



ChemRAE Handheld Chemical Detector

Operator and Unit Support Manual

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1. INTRODUCTION TO CHEMRAE

1.1 Introduction

This technical manual covers all aspects of normal use of the ChemRAE Handheld Chemical Detector, and includes Unit (or Field) Level support functions.

The ChemRAE is the latest in state-of-the-art handheld detection and identification systems. It is RAE Systems' next-generation detector based on tested and proven Open Loop Ion Mobility Spectrometry (IMS) technology. The ChemRAE uses an improved Ion Mobility Cell™, which provides improved selectivity and sensitivity. It is designed to detect Chemical Warfare Agents (CWAs) and Toxic Industrial Compounds/Materials (TICs/TIMs).

The ChemRAE weighs approximately 800g (less than 2 lbs), and is powered by a Lithium-ion rechargeable battery pack. The system has an easy-to-use interface, which can be operated using just one hand. The user display provides the operator with battery life indicator, agent class, horn volume level, and date and time. The ChemRAE stores agent alarm information for retrieval at a later time to provide a historical log of events.

The ChemRAE is small enough to be used as a personal detector, a monitor for surveying after an event, or a fixed-installation detector. It provides continuous operation without the need for expendable desiccant cartridges, like other IMS systems. The ChemRAE has no expendables and is designed for low life-cycle and operating costs.



1.2 For Your Safety

Strictly follow the Instructions for Use

Any use of the ChemRAE requires full understanding and strict observation of these instructions. The instrument is only to be used for purposes specified here.

WARNING: Do not attempt to open the ChemRAE. It contains radioactive material, and can only be repaired by the manufacturer.

Liability for proper function or damage

The liability for the proper function of the instrument is irrevocably transferred to the owner or operator to the extent that the instrument is serviced or repaired by personnel not employed or authorized by RAE Systems Service or if the instrument is used in a manner not conforming to its intended use.

RAE Systems cannot be held responsible for damage caused by noncompliance with the recommendations given above.

The warranty and liability provisions of the terms of sale and delivery of RAE Systems are likewise not modified by the recommendations given above.

1.3 Safety Information

Not for use in areas of explosion hazard



This instrument is neither approved nor certified for use in areas where combustible or explosive gas mixtures are likely to occur.

1.3.1 Radioactive Material

The ChemRAE uses a radioactive ionizing source. The source is Americium 241, and has an activity level of 5.9 MBq (160 μ Ci). The source is contained in a lead-shielded, tamper-proof module and poses no threat to the end user. ChemRAEs are manufactured in a carefully controlled process, and every unit is checked for any radioactive leakage before shipment.

Caution, contains radioactive material Am-241, 160 μ Ci. This Device is authorized for distribution to persons exempt from licence under NRC Lic. 09-23918-01E



In the USA, the ChemRAE is a U.S. NRC Exempted product, which relieves the user from any regulatory burden. In other countries, local, state or national regulations may apply. It is the user's responsibility to ensure that the device is operated in compliance with all appropriate regulations.

1.3.2 Disposal of the ChemRAE

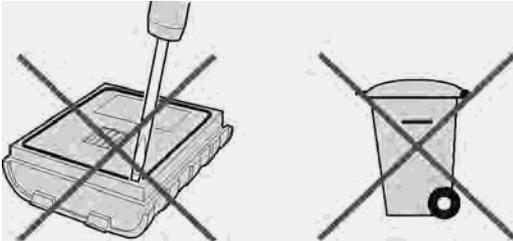
Return the ChemRAE to RAE Systems Inc. for disposal.

A disposed detector contains an ionization source, which is to be treated as radioactive waste.

WARNING: Do not attempt to open the detector.

1.3.3 Lithium-ion Rechargeable Battery

The ChemRAE uses a rechargeable lithium-ion battery. Lithium-ion batteries are very safe, being used commonly in cell phones and laptop computers.



WARNING: The battery should never be opened or disassembled.

WARNING: Lithium-ion batteries must be disposed of properly, and in accordance with local regulations.

1.3.4 Storage and Handling Precautions

ChemRAE is designed to be a very sensitive chemical detector. In order to ensure the detector continues to operate at maximum performance, it is suggested that you:

- Do not store the detector in areas where there are strong odors (e.g., with cleaning supplies).
- Avoid handling the detector's inlet area if your hands might be contaminated with chemicals (e.g., after handling gasoline or fuels, etc.).
- Ensure your hands are clean before changing the inlet filter.

1.3.5 Operation in Unusual Environments

If the ChemRAE is operating during a sandstorm or dust storm and shows the "Check Air Intake" message, turn the ChemRAE off until the storm subsides.

Then visually inspect the Inlet Filter. Replace it if it is dirty or blocked, and then restart ChemRAE.

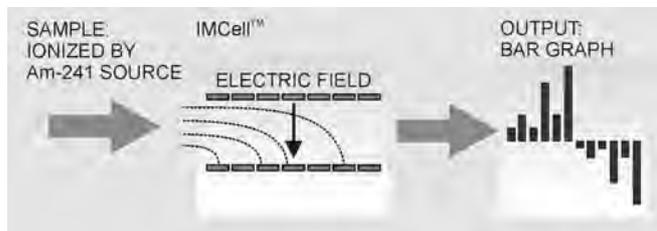
1.4 Technical Description

ChemRAE is a real-time, handheld chemical vapor detector, built into a rugged housing with intuitive controls and a flexible Graphical User Interface (GUI).

The system is based on proven multi-sensor technology:

- Miniaturized IMS sensor with 16 measuring channels
- Semiconductor sensors
- Humidity sensor
- Temperature sensors
- Flow Control System

ChemRAE rapidly integrates data from these sensors, leading to real-time reporting of hazard information.



The patented Ion Mobility Cell is a Modified Aspiration Type IMS. The IMS spectral “fingerprints” are measured with multiple electric fields, and selectivity is based on ion mass and charge (ion mobility). Airflow is continuous through the cell.

The surface of the Tin Oxide SC (semiconductor) Cell absorbs sample gas molecules from the sample stream, which changes the cells electrical resistance. Resulting resistance changes cause an output from this sensor.

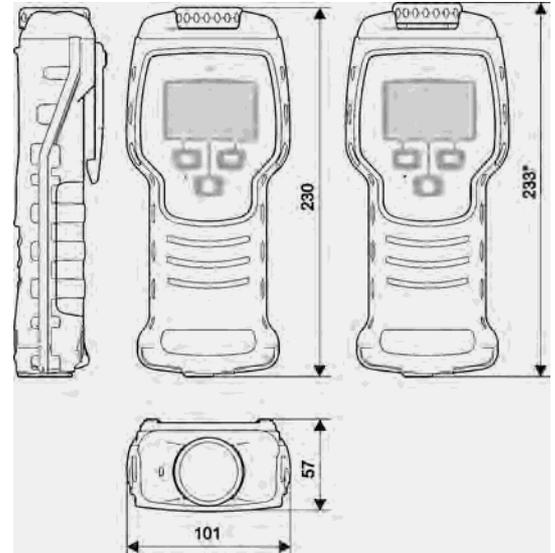
Information from each sensor is integrated within the processing algorithm, which makes use of the decision-making capabilities of Learning Vector Quantization and “Fuzzy Logic.” This “intelligent” processing system leads to very accurate detection performance, and significantly enhances interferent rejection.

