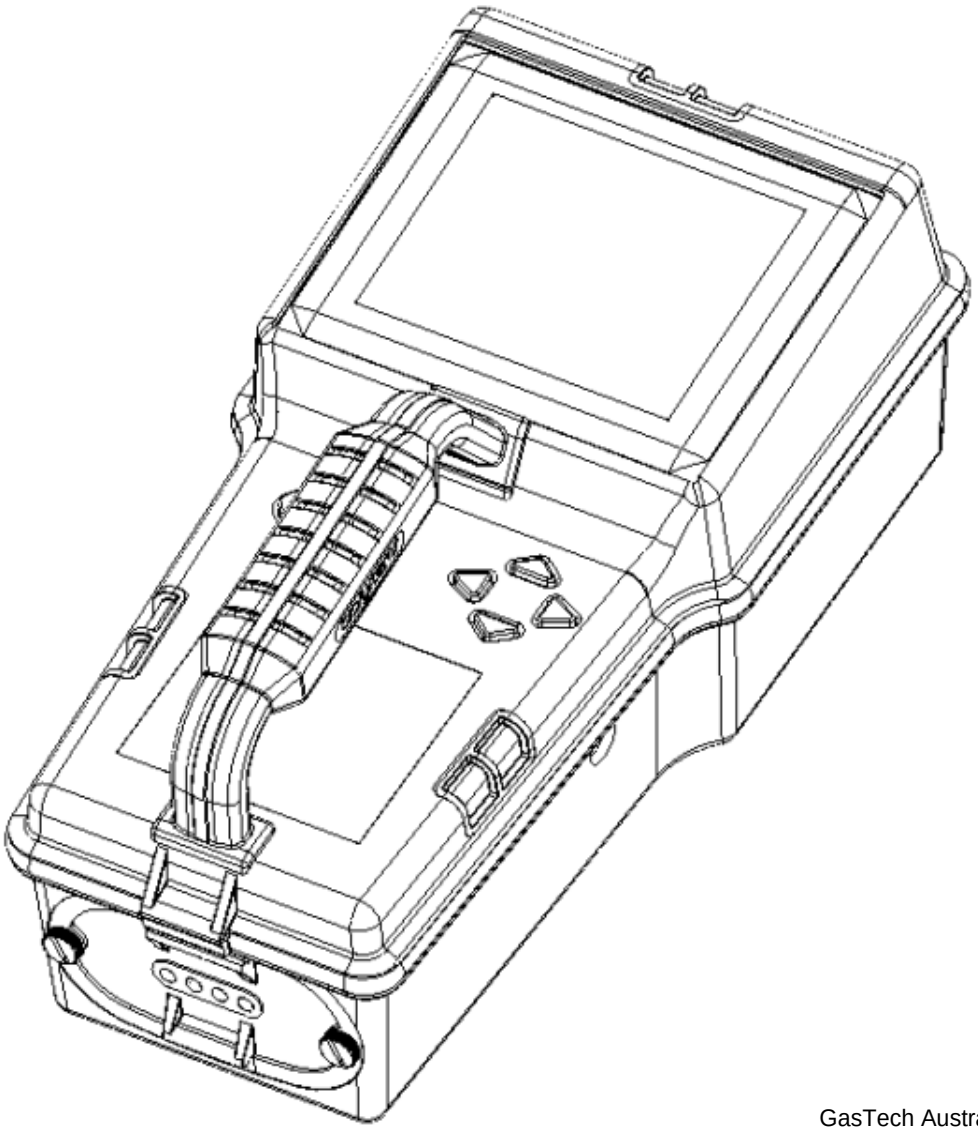
Cannonball3
Multi Gas Detector
Reference Manual



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⚠WARNING

THE Cannonball3 PERSONAL PORTABLE GAS DETECTOR HAS BEEN DESIGNED FOR THE DETECTION OF DEFICIENCIES OF OXYGEN, ACCUMULATIONS OF FLAMMABLE GASES AND VAPORS AND ACCUMULATIONS OF TOXIC VAPORS.

