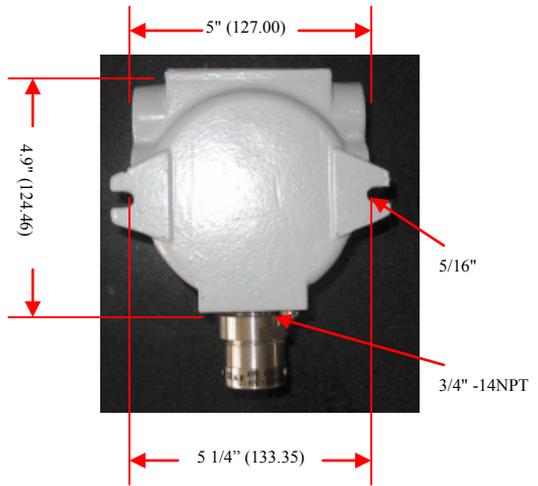
Verify the calibration with a known concentration test gas before use. Recalibrate the unit if readings are off.

Prior to factory shipment, the RAEGuard is calibrated and tested using 50% LEL (2.5% CH₄) gas. However, the user should calibrate the instrument before the first use. After the unit is installed and calibrated, it is ready for immediate operation. 50% LEL is the default LEL calibration setting.

Kit Accessories include: Calibration Adapter, RAEGuard Magnet Key, and User's Guide.

2.1 Physical Description

The design of RAEGuard LEL allows it to be easily mounted and interfaced to a fixed-point gas monitoring system. The detector transmitter is housed in a case measuring 5.0" L x 5.0"W x 4.5" H (127mm x 127mm x 115mm), with two mounting holes spaced 5.25" (133 mm) from center to center.



2.2 Installation and Access Instructions

WARNING

1. A minimum of 18" (457mm) of explosion-proof conduit must be used at cable entry in group B atmospheres. CSA requires seals in conduit exceeding 5' (1.524 m) in group C atmospheres.
2. To prevent ignition of hazardous atmospheres, area must be free of flammable vapors and supply circuit must be disconnected before removing cover.

Mounting

First, decide where the transmitter will be mounted. (Refer to installation drawing, below.) Drill two holes in mounting surface, with the center of the holes 5.25" (133mm) apart.



RAEGuard LEL User's Guide

Instrument Assembly Removal



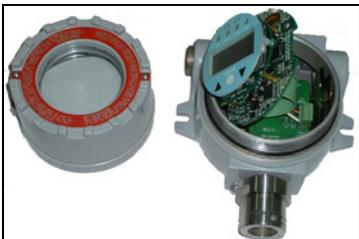
Prior to service: Make sure power is OFF. Observe all Hazardous Location Safety procedures.



1. Unscrew the housing lid from the housing body by rotating it counter-clockwise. As shipped, one of the conduit holes is covered by the provided hex-head plug. The other conduit is shipped with connected wires.



2. Tilt the retaining clip toward the housing to release the instrument assembly.



3. Tilt the instrument assembly 90°.
4. Unlock the black 16-pin connector.
5. Lift the entire instrument assembly out of the housing.



Disassembled instrument.

RAEGuard LEL User's Guide

Electrical Wiring

1. Inside the housing bottom, unplug the two green terminal block plugs from the terminal block on the PC boards. **Note:** The terminal block plugs accept 16 AWG to 28 AWG wire.



2. Lace the wires through the RAEGuard LEL's wire hole and connect wires to the corresponding pin numbers of the terminal blocks:

Wire	Pin#
Alarm Common	1
High Level Alarm	2
Low Level Alarm	3
RS-485A	4
RS-485B	5
4 to 20 mA Output	6
Power Supply Neg/Output Common	7
Power Supply Positive (9 to 36 VDC)	8

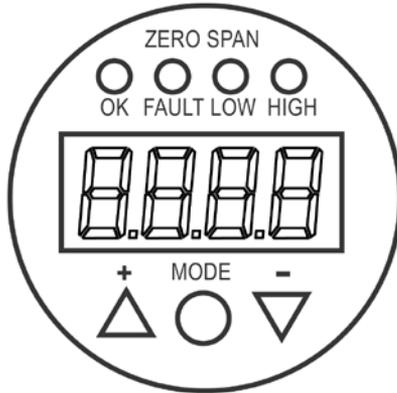
Instrument Assembly Installation

1. Plug all terminal block plugs into the correct terminal block headers. Keep the extra wires as close to the inside enclosure wall as possible.
2. Plug the black 16-pin connector back into its socket.
3. Align the instrument assembly with the tilt point inside the housing.
4. Tilt the retaining clip toward the housing and place the instrument assembly back into the housing bottom. The clip will secure the assembly.
5. Tightly screw the housing top to the housing bottom.