1.5 Technical Data

- **Size (H x W x D):** 230 x 101 x 57 mm (9.0 x 4.0 x 2.2 in.)
- **Weight:** Approx. 610 g (21.5 oz.) without battery
- **Standard Li-Ion battery:** Weights 200 g (6.3 oz.)
 - 12 normal operating hours (+21°).
 - 5 hour recharge from integrated charger.
- **Remote power, 110 to 250VAC Input Adapter**
- **Heavy-duty composite plastic case**
- **Ergonomic design**
- **MIL-STD-461E** (10kHz to 18GHz)
 - Electromagnetic Compatibility (EMC)
 - Electromagnetic Pulse (EMP)
 - Electromagnetic Interference (EMI)
- **MIL-STD-810E**
 - Vibration
 - Shock
 - Sealing (Rain & Watertightness)
- **Operational temperature range:**
 - -30° to +55° C (-22° to +131° F)
- **Storage temperature range:** -50° to +71° C (-58° to +160° F)
- **Waterproof**
- **Serial communications interface**
- **Inlet airflow:** Approximately 1 liter per minute

Technical Features:

- MultiSensor technology
- Patented ASPRM Open Loop IMS
- Provides non-latching alarm
- No field calibration required
- Continuous Sampling of the environment (no back flush or purge)
- Rapid Clear down
- Programmable Storage of alarms
- Field programmable
- Integrated self-test



*Operation mode

1.6 Equipment Description

The ChemRAE comes in a rugged plastic case, which contains all standard accessories. The case has a pressure-equalizing valve below the handle, enabling it to balance the differences in pressure inside and outside the case. The valve automatically equalizes air pressure following transportation.

Two heavy latches hold the case closed. The case also has a feature to enable it to be secured with lock and key if necessary.

Standard Accessories Kit (039-D200-000)

1	ChemRAE (incl. 1 Li-ion battery)	039-D901-000
2	Operating Manual	039-4000-000
3	Test Tube	550-0800-030
4	3 Replacement Inlet Filters	550-0800-040
5	110 to 250 VAC (50 to 60 Hz) Mains Power Supply	550-0800-010
6	Power Cord	550-0800-050
7	Alkaline Battery Adapter	550-0800-080
8	Carrying Case	550-0800-060

Add the following for Kit with modem (039-D100-000):

9	RAELink2 For ChemRAE	029-5002-204
10	RAELink2 Antenna	029-7112-000
11	RAELink2 battery charger and AC cable	500-0700-000
12	Coiled cable for connecting ChemRAE to RAELink2	400-0189-000
13	RAELink2 multi-function cable	029-3028-000
	RAELink2 user's guide	029-4027-000



Fig-1. ChemRAE with accessories and Carrying Case

Available options

ChemRAE Lithium Ion Battery	550-0800-020
ChemRAE Lithium Ion Battery Charger	550-0800-070
ChemRAE Monitoring Cap	550-0800-090
Inlet Tube For Monitoring Cap	550-0800-100

1.7 Key Elements

- 1 LEDs
- 2 Air Inlet Cap
- 3 Display, backlit
- 4 Belt Clip
- 5 Li-ion Battery
- 6 Right button
- 7 Battery Clip
- 8 Connection for RS232 Interface and Charger
- 9 Menu button
- 10 Alarm Buzzer
- 11 Left button



Fig-2. Key Elements

1.8 Normal Sampling Display

The following screen is typical of the Normal Sampling mode:

1 Date & Time:

Refer to paragraph 3.1.10 to set.

2 Alarm Volume:

Solid bars indicate selected audio alarm level. Four open bars indicate the Alarm is muted. Refer to paragraph 2.5 to set.

3 Library in Use:

This icon indicates the current detection Library in use. Refer to paragraph 3.1.7 to select.

4 Key Menu:

The Key Menu block guides the use of the three “soft” buttons.

5 Battery Status:

Solid bars indicate the amount of charge remaining. Each solid bar indicates approximately 25% of battery power remaining.

6 Compound Detected:

In normal sampling, the text block indicates “AIR.”

7 Data Logging:

The animated “tape” symbol appears when Data Logging is enabled.

8 Stabilizing Flow:

This is an autonomous function and part of normal operation. The animated symbol “pump” appears during flow adjustment. Note: No operator actions are required.

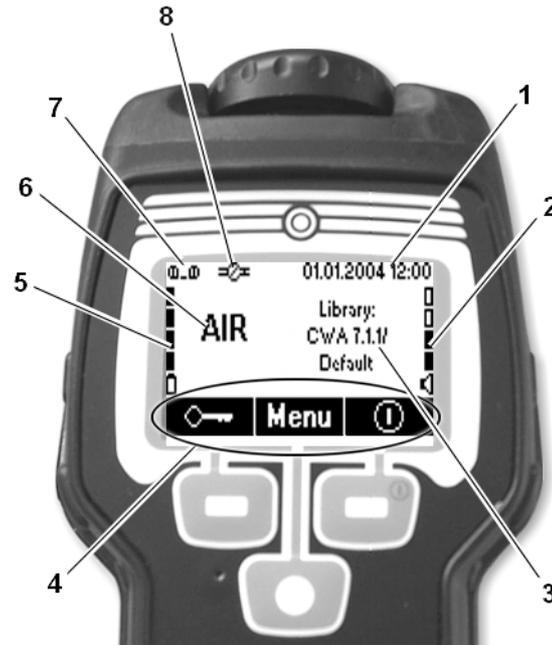


Fig-3. Normal Sampling Display

1.9 Alarm Display

The ChemRAE can give different types of alarms based on the toxicity of the detected compounds. Refer to the Library Data Sheet for more detailed information for the library in use.

In the alarm mode the ChemRAE indicates:

1 Detected Compound:

Indicated detected compound or compound group/class (library dependent).

2 Agent Concentration:

Gives concentration indication: one bar (low), two bars (medium) or three bars (high) (library dependent).

3 Agent Related Icon:

Icon gives agent related visual information, typically universal symbol (library dependent). Refer to paragraph 1.9.1 for explanation of icons.

4 Alarm Acknowledge / Mute Button:

Press the right button to mute the audio alarm (refer to paragraph 1.9.2 for a description of the alarm sound) and to acknowledge the detection event. The "Speaker" symbol is replaced with the text "Ack" (acknowledge) when "Covert Operation" mode is active (no audible alarm). Refer to paragraph 2.5 to set.

5 Blinking Status LEDs:

Refer to paragraph 1.9.3 for description of LED indications.