IN ORDER TO ENSURE THAT THE USER IS PROPERLY WARNED OF POTENTIALLY DANGEROUS ATMOSPHERIC CONDITIONS, IT IS ESSENTIAL THAT THE INSTRUCTIONS IN THIS REFERENCE MANUAL BE READ, FULLY UNDERSTOOD, AND FOLLOWED.

FOR INSTRUMENTS WITH DILUTION CAPABILITY, SEE THE CANNONBALL3 DILUTION MANUAL - SPERIAN INSTRUMENTATION PART NUMBER 13-186.

FOR INSTRUMENTS INCLUDING THE HC/LEL SENSOR, SEE THE HC/LEL ADDENDUM TO THE CANNONBALL3 REFERENCE MANUAL - SPERIAN INSTRUMENTATION PART NUMBER 13-236.

Cannonball3 Reference Manual
Version 1.50

Sperian Instrumentation, LLC
Middletown, Connecticut 06457

Patent Information

The Cannonball3 is protected by United States Patent Number 6,604,405.

Table of Contents

Signal Words

The following signal words, as defined by ANSI Z535.4-1998, are used in the Cannonball3 Reference Manual.

⚠DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠CAUTION indicates a potentially hazardous situation, which if not avoided, may result in moderate or minor injury.

CAUTION used without the safety alert symbol indicates a potentially hazardous situation which, if not avoided, may result in property damage.

Warnings

1. **⚠WARNING The Cannonball3 personal, portable gas detector has been designed for the detection of dangerous atmospheric conditions. An alarm condition indicates the presence of a potentially life-threatening hazard and should be taken very seriously. Failure to immediately leave the area during an alarm condition may result in serious injury or death.**
2. **⚠WARNING In the event of an alarm condition it is important to follow established procedures. The safest course of action is to immediately leave the affected area, and to return only after further testing determines that the area is once again safe for entry. Failure to immediately leave the area during an alarm condition may result in serious injury or death.**
3. **⚠WARNING Use only Energizer E95 or EN95, Duracell MN1300, or Duracell PC1300, 1.5V D cell Alkaline batteries in the Cannonball3. Substitution of batteries may impair intrinsic safety.**
4. **⚠WARNING The accuracy of the Cannonball3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.**
5. **⚠WARNING The accuracy of the Cannonball3 should be checked immediately following any known exposure to contaminants by testing with known concentration test gas before further use. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.**
6. **⚠WARNING A sensor that cannot be calibrated or is found to be out of tolerance should be replaced immediately. An instrument that fails calibration may not be used until testing with known concentration test gas determines that accuracy has been restored, and the instrument is once again fit for use.**
7. **⚠WARNING Do not reset the calibration gas concentration unless you are using a calibration gas concentration that differs from the one that is normally supplied by Sperian Instrumentation for use in calibrating the Cannonball3. Use of inappropriate calibration gas may lead to in accurate and potentially dangerous readings.**

   Customers are strongly urged to use only Sperian Instrumentation calibration materials when calibrating the Cannonball3. Use of non-standard calibration gas and/or calibration kit components can lead to dangerously inaccurate readings and may void the standard Sperian Instrumentation warranty.
8. **⚠WARNING Use of non-standard calibration gas and/or calibration kit components when calibrating the Cannonball3 can lead to inaccurate and potentially dangerous readings and may void the standard Sperian Instrumentation warranty.**

Sperian Instrumentation offers calibration kits and long-lasting cylinders of test gas specifically developed for easy Cannonball3 calibration. Customers are strongly urged to use only Sperian Instrumentation calibration materials when calibrating the Cannonball3.