2.3 Display And User Interface

User Interface

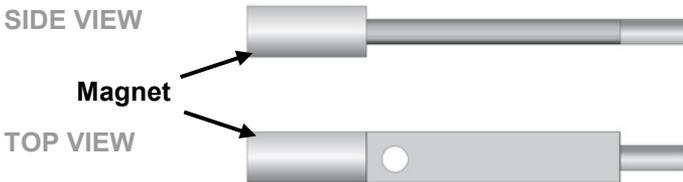
The RAEGuard LEL's user interface consists of four status LEDs, a 4-digit LCD display, and three keys, [+], [MODE], and [-]. The three keys are operated by using the Magnet Key.



RAEGuard LEL user interface.

Magnet Key

The RAEGuard LEL has no external switches, but instead uses the magnetic end of the RAEGuard Magnet Key (p/n 033-2032-000) to activate switches built into the unit.



RAEGuard Magnet Key.

RAEGuard LEL User's Guide

Using The Magnet Key

Using the magnet end of the Magnet Key, briefly touch the glass above the MODE circle or the triangles labeled [+] and [-]. Then remove the key straight out and away from the RAEGuard LEL.



RAEGuard Magnet Key touching glass above the [+] triangle.

Important! Never drag the key sideways, or two functions may be activated.

System Initialization

When the RAEGuard LEL system power is turned on, it initializes and an “InIt” message appears on the display. As the transmitter is warming up, each component is checked, and the LEDs blink all at once. The countdown timer appears on the screen for the 15-second warm-up.

Reading Display

As the transmitter enters the Reading Display, it automatically starts testing for errors and goes through a cycle of checking each alarm condition. If there are no errors or alarm conditions, the green “OK” LED is lit and the gas concentration is displayed.

RAEGuard LEL User's Guide

If there is an error, the "Fault" LED blinks and an error message blinks on the screen and the external alarm sounds. Each alarm condition has a corresponding LED that blinks an amber color when the readings are outside a specified range or limit. The transmitter automatically checks for errors again until normal readings resume.

If errors continue to be found, contact your distributor or RAE Systems.

Refer to Section 5: Troubleshooting Tips for alarm relay logic details.

When the transmitter is error-free, the reading appears on the screen.

Range

Range	Analog Output	Analog Output For LEL Off	Display For LEL Off
0% ~ 103%	4mA to 20.5mA	22mA	flashing 8888

Calibration

- Zero calibration – use cylinder of air for 99 seconds
- Span calibration – use span gas for 99 seconds

Reading Calculation

Compensation on high concentration

4-second average

Dead-band reading

LEL On/Off Mechanism

- At the end of fresh air calibration LEL zero raw count is saved.
- Saves raw count (ZeroCountInTC) in TC mode.
- Turns off LEL sensor if reading exceeds 103%.
- Switches to TC mode right after LEL is off and saves TC raw count (OffCountInTC) to memory.
- Monitors TC raw count (CountInTC) and turn LEL back on when $(\text{CountInTC} - \text{ZeroCountInTC}) < 90\% * (\text{OffCountInTC} - \text{ZeroCountInTC})$

RAEGuard LEL User's Guide

Alarm Contacts

The alarm contacts can be used to drive user-supplied external alarms such as a light or buzzer. The low alarm contact closes when the display reads over the programmed low alarm limit. When the reading exceeds the high alarm limit, the low alarm contact opens and the high alarm contact closes. When the display is over-range, the high alarm contact remains closed and the output jumps to 22 mA to allow remote detection. A fault condition can be detected by a drop to 2 mA output; no dry contact closure occurs.

Default Alarm Relay Logic

	External Alarm	LED	LCD	Analog Output
Exceed Low alarm limit	Low alarm	Low	reading	Based on reading
Exceed High alarm limit	High alarm	High	reading	Based on reading
LEL Off (exceed 100%)	High alarm	High	Flashing 8888	22mA
Sensor fault, Calibration fail	Low alarm	Fault	Flashing E003	2mA
Sensor fault, Sensor drift	Low alarm	Fault	Flashing E004	2mA
ADC saturated (max)	High alarm	Fault	Flashing E005	2mA

2.4 Calibration

The RAEGuard LEL is calibrated using a two-point calibration process. First, use a “zero gas.” Then use a “span gas” containing a known concentration of a standard reference gas, to set the second point of reference.

Calibration

- Zero calibration: Use a cylinder of zero gas (air).
- Span calibration: Use a cylinder of span gas.

Note: Zero calibration must be performed before span calibration.

To perform a calibration, you need a cylinder of zero gas, a cylinder of span gas, and a calibration adapter.



RAEGuard LEL connected to gas cylinder with a calibration adapter.