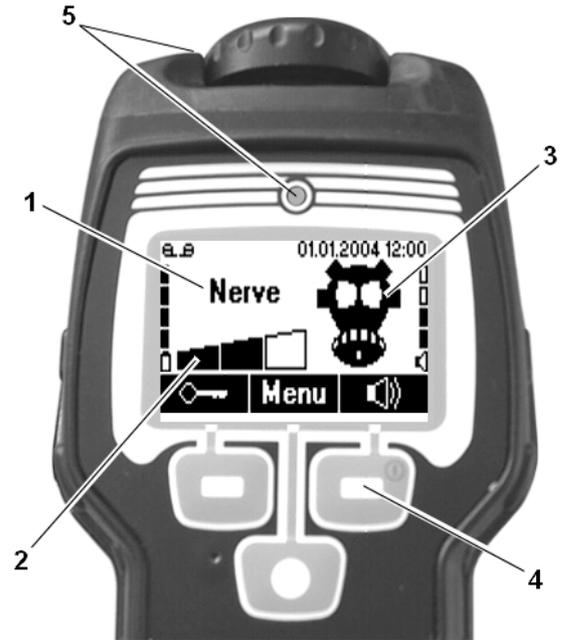


Fig-4. Alarm Display

1.9.1 Agent Related Icons

Due to the flexibility of the ChemRAE's display, a wide variety of different text messages and icons can be programmed to appear when any of the compounds in the current Library are detected.

Table 1 shows some of the special icons that may be programmed to appear, depending upon the Library in use. Additional custom Icons can be created if necessary.

Icon	Description	Icon	Description
	Toxic / Very toxic		Respiratory equipment must be used

Table 1. Agent related icons.

Refer to the Library Data Sheet for more detailed information for the library in use.

1.9.2 Alarm Sound Description

The audible signals emitted by the ChemRAE are:

	Initialization done
	Functional exception
	Alarm at toxic concentration (library dependent)
	Alarm at non-toxic concentration

Table 2. Audible Signals

1.9.3 LED Indications

The LEDs indications are as listed in Table 3.

State	Indication
Red and green flashing slowly	Initialization
Red flashing slowly	Functional exception
Green flashing slowly	Stabilizing flow
Red flashing fast	Alarm at toxic concentration (library dependent)
Green flashing slowly	Alarm at non-toxic concentration

Table 3. LED Indications

1.10 Preparing for First Use

The ChemRAE has been fully tested and configured with appropriate user options and Libraries prior to shipping.

Before first use, do the following:

- Install the battery (if it is not already installed).
- Connect the power supply and charge the battery.
- Adjust the display contrast.

These are outlined in sections 1.10.1 through 1.11.

1.10.1 Installing the Lithium Ion Battery

(If not installed already)

1. Set the ChemRAE onto a soft surface face-down.
2. Ensure the battery clip (**A**) is in the “unlocked” position (shown). If it is locked, grasp the ChemRAE with both hands and use both thumbs to push the clip away from you, which unlocks it.
3. Insert the Li-ion battery with the two small tabs on the end of the battery (**B**) facing the top of the unit.
4. Slide the battery clip into the “locked” position to secure the battery.

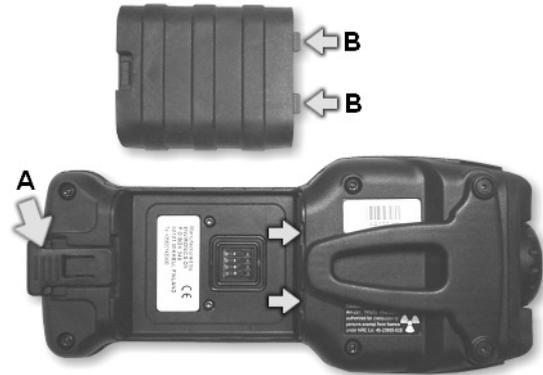


Fig-5. Installing the Lithium-ion Battery

1.10.2 Connecting Mains Power Supply

Before first use, it is recommended that the lithium-ion battery is charged for approximately four hours from the ChemRAE's integrated charger. The Mains Power Supply requires between 110 and 250 VAC input.

- Connect the output of the Mains Power Supply to the "Comms. Port" in the ChemRAE by rotating its connector clockwise, as indicated in Fig. 6.

The display's backlight of the ChemRAE is always on when the Mains Power Supply is connected (not in "Covert operation" mode).

A bar display indicates the charging state of the battery on the ChemRAE's display when the ChemRAE is off, but connected to the AC power with the mains power supply

Note: Be sure to charge the Li-Ion Battery within the temperature range of 0° to 50° C (32° to 122° F). For best results, we recommend an air temperature between 10° and 30° C (50° to 86° F).

Note: The Li-ion Battery may also be charged in the optional, External Charger. See "Battery Charger" on page 46.



Fig-6. Connect Mains Power Supply

1.10.3 Installing the Inlet Filter

The ChemRAE uses a special Inlet Filter to protect the detector from buildup of dust, particulates and other contamination. It is important to always ensure the Inlet Filter is installed prior to use.

- With clean hands (clean hands will ensure the new filter does not become contaminated), grasp the Inlet Cap and rotate counterclockwise: passing the “open” indent to completely remove the cap. The spring-loaded cap will come off in your hand.

The detector should already have an Inlet Filter (A) installed.

- To remove the filter, simply invert the unit and the filter should fall out. Never use a tool to force the filter out, as this may seriously damage the detector.

Use of safety gloves is recommended when handling a used filter. Used filters should be disposed of in accordance with local, state, or national regulations.

Under the Inlet Filter is a small metal fitting, which is the air inlet feed to the detector cells (1); there is also a small and delicate thermistor (2), a component used to measure inlet temperature. The thermistor looks like a black pin-head.

Be sure to avoid touching or damaging the Thermistor.

- **Place the new filter in recess by placing the corner chamfer downwards and replace the Inlet Cap.**



Fig-7. Remove Air Inlet Cap

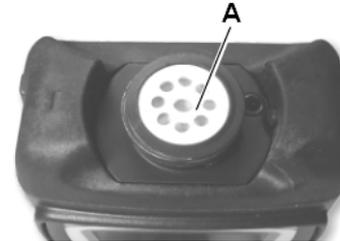


Fig-8. Inlet Filter

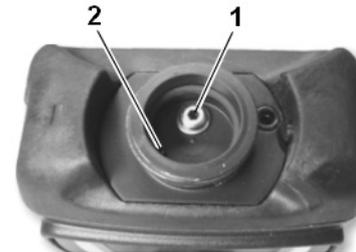


Fig-9. Inlet Port (1) and Thermistor (2)

1.11 Adjusting the Display Contrast

It is possible to adjust the contrast of the display before starting the ChemRAE.

To adjust the display's contrast:

1. Hold down the Menu button and start the ChemRAE by pressing the right button.
2. Adjust the contrast of the display by pressing the left button (dim) and right button (bright).
3. Release the Menu button to exit the contrast-adjusting function.



2 NORMAL OPERATION OF CHEMRAE

2.1 Starting up ChemRAE

The start-up procedure lasts between one and three minutes, depending on the ambient temperature and previous usage.

During the start up:

- The LEDs (front & top) illuminate.
- The display shows the ChemRAE logo.
- Built-in test (BIT) checks RAM and FLASH memory, IMCell channels, bias voltages, and Flow measurements.
- Adjustments are made to the Flowrate, IMCell and SCCell temperature.

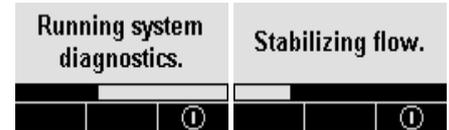
ChemRAE is operable when:

- Both LEDs stop flashing.
- Main display appears on the LCD.

Check the chemical library in use. If it is not the appropriate library for the mission, it should be changed.