9. **⚠WARNING Substitution of components may impair intrinsic safety.**
10. **⚠WARNING For safety reasons this equipment must be operated and serviced by qualified personnel only. Read and understand this reference manual before operating or servicing the Cannonball3.**
11. **⚠WARNING A rapid up-scale reading followed by a declining or erratic reading may indicate a hazardous combustible gas concentration that exceeds the Cannonball3's zero to 100 percent LEL detection range for units without a dilution pump, or zero to approximately 200 percent detection range for units with a dilution pump. The safest course of action is to immediately leave the affected area, and to return only after further testing determines that the area is once again safe for entry.**

Chapter 1. Description

1.1 Cannonball3 capabilities

The Cannonball3 is a gas detector that can be configured to meet a wide variety of requirements. This chapter provides an overview of many of the features of the Cannonball3. More detailed descriptions of the features of the Cannonball3 are contained in the subsequent chapters of this manual.

1.2 Methods of sampling

Every Cannonball3 includes a built-in continuous sample draw pump. Since the Cannonball3's sensor compartment is contained within the instrument, the gas sample must be drawn into the instrument by the pump through a probe assembly that is attached to the inlet coupling on the front of the unit.

Once turned on, the Cannonball3 monitors continuously. The Cannonball3's sensors react quickly to changes in the concentrations of the gases being measured. This type of operation monitors only the atmosphere in the immediate area of the end of the probe assembly.

For more details on sampling the atmosphere, see section 2.5.

A detailed description of the Cannonball3 probe assembly is given in section 6.3.

1.3 Multi-sensor capability

The Cannonball3 can be configured to simultaneously monitor oxygen, combustible gases and up to three toxic gases. Sensors can be added, removed, changed, or replaced in the field. The Cannonball3 microprocessor and "Smart Sensor" circuitry eliminates the need for laborious set-up procedures.

⚠WARNING Accuracy of the Cannonball3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.

Calibration procedures are discussed in detail in Chapter 4.

The Cannonball3 uses electrochemical toxic sensors that have been designed to minimize the effects of common interfering gases. These sensors provide accurate, dependable readings for toxic gases commonly encountered during confined space entry and other industrial applications. Toxic sensors available for use in the Cannonball3 include hydrogen sulfide (H_2S), carbon monoxide (CO), sulfur dioxide (SO_2), phosphine (PH_3), ammonia (NH_3), chlorine (Cl2), chlorine dioxide (ClO_2), hydrogen cyanide (HCN) and nitrogen dioxide (NO_2).

In addition to sensors designed to measure specific toxic hazards, Sperian Instrumentation also offers two different sensors that allow for the simultaneous detection of both carbon monoxide and hydrogen sulfide.

The "Duo-Tox" sensor is a dual channel electrochemical sensor designed to detect both carbon monoxide and hydrogen sulfide. The Duo-Tox allows one sensor port to be used for discriminate detection of both carbon monoxide and hydrogen sulfide without cross interference.

For more information on the Duo-Tox sensor see section 4.3.1.1.

The "CO Plus" sensor is a single channel electrochemical sensor. The CO Plus is ideal for situations requiring the use of a single sensor to monitor for both carbon monoxide and hydrogen sulfide, but where the user does not need to know specifically which gas is present.

For more information on the CO Plus sensor see section 4.3.1.2.

Different measurement units are used depending on the gas being measured.

Type of Hazard	Measurement unit
Oxygen (O2)	Percentage of air by volume
Combustible gas	Percentage of lower explosive limit (LEL)
All toxic sensors	Parts per million in air

Table 1.3: Cannonball3 Units of Measurement

Sensor configuration procedures are discussed in greater detail in Chapter 2.

1.4 Calibration

The Cannonball3 detector features fully automatic fresh air and span calibration.

⚠WARNING Accuracy of the Cannonball3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.

Calibration procedures are discussed in Chapter 4.

Sperian Instrumentation's calibration frequency recommendations are discussed in Appendix E.

Use of these procedures is reserved for authorized personnel.