RAEGuard LEL User's Guide

Zero Calibration

1. Connect the zero gas cylinder to the metal filter gas adapter on the RAEGuard LEL transmitter using the provided calibration adapter.
2. To access the Calibration menu, press [MODE] from the Reading Display. Zero calibration appears first, as indicated by the "ZEro" message on the screen.

Optional: To advance to span calibration, press [MODE] a second time. "SPAN" appears on the screen. Skip to Span Calibration instructions on the next page.

Optional: To exit the Calibration menu, press [-] to return to the Reading Display.

3. Turn on the gas flow. Allow gas to flow into the sensor for 30 seconds before zero calibration. Then press [+] to start calibration. The "Zero" LED starts blinking, and the "Zero" message alternates with a 60-second countdown timer (for H₂S sensor).

Optional: Before the countdown reaches zero, you may press any key to interrupt zero calibration and advance to span calibration.

4. Once the countdown reaches zero, the "Zero" LED stops blinking, and the zero calibration data is saved. Zero calibration automatically advances to span calibration when complete.

Note: The transmitter returns to the Reading Display after 60 seconds of idle time.

5. Turn off the zero calibration gas and remove the cylinder.

RAEGuard LEL User's Guide

Span Calibration

1. Connect the span gas cylinder to the metal filter gas adapter on the RAEGuard LEL transmitter using the provided calibration adapter.

Optional: To access span calibration from the Reading Display, press [MODE]. After "Zero" appears on the screen, press [MODE] a second time to advance to span calibration.

Optional: To access span calibration after zero calibration has already started, press any key to advance to span calibration.

Optional: To exit the calibration menu, press [-] to return to the Reading Display.

Note: It is not necessary to exit like this. After 60 seconds of idle time, the RAEGuard LEL automatically returns to the Reading Display.

2. Turn on the gas flow. First, let gas flow into the sensor for 30 seconds before span calibration. Then press [+] to start calibration. The "Span" LED starts blinking. The "Span" message alternates with a 99-second countdown timer.

Note: Span calibration takes 99 seconds.

Optional: Before the countdown reaches zero, you may press any key to interrupt span calibration and return to the Reading Display.

3. Once the countdown reaches zero, the "Span" LED stops blinking.
4. If the LEL sensor sensitivities are unacceptable, the screen alternately flashes a "SPAN" and "FAIL" message until any key is pressed.

RAEGuard LEL User's Guide

Note: If span calibration fails, it may be necessary to replace the LEL sensor.

5. You may choose to restore original data by pressing [+] when "rStr" appears on the screen. The RAEGuard LEL returns to the Reading Display. Otherwise, press [-] or [MODE] to return to zero calibration and to restart the entire calibration process.
6. If the LEL sensor's sensitivity is acceptable, the span data is calculated and saved.
7. The calibration procedure is complete. After a few seconds, the transmitter returns to the Reading Display.
8. Turn off span calibration gas and remove the cylinder.

2.5 Calibration For Other Gases

To obtain correction factors (CFs) for other span gases, simply divide the value on the methane scale in the table by the methane value for the span compound. For example, to obtain CFs on the pentane scale, divide all the numbers in the table by 1.8. Thus, when calibrating with pentane, the new CF for acetylene is $2.8/1.8=0.4$.

Appendix A contains a list of correction factors for common combustible vapors.

2.6 Advanced Menu

The Advanced menu allows you to change the values for each reading option. To access the Advanced menu from the Reading Display, first press [+], [-], and then [MODE] in sequence. Then scroll through the parameters shown below by pressing [MODE].

Submenu Parameter	Message on screen
Span Gas Value	C50
Correction Factor	CF1.0
Low Alarm Limit (10%)	L010
High Alarm Limit (20%)	H020

Note: Anytime a submenu screen is idle for more than 15 seconds, the transmitter returns to the Reading Display.

To change a value, press [MODE] until the correct parameter appears.

- To increase a value, press [+].
- To decrease a value, press [-].

When finished changing the value, press [MODE].

If a value has changed, the new value blinks on the LCD.

- Press [-] to discard changes and advance to the next submenu item.
- Press [+] to save changes.

The "SAVE" message appears on the screen to confirm changes have been saved.

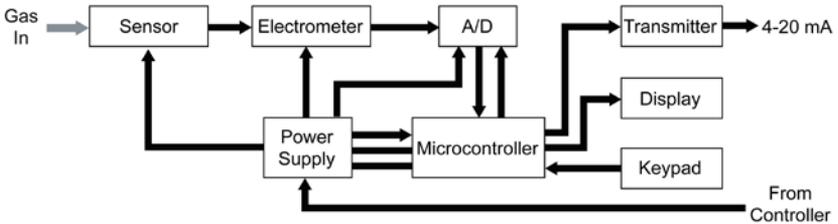
3. Theory of Operation

The RAEGuard uses a combustion LEL sensor. After sample gas diffuses through the metal sinter into the combustion chamber. A pair of combustion elements inside the combustion chamber burn the combustible gas and generates an electrical signal.