1. Open the Inlet Cap by turning it counterclockwise until it clicks.
2. Push the right button for about 3 seconds.
3. Automatic starting procedures begin.



2.2 Selecting Menu

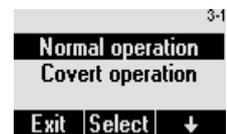
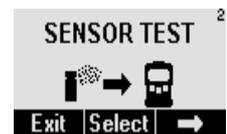
The ChemRAE has a wide variety of user features/options available, some of which are directly accessible to all users. Other more critical functions are Password Protected.

The features/options are sorted into individual Menus, which user can select by the user interface.

The display's backlight is always on when the ChemRAE is not in Normal Sampling mode (except in "Covert Operation" mode). This feature allows you to scroll through the menus of the ChemRAE in low-light conditions.



1. Press the Menu button in Main display.
2. Select the target menu by pressing the right button (indicated by the arrow) several times until the correct menu appears.
3. Enter the target menu by pressing the Menu button (to select).



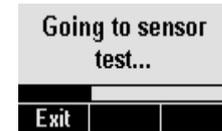
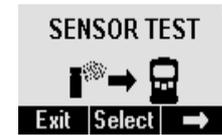
2.3 Sensor Test

The Sensor Test is a confidence check for both of the detector's main sensors (IMCell and SCCell).

The ChemRAE has a very capable and fully integrated self-test system. To be completely sure the entire detector is functioning normally, **it is strongly recommended that every mission is started with a Sensor Test.**

Note: To ensure reliable test results, note the following important points:

- In windy conditions, cover the air inlet with your (clean) hand while performing the Sensor Test.
 - The Test Tube will not work properly if it is too cold. To work correctly, the Test Tube needs to be warmed up to at least +10°C (+50°F). Warm the Test Tube in your hands if necessary.
 -
1. Select the Sensor Test menu.
 2. Ensure the Test Tube is not cold. Warm it in your hands if necessary.
 3. Open the Test Tube cap until the hole inside the test tube is fully exposed.
 4. Place the Test Tube into the detector according to the figure above.



The result of the sensor test should be “Test passed,” which indicates that the detector is fully operative.

If the result is “Test failed,” see Troubleshooting on page 25.

Note: The Test Tube contains a mixture of two safe chemicals: Methyl Salicylate and Di-isopropyl Methyl Phosphonate (DIMP).

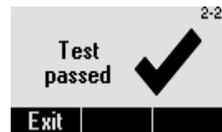
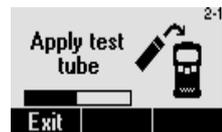
Before proceeding with actual sampling, it is recommended that the ChemRAE is always challenged with the test sample to ensure the entire system is working normally.

Note: The ChemRAE should operate for at least 30 minutes after conducting a sensor test and prior to turning the detector off.

5. Wait until the display shows the sensors' condition (“Test passed” or “Test failed”).
6. Close the Test Tube.
7. Exit the sensor test mode after 30 seconds.



In windy conditions, cover the air inlet with your hand as shown in the figure above.



2.3.1 Troubleshooting

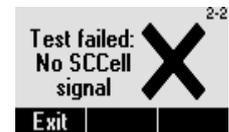
One of the following messages may appear if the Sensor Test has not been conducted successfully.

A failure message may appear if:

- There are problems with the test conditions (see Notes on page 23). A “Pattern mismatch” indication can appear when the background air is not clean enough. For example if you are indoors and the floors have been recently waxed. The residual vapor from the cleaning detergents may cause the failure message to appear.
- There is a problem with any of the ChemRAE’s sensors. A low response from the IMCell or the SCCell could trigger the failure message.

For troubleshooting, proceed as follows:

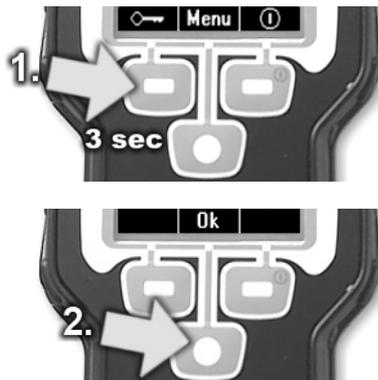
1. Exit the Sensor Test mode by pressing the left button.
2. Let the ChemRAE run for at least 1 minute and repeat the test procedure, see “Sensor Test” on page 23.
3. If you see the “Pattern mismatch” indication, repeat the test procedure after moving the detector to a cleaner environment.
4. If the test still fails, repeat the test with another Test Tube, if available.
5. If this does not resolve the problem, contact the RAE Systems service department.



2.4 Keypad Lock

The keypad of the ChemRAE can be locked to avoid unintentional use of the keypad.

Activating the keypad lock before a mission is recommended.



1. Press the left button (key icon) for about three seconds to select the keypad lock.
2. Accept the change of status ("Lock Keypad" or "Unlock Keypad") by pressing the Menu button.

Note: The change is cancelled if it is not accepted within few seconds.



Lock Keypad

Unlock Keypad

2.5 Changing Alarm Volume

The “Alarm Settings” menu function enables control of the audible alarm volume to four levels plus “mute.”

The last alarm volume level selected becomes the default volume. It is remembered and used the next time the ChemRAE is started.

As the volume is changed, the audible alarm beeps to demonstrate the selected level. When all bars are empty, the system is muted.

In the “Covert operation” mode, the LEDs, display’s backlight, and audible alarm are turned off. Note that the LCD display is only operative from -30° C (-22° F) upwards.

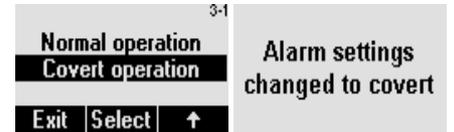
To change the volume level:

1. Select “Alarm Settings” menu.
2. Select “Normal operation.” Change desired volume level by pressing Menu button (Change) to increase the volume level and to mute.
3. Accept the selected volume level by pressing Left button (Exit).



To select the “Covert operation”:

1. Select “Alarm Settings” menu.
2. Select “Covert operation” by pressing Right button (Arrow).
3. Accept the “Covert operation” mode by pressing Left button (Exit).



2.6 Operational Guidelines

The ChemRAE is an early warning device designed to provide the operator with notification that there are levels of harmful chemical vapors present.

Prior to starting the ChemRAE the user needs to determine what type of environment you are going to detect in (indoor or outdoor). The ChemRAE should be put into operations in the same conditions that you want to detect in.

If startup occurs outdoors and the ChemRAE is taken indoors the stabilizing flow icon could appear indicating that a sudden change in the Temperature or Relative Humidity has happened. Detection maybe suppressed during while the stabilizing flow icon is present. This stabilizing flow is an autonomous function and part of normal operation. The animated symbol "pump" appears during flow adjustment. Note: No operator actions are required

While using the ChemPro, the operator receives a Chemical Hazard alarm, operators need to take measures. After the protective measure have been

conducted, the operator may want to change libraries in the ChemRAE to possibly determine the type of chemical agent they have been exposed. For example if using the ChemRAE with a CWA library the operator receives a Chemical Hazard Alarm, they would take protective measures if the alarm continued but no classification was made (Nerve, Blister or Blood) the operator would then change libraries such as the First Responder. If a match of the chemical in the library was found, it would produce a classification Toxic. Chemical Hazard Alarm appears when low levels of a chemical vapors are present.