1.5 Alarm logic

Cannonball3 gas alarms are user-adjustable and may be set anywhere within the range of the specific sensor type. When an alarm set point is exceeded a loud audible alarm sounds, and the bright red LED alarm lights flash.

The procedure for adjusting alarm levels is covered in section 3.5.2.

1.5.1 Alarm latch

The Cannonball3 includes a latching alarm that can be enabled or disabled according to the needs of the user. When the Cannonball3's alarm latch is enabled, the audible and visible alarm will continue to sound after the atmospheric hazard has cleared. To reset the instrument, simply press the MODE button. If the Cannonball3's alarm latch is disabled and the alarm condition is no longer present, the instrument automatically returns to normal operation, and the visible and audible alarms cease without further input from the user.

The procedure for changing alarm latch settings is covered in section 3.5.3.

1.5.2 Atmospheric hazard alarms

⚠WARNING The Cannonball3 personal, portable gas detector has been designed for the detection of oxygen deficiencies, and flammable gas and toxic vapor accumulations. An alarm condition indicating the presence of one or more of these potentially life-threatening hazards should be taken very seriously.

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

⚠WARNING A rapid up-scale reading followed by a declining or erratic reading may indicate a hazardous combustible gas concentration that exceeds the

Cannonball3's zero to 100 percent LEL detection range for units without a dilution pump, or zero to approximately 200 percent detection range for units with a dilution pump. The safest course of action is to immediately leave the affected area, and to return only after further testing determines that the area is once again safe for entry.

The combustible gas alarm is activated when the percent LEL (Lower Explosive Limit) gas concentration exceeds the pre-set alarm level.

Two oxygen alarm set points have been provided; one for low concentrations associated with oxygen deficiencies and one for high concentrations associated with oxygen enrichments.

Two additional oxygen alarm set points have been provided for Cannonball3 instruments equipped with the dilution pump for use in inert or nearly inert atmospheres.

Three alarm set points have been provided for each toxic gas monitored: TWA (Time Weighted Average), STEL (Short Term Exposure Limit), and Ceiling.

Appendix A discusses alarm levels.

The procedure for adjusting alarm settings is covered in section 3.5.2.

1.5.3 Sensor overrange alarms.

The Cannonball3 will go into alarm if a sensor is exposed to a concentration of gas that exceeds its established range. If the peak alarm is enabled it will go off before an overrange alarm provided a STEL or TWA alarm is not activated first. If the peak alarm is disabled and a toxic sensor goes into overrange alarm a "SENSOR OUT OF RANGE" message will appear at the bottom of the display while the audible and visible are activated. The maximum range value will be displayed for the sensor in alarm. If the LEL sensor goes into overrange alarm, the message "LEL OVERRANGE" will appear at the bottom of the screen, both the audible alarm and the flashing LED alarms will be activated and an "X" will appear on the LCD in the place of the numeric reading for the LEL sensor.

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

⚠WARNING In the event of an LEL overrange alarm the Cannonball3 must be turned off, brought to an area that is known to be safe and then turned on again to reset the alarm.

Note: The Cannonball3 features automatic warning against LEL sensor failure due to lack of oxygen. In the case of oxygen levels below the safe limit for the LEL sensor to operate, the Cannonball3 will display a message indicating that O_2 is too low for LEL to operate.

1.5.4 Low battery alarms

Note: The voltage figures given below are for Cannonball3 instruments with firmware version 1.55 and may be slightly different for units with other versions of instrument firmware.

The Cannonball3 includes low battery alarms that are activated whenever battery voltage approaches a level that will soon lead to instrument shut down. When the battery voltage is reduced to approximately 5.15 volts in alkaline units, or 4.82 volts in NiMH rechargeable units, an audible alarm will sound, and the display screen will indicate that a low battery condition exists. At this stage, the low battery alarms may be silenced for up to fifteen minutes by pressing the MODE button. After the first low battery alarm, the alarm will sound again every fifteen minutes until the voltage drops to the "Very Low Battery" level.