The RAEGuard LEL is a microcontroller-based instrument. After the electrical signal is conditioned and converted to digital, the microcontroller processes the data, which displays the results locally and reconstructs the digital data into a standard 4-20 mA current signal.

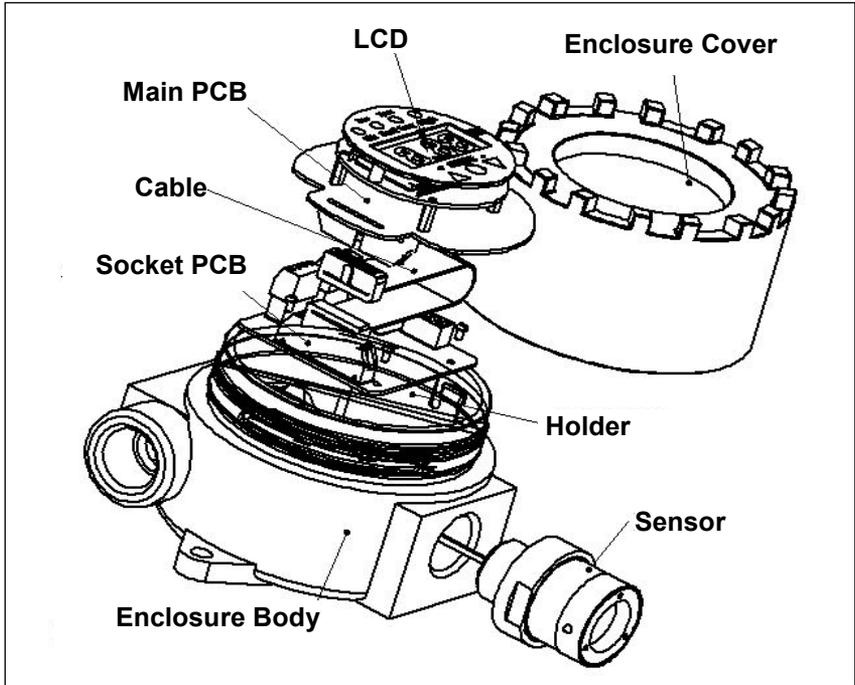
The instrument has three magnetic sensing keys. The user may calibrate the transmitter and change the alarm level setting via the magnetic front-panel key pad.

The instrument is powered by a DC power supply located in a safe area. The power supply on the PC board contains a switching and linear regulator that converts the main input voltage to 3.3V and 5V DC to power the entire circuit.



4. Maintenance

As a guide, it is recommended to regularly “bump test” the RAEGuard LEL unit with a known percentage gas.



Exploded View of RAEGuard LEL Components

Periodically examine the sensor's opening to make sure it is not dirty or covered in dust or debris.

If the sensor requires replacement, refer this unit to qualified service personnel.

5. Troubleshooting Tips

Note: Before diagnosing measurement problems, perform zero and span calibration.

Symptom	Reason & Solution
E003	Reason: Calibration fail Solution: Make sure of standard gas flow and recalibrate; replace sensor;
E004	Reason: LEL zero drift Solution: Recalibration
E005	Reason: LEL exceeds max raw count Solution: Consult RAE Systems support.
Couldn't turn on the unit	Reason: Wrong position of one switch (S3) Solution: Check the position of S3.
Reading abnormally High	Reason: Calibration failure; excessive moisture Solution: Recalibrate; Eliminate/control source of temperature difference
"Span failure" signal	Reason: Sensor broken Solution: Replace Sensor
Low 4/20mA output	Reason: Power supply voltage is lower than specified. Solution: Check power supply voltage and connections.
"Err"	Reason: Sensor ID is producing an error. Solution: Double check the setting of the Sensor ID (check the setting of a switch S2)

6. Appendix A

The following table contains correction factors for common combustible vapors.

Correction Factors		
Gas/ Vapor	LEL(%vol)	LEL CF*
Acetic acid	4.0	3.4
Acetone	2.5	2.2
Ammonia	15.0	0.8
Benzene	1.2	2.2
Carbon monoxide	12.5	1.2
Chlorobenzene	1.3	3.0
Ethanol	3.3	1.7
Hydrogen	4.0	1.1
Methane	5.0	1.0
Methanol	6.0	1.5
Methyl ethyl ketone	1.4	2.6
Propane	2.1	1.6
Toluene	1.1	2.6

* Values in Bold Italic are calculated from diffusion properties; values in normal type are confirmed with RAE sensors.



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P/N 033-4103-000
Rev. B
May 2007