2.7 Rules for Use

The ChemRae needs to be in the chemical vapor cloud (air stream) to detect chemicals

Liquid inside of the detector will prevent detection and disable the detector.

ChemRAE represents the state-of-the-art in hand-held chemical detection. However, it is not a perfect detector. The technology inside ChemRAE looks

for recognized patterns, and only alarms with an approximate 98% match. However, unlike a Mass Spectrometer, it can be misled.

2.7.1 Recommendation

Get to know the normal operating environments BEFORE a threat situation, such that common 'interferences' can be identified and recognized

Use ChemRAE in concert with a suite of other information (visual cues, intelligence information, and other detectors) in order to make the smartest decision.

2.8 Shutting Down ChemRAE

Note: The ChemRAE should operate for at least 30 minutes after conducting a sensor test and prior to turning the detector off.

The ChemRAE will shut down with a combination of two button presses. This process avoids unwanted shut down.

Whenever the symbol “Shut down” appears in the Key Menu block, the detector can be switched off.

During the shutdown procedure, the ChemRAE stores all changed settings in memory.

It is recommended that the Inlet Cap be rotated clockwise until tight and returned to the closed position as soon as the detector is switched off. This protects the ChemRAE from contamination.



1. Press the right button (Shut down) for about three seconds and wait for the shutdown screen.
2. Press the menu button (Ok) to accept the shutdown.
3. Close the Inlet Cap by turning it clockwise.

Note: The shutdown is cancelled if not accepted within a few seconds.

3 OPTIONAL CONFIGURATION

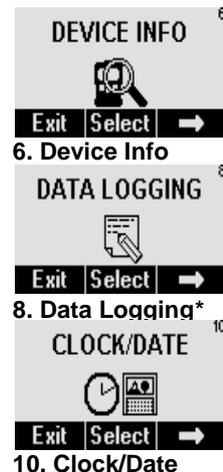
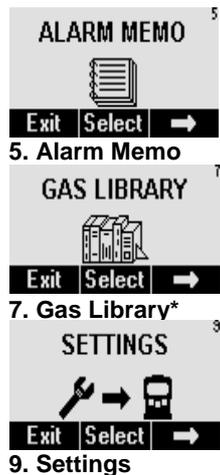
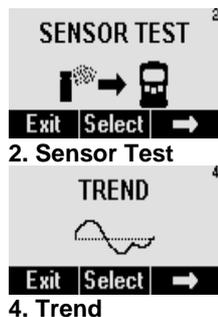
3.1 Menu Functions

The ChemRAE has a wide variety of options available, some of which are directly accessible to all users. Settings are password protected.

The password can be changed directly on the ChemRAE or using the optional ChemRAE-UIP software.

Note: If a password is set by mistake, or the password is forgotten, it can only be reset by a factory technician. Make sure you keep the password in a safe place.

All menu selections are made by first depressing the Menu button from the normal sampling screen. This opens the individual main screens for the menus. There are up to 10 Menu screens that appear, and they can be cycled in order:



* The screen only appears in Main Operator Level Menu if enabled from Miscellaneous Settings.

† This screen and submenu features should only be used by advanced users.

3.1.1 Basic Levels †

Allows user to artificially establish a new detector basic level

This feature is hidden by factory default and is not required or used for standard operations

3.1.2 Sensor Test

The Sensor Test menu is used to check the signals from the IMCell and SCCell. Selecting Sensor Test requires waiting for a few seconds while signals stabilize.

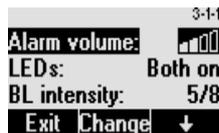
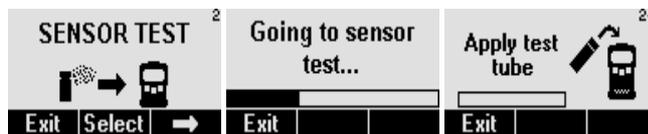
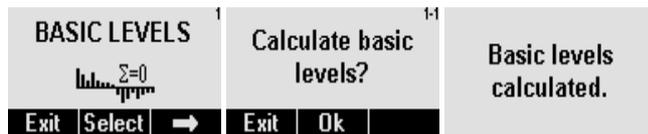
Use of the Sensor Test mode is discussed in detail in paragraph 2.3, “Sensor Test,” on page 23.

3.1.3 Alarm Settings

You can select between “normal operation” and “covert operation” modes. When “normal operation” is selected, the following settings can be adjusted under this menu:

Alarm volume:

Enables four-level control of the audible alarm volume. When all bars are empty, the system is muted.



LEDs:

Options: Both on, both off, top on, front on.

BL (Backlight) intensity:

Adjusts the intensity of the display's backlight on a scale from 0 to 8:

0=backlights off

8=bright

Pressing the Left button (Exit) saves any changes made.

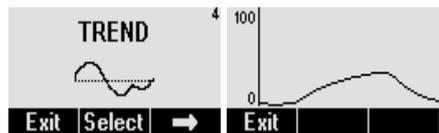
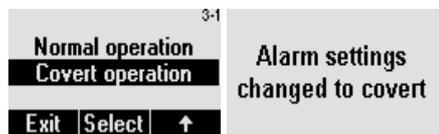
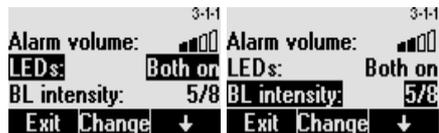
In the "covert operation" mode, the LEDs, the display's backlight and the audible alarm are turned off. Note that the LCD display is only operative from -30° C (-22° F) upwards.

Selected Alarm settings are maintained and applied the next time the ChemRAE is started.

3.1.4 Trend

The Trend function allows you to view the IMCell response as an analog graph. This can be useful for viewing gross changes in environmental air quality over time. Selecting this option leads to a graphical screen, which updates in accordance with settings in real-time.

The analog plot moves from left to right, showing total detector current against a vertical scale.



3.1.5 Alarm Memo

The Alarm Memo function allows tracking a history of detection information. This can be very useful for tracking exposures to toxic compounds in the field; levels are recorded as Low, Medium, or High. These examples show Alarm Memo screens from the ChemRAE.

Each alarm detected is saved as an individual page of information. The example shows there are 22 (out of a possible 200) stored alarms in this case, and pressing the arrow keys allows you to view any of the records in turn. Saved information includes:

- Date & Time
- Alarm (type)
- Level (Low, Medium or High)
- Acknowledged
- Duration

Resetting Alarm Memo is covered in a later section and is password protected to ensure critical information is not lost. If no alarms are stored, the screen will display "No Alarms."



3.1.6 Device Info

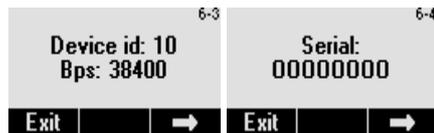
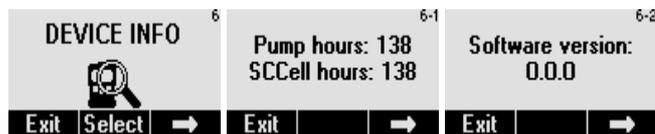
This screen is used to track the operating hours of the pump and the SCCell, software version, communication protocol and, unit serial number. The tracking of operating hours screen permits the operator to determine the amount of hours remaining before recommended service (3000 hours)

Defaults:

Software version 3.2.3

BPS 19,200

Serial Number: Same as on the back of the detector



3.1.7 Gas Library*

This option allows selecting the Gas Library being used by the ChemRAE. A library can contain up to 50 compounds. Therefore, it is important to confirm that the correct library is in use. This example shows a ChemRAE that has two libraries installed. By using the down arrow key, the required library can be chosen. Next, the Menu button (Select) is pressed to confirm the library selection.