The "Very Low Battery" level occurs when the battery voltage drops to 5.06 volts in alkaline units, or 4.75 volts in NiMH rechargeable units. Due to the risk of imminent shut down, when the battery voltage reaches the "Very Low Battery" level it is no longer possible to silence the low battery alarms. At this point, it is necessary to either immediately leave the hazardous area in which the instrument is being used or to immediately install a new battery pack with a charge sufficient to avoid the low battery alarms.

When the voltage drops to 5.00 volts in alkaline units, or 4.73 volts in NiMH rechargeable units. the Cannonball3 will display a "Dead Battery" message to warn the user of imminent shut down. The instrument will then automatically turn itself off.

After any low battery alarm the batteries should be replaced if the Cannonball3 is equipped with alkaline batteries or the battery should be recharged if the Cannonball3 is equipped with a NiMH rechargeable battery.

⚠WARNING Use only Energizer E95 or EN95, Duracell MN1300, or Duracell PC1300, 1.5V D cell Alkaline batteries in the Cannonball3. Substitution of batteries may impair intrinsic safety.

1.5.5 Calibration reminder

The Cannonball3 has a calibration reminder to let the user know that the instrument is due for calibration. The reminder can be set to any interval between 1 and 180 days, or can be disabled entirely. Additional controls allow the user to determine if the reminder will be shown once per operating session, or every 15 minutes. Successful calibration resets the reminder.

See section 4.7.4 for further details about the calibration reminder.

1.5.6 Other alarms and special microprocessor features

Cannonball3 software includes a number of additional alarms designed to ensure the proper use of the instrument. When the Cannonball3 detects that an electronic fault or failure condition has occurred, the proper audible and visible alarms are activated and an explanatory message is displayed.

⚠WARNING The Cannonball3 is designed to detect potentially life threatening atmospheric conditions. Any alarm condition should be taken seriously. The safest course of action is to immediately leave the affected area, and return only after further testing determines that the area is once again safe for entry.

1.6 Other electronic safeguards

Several automatic programs prevent tampering and misuse of the Cannonball3 by unauthorized persons. Each time the detector is turned on, the Cannonball3 automatically tests the LED alarm lights and audible alarm. The battery is monitored continuously for proper voltage. The Cannonball3 also monitors the connection of sensors that are currently installed. The detection of any electronic faults causes the activation of the audible and visible alarms and causes the display of the appropriate explanatory message.

1.6.1 Security beep

The Cannonball3 offers a security beep that may be configured to "beep" at defined intervals to indicate that the instrument is turned on.

Optional set-up choices, including security beep settings, are accessed through the Options Menu. See section 3.7 for details.

1.7 Classification for intrinsic safety

The Cannonball3 has been classified for intrinsic safety by the following testing laboratories:

Underwriters Laboratories, Inc. (file number E109447) for use in Hazardous Locations Class I, Division 1, Groups A, B, C, and D Temp T3C.

CSA (file number 159202) Class I Division 1 Groups A,B,C,D Exia Temp T3C.

1.8 Sensors

The Cannonball3 can be configured to measure oxygen, combustible gas, and up to three additional toxic gases. Up to four sensors can be installed in the Cannonball3. With the "Duo-Tox" dual channel CO/H_2S sensor installed, the instrument is capable of displaying readings for up to five different channels of detection: O_2, LEL, CO, H_2S and one other toxic sensor. The sensor configuration of the Cannonball3 can be specified at the time of purchase, or changed in the field by appropriately trained personnel.

⚠WARNING Accuracy of the Cannonball3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.

Calibration procedures are discussed in detail in Chapter 4.

1.9 Continuous sample draw pump

Every Cannonball3 includes a built-in continuous sample draw pump. Since the Cannonball3's sensor compartment is contained within the instrument, the gas sample must be drawn into the instrument by the pump through a probe assembly that is attached to the inlet coupling on the front of the unit.

The pump contains a pressure sensor that detects restrictions in airflow caused by water or other fluids being drawn into the unit and immediately acts to shut the pump off in order to protect the sensors, pump, and other Cannonball3 components from damage.

Pump status is continuously monitored by the Cannonball3 microprocessor. Low flow or other pump fault conditions activate audible and visible alarms and cause the display of the appropriate explanatory message.

Cannonball3 instruments equipped with alkaline battery packs and fresh D-cell alkaline batteries are designed to provide at least 24 hours of continuous operation even when the instrument is operated in low light conditions and the backlight is continuously on.

⚠WARNING Use only Energizer E95 or EN95, Duracell MN1300, or Duracell PC1300, 1.5V D cell Alkaline batteries in the Cannonball3. Substitution of batteries may impair intrinsic safety.

Cannonball3 instruments equipped with NiMH rechargeable battery packs are designed to provide at least 16 hours of continuous operation between charges even when the instrument is operated in low light conditions and the backlight is continuously on.

1.10 Black box data recorder

Every Cannonball3 purchased without a datalogger includes a "black box" data recorder that functions similarly to a datalogger, with one important distinction: The data stored in a Cannonball3 with a datalogger option can be accessed directly by the user with Sperian Instrumentation's Biotrak Database Software. Instruments with the black box data recorder must be sent back to Sperian Instrumentation for data retrieval.

If the data stored in a Cannonball3 equipped with a black box data recorder is needed, simply call Sperian's Instrument Service Department at (800) 711-6776 for a return authorization number and send the instrument back to Sperian Instrumentation. Sperian Instrumentation will extract the data from the instrument and print an incident report at no charge. You only pay for shipping.

Datalogging functions are discussed in detail in Chapter 5.

1.11 Cannonball3 design components

Case: The instrument is enclosed in a solid ABS case with two gaskets between its upper and lower sections. The first is a water-resistant PVC gasket that protects against leakage or exposure to dust and liquids. The second gasket is a metal-braided O-ring that increases the Cannonball3's immunity to radio frequency interference.

Front face: The front face of the Cannonball3 houses the graphics-capable LCD display, MODE button, four navigation arrows, three alarm light ports, and the quick reference card.

LCD display: A large graphics-capable liquid crystal display (LCD) shows readings, messages, menus and other information. An automatically activated backlight allows the display to be read in dim light conditions.

Alarm light: Three alarm light ports located on three different sides of the Cannonball3 ensure that at least one of the alarm light ports is visible from any angle.

Control buttons: The large oval push-button to the left of the handle is the MODE button. The MODE button is used to turn the Cannonball3 on and off, and to control many other basic operations, including automatic calibration adjustments. The four triangular navigation arrows are used to scroll or navigate through additional menu choices and screens of information.

Sensor compartment: The sensor compartment is contained within the Cannonball3 itself. Gas samples are drawn into the Cannonball3 by the continuous sample pump through an externally vented sensor compartment cover.

Audible alarm orifice: The audible alarm orifice is located on the right side of the instrument.

Battery packs: Rechargeable and alkaline battery packs are inserted at the base of the Cannonball3 and are held in place with two retention screws.

Handle: The soft rubber handle provides a sure grip in any condition.

Pump compartment: The sample and dilution diaphragm pumps are housed in a field-replaceable assembly that is accessible from the bottom of the instrument.

External filter compartment: The clear plastic compartment on the front of the Cannonball3 provides visual access to the filter compartment. When filters appear dirty, a single screw provides access to the filter compartment for easy filter replacement in the field.

Sample inlet coupling: The sample inlet coupling is a metal quick disconnect fitting located at the front of the Cannonball3. Sample draw probe assemblies must be attached to the sample inlet coupling for the Cannonball3 to function properly.

1.12 Cannonball3 accessories

Each Cannonball3 is delivered in a foam-lined box containing the Cannonball3 detector, sample probe assembly, 10 feet of sample draw tubing with quick disconnect fitting, reference manual, shoulder strap, replacement sample probe filters and chosen battery pack.