The library in use can be reconfirmed by viewing the Main Screen.

Default: CWA 7.1.1.6



3.1.8 Data Logging*

This menu disables/enables the ChemRAE's data logging. The animated "tape" symbol appears in the Main Screen when data logging is enabled.

Items capable of being logged are:

- Real time detector data
- User operations

3.1.9 Settings*

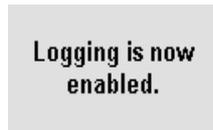
This section covers setup of a number of critical areas of the ChemRAE, and they are password protected. The default password is "0000."

Note: If the password is inadvertently changed or forgotten, it can only be reset by the factory. Make sure you keep the password in a safe place for later reference.

Use the right arrow to select each numeral of the Password; and change the numbers with the Menu button (+). The password will either be accepted or rejected.

There are five areas of settings that can be changed under this menu:

- Gas Library
- Clear Alarm Memo
- Set Password
- Miscellaneous Settings†
- Log Settings†



Gas Library

See “Gas Library” on page 34.

Clear Alarm Memo

This feature allows the Alarm Memo to be cleared.

As a safety feature, the ChemRAE confirms that all alarms are to be deleted. Depending upon conditions, one of the screens shown on the right will be displayed to confirm the status.

Set password

This feature enables the password to be set.

The new password is set by using the right arrow and the Menu button (+). As a safety feature, the new password has to be verified again before it can be accepted by the ChemRAE. Once the new password is verified, the ChemRAE confirms a change has been made.



Miscellaneous Settings†

Several minor settings can be adjusted under this menu:

Date format

Sets the date format for different international conventions.

Time format

Selects between 12-hour and 24-hour clock formats.

MainMenuBL

Defines if basic level calculation should be possible in Main Level Menu. Choices: On / Off. Default : Off

Language

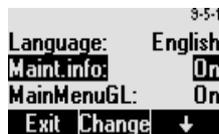
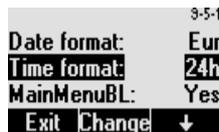
This is the language-setting utility.

Maint.info

Defines if the device should inform the user when the SCCell/pump are near the end of their life. Choices: On or Off. Default: On

MainMenuGL

Defines if the gas library change is possible in the Main Level Menu. Choices: On or Off. Default: On



Log Settings

This menu enables the user to change the setting of the ChemRAE's various data logging options. These settings are normally used when communicating with the optional ChemRAE-UIP software.

Logging

Enable or disable data logging. Default: Enable

Log sigchanges

Store signal changes. Choices: Yes or No. Default: On

Log UI events

Store the user interface events. Choices: Yes or No. Default: On

Log alarms

Store alarms. Choices: Yes or No. Default: On

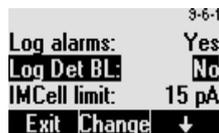
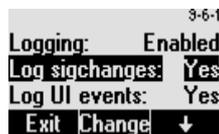
Log Det BL

Store the basic level changes. Choices: Yes or No. Default: Yes

The following settings ("IMCell limit" to "Flow limit") are only valid when "Log sigchanges" is set to "Yes."

IMCell limit†

Maximum allowable sum of all changes in IMCell channels before logging.



SCCell limit†

Maximum allowable change in SCCell before logging.

```

3-6-1
SCCell limit: 0.10 V
SCCell2 limit: 0.10 V
Ext temp limit: 1.0 °C
Exit Change ↓
  
```

SCCell2 limit†

Maximum allowable change in SCCell2 before logging (only with a dual-SCCell unit).

Ext temp limit†

Maximum allowable change in external temperature before logging.

Celltemp limit†

Maximum allowable change in IMCell temperature before logging.

```

3-6-1
Celltemp limit: 0.5 °C
RH limit: 5 %
AH limit: 5.00 g/m3
Exit Change ↓
  
```

'RH limit†

Maximum allowable change in relative humidity before logging.

AH limit†

Maximum allowable change in absolute humidity before logging.

Flow limit†

Maximum allowable change in flow before logging.

```

3-6-1
Flow limit: 0.05 l/min
BattVolt. limit: 0.10 V
PumpPwm limit: 10
Exit Change ↓
  
```

BattVolt. limit†

Maximum allowable change in battery voltage before logging.

PumpPwm limit†

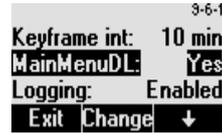
Maximum allowable change in pump's pulse width modulation before logging.

Keyframe int†

Time between keyframes. The Keyframe contains all stored data items.

MainMenu DL

Defines if the data logging enable / disable is possible in Main Level Menu. Choices: Yes or No. Default : Yes