1.12.1 Alkaline Cannonball3 detectors

Cannonball3 instruments purchased as alkaline instruments include all of the standard accessories plus the alkaline battery pack and a set of 5 disposable D-cell alkaline batteries.

1.12.2 NiMH Cannonball3 detectors

Cannonball3 instruments purchased as “NiMH” instruments include all of the standard accessories plus the NiMH battery pack and Cannonball3 fast charger.

Chapter 2. Basic operation

This chapter will cover how to use the Cannonball3 for safe work in potentially hazardous atmospheres.

2.1 Operational warnings and cautions

1. **⚠WARNING The Cannonball3 personal, portable gas detector has been designed for the detection of dangerous atmospheric conditions. An alarm condition indicates the presence of a potentially life-threatening hazard and should be taken very seriously. Failure to immediately leave the area during an alarm condition may result in serious injury or death.**
2. **⚠WARNING In the event of an alarm condition it is important to follow established procedures. The safest course of action is to immediately leave the affected area, and to return only after further testing determines that the area is once again safe for entry. Failure to immediately leave the area during an alarm condition may result in serious injury or death.**
3. **⚠WARNING Use only Energizer E95 or EN95, Duracell MN1300, or Duracell PC1300, 1.5V D cell Alkaline batteries in the Cannonball3. Substitution of batteries may impair intrinsic safety.**
4. **⚠WARNING The accuracy of the Cannonball3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.**
5. **⚠WARNING The accuracy of the Cannonball3 should be checked immediately following any known exposure to contaminants by testing with known concentration test gas before further use. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.**
6. **⚠WARNING A sensor that cannot be calibrated or is found to be out of tolerance should be replaced immediately. An instrument that fails calibration may not be used until testing with known concentration test gas determines that accuracy has been restored, and the instrument is once again fit for use.**
7. **⚠WARNING Do not reset the calibration gas concentration unless you are using a calibration gas concentration that differs from the one that is normally supplied by Sperian Instrumentation for use in calibrating the Cannonball3. Use of inappropriate calibration gas may lead to in accurate and potentially dangerous readings.**

   Customers are strongly urged to use only Sperian Instrumentation calibration materials when calibrating the Cannonball3. Use of non-standard calibration gas and/or calibration kit components can lead to dangerously inaccurate readings and may void the standard Sperian Instrumentation warranty.
8. **⚠WARNING Use of non-standard calibration gas and/or calibration kit components when calibrating the Cannonball3 can lead to inaccurate and**

potentially dangerous readings and may void the standard Sperian Instrumentation warranty.

Sperian Instrumentation offers calibration kits and long-lasting cylinders of test gas specifically developed for easy Cannonball3 calibration. Customers are strongly urged to use only Sperian Instrumentation calibration materials when calibrating the Cannonball3.

9. **⚠WARNING Substitution of components may impair intrinsic safety.**
10. **⚠WARNING For safety reasons this equipment must be operated and serviced by qualified personnel only. Read and understand this reference manual before operating or servicing the Cannonball3.**
11. **⚠WARNING A rapid up-scale reading followed by a declining or erratic reading may indicate a hazardous combustible gas concentration that exceeds the Cannonball3's zero to 100 percent LEL detection range for units without a dilution pump, or zero to approximately 200 percent detection range for units with a dilution pump. The safest course of action is to immediately leave the affected area, and to return only after further testing determines that the area is once again safe for entry.**

2.2 On and off sequences

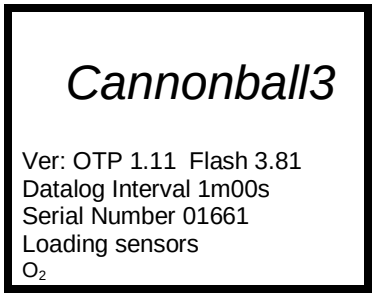
The large oval push-button on the top of the Cannonball3 case is called the "MODE" button. It is used to turn the Cannonball3 on and off, and to control basic instrument functions.