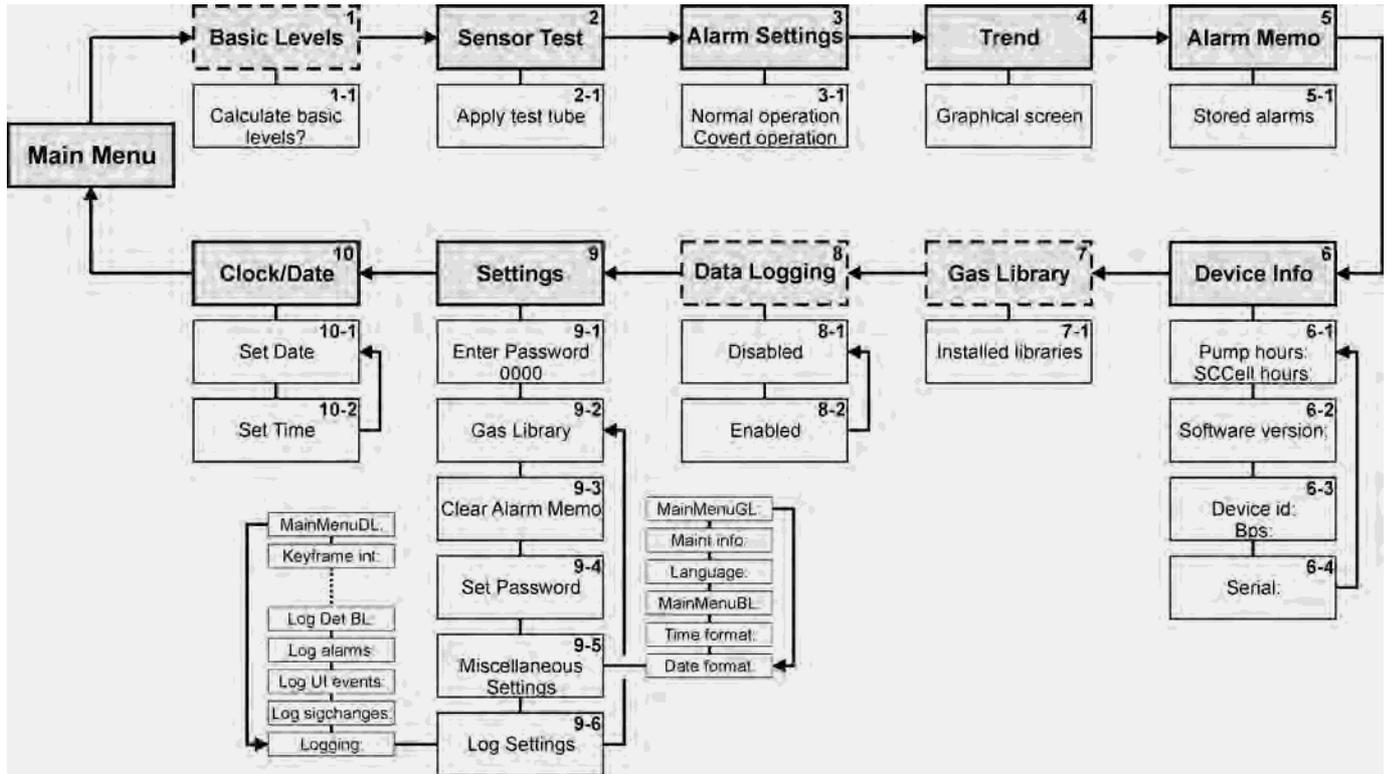
3.1.10 Clock/Date

This is the Clock and Date setting utility for the ChemRAE's real-time clock. Option of either the 12 or 24 hour format

The Time and Date are set through an intuitive interface.



3.2 Menu Hierarchy



4 MAINTENANCE AND TROUBLESHOOTING

4.1 Maintenance

ChemRAE has been designed to be rugged and reliable, and has only a small number of maintenance actions that can be performed by the operator.

Normal operator maintenance actions are:

- Replacement of Li-Ion Battery, Paragraph 1.10.1
- Replacement of the Inlet Filter, Paragraph 1.10.3
- Replacement of the Inlet Cap, Paragraph 1.10.3

4.1.1 Low Battery Indication

The “Low battery!” indication illuminates in the display to indicate battery voltage is very low. The Li-ion battery should be charged or replaced immediately to ensure proper function.

4.1.2 Inspecting the Inlet Cap and Filter

Regular inspection of the Inlet Cap and Inlet Filter ensures appropriate action is taken before the filter is blocked. Change the filter as necessary.

With the detector in the off position, carefully inspect the entire inlet area for dirt, and if necessary, gently clean out any dust or dirt with a cotton-tipped swab and water.

Note : Take care that no water enters the sample inlet

4.1.3 Cleaning the ChemRAE

A build-up of dirt or organic materials (such as wax, cleaners, etc.) on the case could compromise operational performance. Make sure the detector is kept clean.

It is safe to wash the ChemRAE’s external surfaces with mild soap and water.

CAUTION: Ensure the ChemRAE is turned off and the Inlet Cap is closed before and during cleaning.

Avoid immersing the unit in fluid. Do not use any solvents or cleaners other than mild soap or unscented detergent.

It is recommended that the ChemRAE is kept in its Transit Case when not in use. Make sure the Inlet Cap is closed for storage.

4.1.4 Decontamination

It is safe to wash the ChemRAE’s external surfaces with mild soap (or unscented dishwashing liquid) and water. This method usually cleans lightly contaminated outside surfaces. After a short drying period, the ChemRAE is ready to be put back into service. This is a standard, proven method.

When the ChemRAE has been heavily exposed and moderately contaminated with chemical warfare agents (CWAs), a more thorough cleaning method may be required. First, the outer surfaces of the detector should be wiped using a towel dampened with alcohol. This dissolves most of the grease and soils. Second, the outer surfaces of the ChemRAE should be wiped using a towel dampened with mild sodium hypochlorite solution. The final decontamination step is complete with a normal washing with soap or dishwashing liquid. The cleaning steps should be repeated as required.

The towels and water should be treated as hazardous wastes in accordance with the local or national regulations and instructions.

The internal surfaces and materials that come in contact with CWAs are mostly Teflon, to which most of the chemical compounds have a very small absorption; therefore, they are very resistant to CWAs. Additionally, the open-loop construction of the detector is open to the atmosphere at all times, which helps to prevent internal contamination. Even small residues should dissipate quickly.

The internal surfaces of the detector that have been in contact with the CWA vapors (i.e., tubes and flow channels) are decontaminated by pumping clean air through the detector by its own pump for at least two hours. The operation is carried out in a fume hood, and the outlet of the detector is connected to the vent of the fume hood. The air temperature can be increased 10 to 20 degrees above the ambient temperature to make the cleaning more effective.

After the decontamination steps, the ChemRAE's performance can be verified with a sensor test described in "Sensor Test" on page 23.

List of decontaminants that can be used, in preferred order:

- Soap and water
- Mild dishwashing liquid (and water)
- Mild Sodium hypochlorite
- Mild Sodium hydroxide

4.2 Troubleshooting

The ChemRAE has been designed with a high level of integrated self-testing. It alerts you to any potential failures that could affect operational performance. If the ChemRAE senses a hardware or software failure, it will stop and does not enter the normal operating mode.

Due to the system's integrated design, you can perform only very limited maintenance.

Common Problems and Solutions:

PROBLEM	POSSIBLE CAUSE	SOLUTION
The ChemRAE will not enter normal operation.	The ChemRAE's built-in diagnostics will not allow the system to go into normal operation in the event of a hardware or software failure.	It is recommended that the detector is restarted. However, if this does not resolve the issue, then it should be returned for factory maintenance.
The ChemRAE will not start.	The most likely cause is a discharged Battery.	First try connecting the ChemRAE to its Mains Power Supply. If it operates, then the battery needs charging. Leave the Li-ion battery in the ChemRAE and charge for four hours with the Mains Power Supply plugged in. If the battery refuses to accept a charge, try another Li-ion battery if a spare is available. Alternatively, return the ChemRAE, its battery, and the Mains Power Supply for factory maintenance. Remove the lithium-ion battery. Reinstall the battery while holding down the right button (Start). Release the right button. Restart the ChemRAE.

If the following solutions do not resolve a problem, it is recommended that the ChemRAE be returned to the factory for maintenance.

WARNING: Per the NRC exemption, the operator is not authorized to open the detector. The detector must be returned to the manufacturer. If the case is opened by the operator, they risk exposure to radioactive material. Return the detector to RAE Systems unopened.

PROBLEM	POSSIBLE CAUSE	SOLUTION
The buttons do not work.	The most common cause of this is that the Key Lock function has been executed.	Check and reset. See “Starting up ChemRAE” on page 21.
The ChemRAE indicates a flow problem.	The most common causes of this failure are insufficient inlet flow because the Inlet Cap is not in the “Open” position.	Check and reset. See “Starting up ChemRAE” on page 21. This problem can also be caused by a “clogged” Inlet Filter, which must be replaced. See “Installing the Inlet Filter” on page 19.
The Battery will not charge.	Lithium Ion Batteries have a finite recharge life (typically several hundred cycles). Try a replacement if available.	Make sure the ChemRAE's Mains Power Supply is plugged in and the LED indicator shows green. The Power Adaptor has an internal overheating protection switch. If the Mains Power Supply is hot, allow it to cool and then try again. Try recharging the Battery from the optional Battery Charger, if available. If all the above fail then return the ChemRAE, the Li-Ion Battery and the Mains Power Supply for factory maintenance.
The ChemRAE won't respond to the Test Tube.	Make sure that the “Sensor Test” procedure on page 23 is being followed correctly.	Try another Test Tube, if available. Check the Inlet Filter for build up of dirt / contamination, which may prevent the sample from reaching the detector. Finally, restart the ChemRAE and try again.
Functional Exception	This type of screen message indicates a terminal failure requiring factory maintenance.	Restart the ChemRAE and if this screen appears again, return the ChemRAE to the factory.

5 OPTIONAL ACCESSORIES

5.1 Battery Charger

The Lithium Ion Battery Charger is powered from the ChemRAE's standard Mains Power Supply.

The Lithium Ion Battery Charger can be used to keep a spare battery charged; for example, to extend the ChemRAE's hand-held sampling missions.

- 1 Battery Charger
- 2 Connector for Mains Power Supply
- 3 LED Charging Indicator



Fig-10. External Battery Charger

5.2 Battery Pack

When used with Alkaline Battery Adapter for alkaline batteries, the operation time depends on the batteries used.

Battery Type	Run Hours
AA/LR6 Alkaline (6 pieces)	6.5 Hours @ 21° C
AA Lithium PhotoCells	16 hours @ 21° C

Weight: Approx. 210 g (with batteries)



Fig-11. Battery Pack. The four Battery symbols are displayed in the Main Display.

5.7 Monitoring Cap

A special Monitoring Cap (550-0800-090) makes it possible for the operator to conduct a more defined chemical survey of a specific area in a monitoring mode.

Note: Use only Teflon[®] PFA tubing (4mm outer diameter). Other types of tubing could cause the ChemRAE to malfunction.



Fig-15. Monitoring Cap

6 LIBRARIES

Two libraries of substances are pre-loaded in the ChemRAE. These are First Responder and CWA. Details are included in the following section.

6.1 First Responder 1.0.1 Library

6.1.1 Alarm indications and agent coverage

Alarm indication Text	Icon	Library Specified Agents	Low Alarm Limit ⁽¹⁾ ppm	Low Alarm Limit mg/m3
Toxic		Ethylene Oxide	100	Toxic
		Acrylonitrile	100	
		Hydrogen Sulfide	10	
		Arsine	5	
		Ammonia	400	
		Carbon Disulphide	500	

		Allyl Alcohol	40	
Chemical Hazard		Agent in hazardous concentration		Chemical Hazard

Notes

- (1) Operation in cold (< 5° C) and hot environments (>35° C) may lead to increased alarm limits.

Operation in conditions where background air is slightly contaminated can also lead to increased alarm limits.

See following paragraphs for other general limitations and conditions in detail.

- **Toxic:** Toxic Industrial Compounds like Ethylene Oxide (ETOX), Acrylonitrile, Arsine (AsH₃), Hydrogen Sulfide (H₂S), Ammonia (NH₃), Phosphor Trichloride (PCl₃), Carbon Disulfide (CS₂) and Allyl Alcohol as well as Chemical Warfare Agents like G-type Nerve agents and HD-Blister agent.
- **Chemical Hazard:** Library specified agents in concentrations and conditions lower than Alarm Limit. May indicate the other Toxic compounds may be present.

6.1.2 False Positives

Alarm due to presence of other chemicals than the library specified is also possible. However, in such case the chemical causes a danger to a human life with high probability.

Alarms due to presence of Floor waxes, solvents and fuel vapours are possible.

6.1.3 False Negatives

The highest risk to the false negative (i.e. no alarm, although specified chemical is present) is associated to the following two cases:

1. The power is switched on in the context when the surrounding air is contaminated by any chemical vapor or gas. In order to avoid false negative, the device should never be switched on in the contaminated environment. Typical contamination can be identified as a presence of smoke or odors.
2. The concentration of the toxic chemical vapor or gas increases very slowly. The false negative may occur if the alarm level concentration is reached slower than within 6 minutes from the beginning of the exposure to the detector. Normally by approaching the contaminated area and especially the target spot that should not happen.

6.1.4 Condition Ranges

Temperature:	-10° C to +50° C
Relative Humidity:	5% to 95%
Absolute Humidity:	0 to 35 g(H ₂ O)/m ³

6.2 CWA 7.1.1.6 Library

6.2.1 Alarm Indications And Agent Coverage

Alarm indication Text	Icon	Library specified agents	Low alarm limit ⁽¹⁾ ppm	Low Alarm limit mg/m ³
Nerve		GA, GB, GD, GF / VX	0.2 0.1 ⁽²⁾	Nerve
Blister		HD L	.312 .242 ⁽³⁾	Blister
Chemical Hazard		Agent in Hazardous concentration	-	Chemical Hazard

Notes

- (1) Low = Alarm limit. Note: Alarm may occur also below this concentration limit.
- (2) Valid in <35°C and <20 g(H₂O)/m³ ambient conditions.
- (3) Valid in <17g(H₂O)/m³ ambient conditions. See following paragraphs for other general limitations and conditions in detail.

6.2.2 Library Specified Agents

- **Nerve:** Nerve agents Tabun (GA), Sarin (GB), Soman (GD), Cyclo-Sarin (GF) and VX. Alarm indication 'Chemical Hazard' may occur in high nerve agent concentrations.
- **Blister:** Blister agents Sulphur mustard (HD) and Lewisite (L). Alarm indication 'Chemical Hazard' may occur in high blister agent concentrations.
- **Chem Hazard:** Library specified agents in concentrations and conditions lower than Alarm Limit. May indicate the other Toxic compounds may be present.

6.2.3 Possible False Positives

- **Nerve:** False alarm due to Acrylonitrile in high concentrations may be possible. Alarm due to nerve agent precursors such as Dimethyl phosphite, Methyl phosphonic dichloride and Dimethyl methyl phosphonate is probable.

Blister: Alarm due to vesicant precursor Thiodiglycol is possible. Possible False alarm due to high concentration of solvent and fuel vapors, engine exhausts or smokes may be possible. In addition, false alarm due to certain TICs (Toxic Industrial Compounds) is possible.

False negatives are possible; if the agent concentration gradient is low enough for long periods of time. At normal outdoor conditions, however, this kind of situation rarely happens.

6.2.4 Possible False Negatives

When the detector is used in environment where background air is contaminated, the possibility of false negatives is increased (e.g. visible smokes around). However, when exposing the detector in those conditions to toxic vapor, there will still be a possibility of a "Chemical Hazard" indication.

Hence, the best agent performance is reached when ChemRAE is used in areas where high concentrations of background contaminants are not likely to occur.

False negatives are possible; if the agent concentration gradient is low enough for long periods of time. At normal outdoor conditions, however, this kind of situation rarely happens.

6.2.5 Condition Ranges

Temperature:	-30° C to +50° C
Relative Humidity:	5% to 95%
Absolute Humidity:	0 to 35 g(H ₂ O)/m ³

7 RAE SYSTEMS CONTACTS

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Life-critical after-hours support is available
+1.408.952.8200 select option 9



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