2.2.1 Start-up sequence

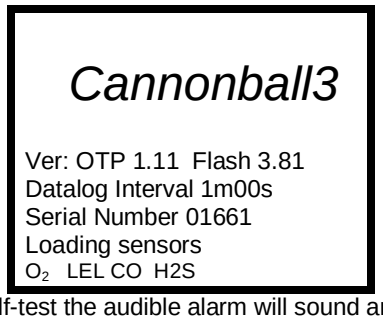
After the Cannonball3 has been turned on, it will automatically go through an electronic self-test and start-up sequence that will take approximately thirty seconds. During the self-test sequence, the display backlight will momentarily turn on, the visual LED alarm lights will flash, and the audible alarm will sound. The Cannonball3 will also determine which "Smart Sensors" are currently installed in the instrument, and whether there have been any changes since the last time the instrument was used.

To turn the Cannonball3 on, do the following:

1. Attach the sample probe and hose assembly to the inlet coupling on the front of the Cannonball3.
2. Press and hold the MODE button until the Cannonball3 tells you to release it. Several screens will be shown as the instrument loads and evaluates information from the "Smart Sensors" that are currently recognized.

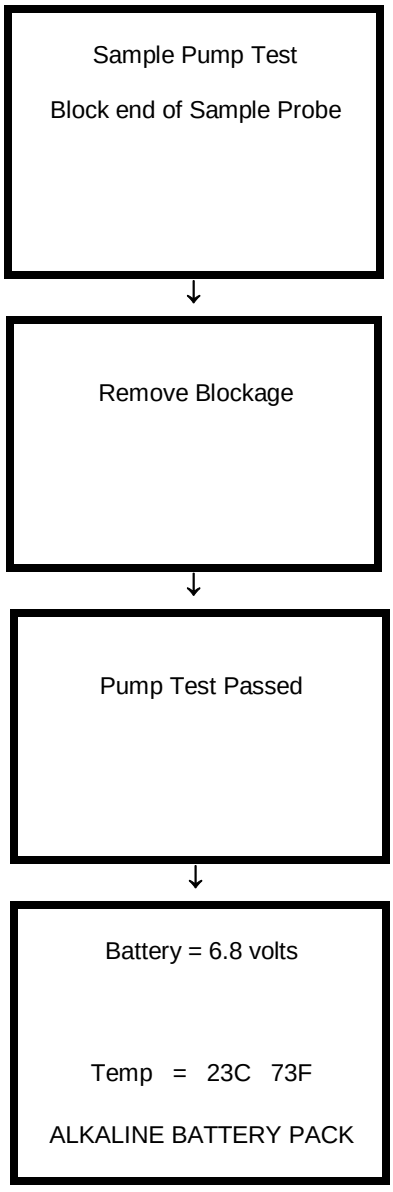


The Cannonball3 will continue to load all sensors that it recognizes in the unit.



During the self-test the audible alarm will sound and the LED alarm lights will be briefly activated. The instrument will proceed through a few additional screens before it tests the sample draw system. At this point the instrument will instruct you to block the end of the sample probe tube.

CAUTION: The sample probe and hose assembly must be attached to the inlet port for the Cannonball3 to operate properly. Operation of the instrument without the sample probe assembly may result in damage to the instrument.



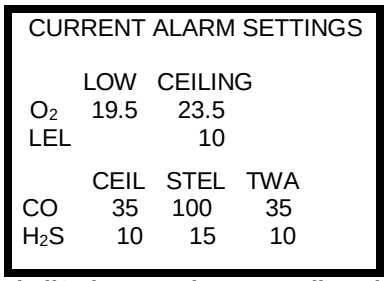
Note: If the sample pump test fails, see section 6.2.3.

⚠WARNING The accuracy of the Cannonball3 should be checked periodically with known concentration

calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.

Note: The temperature shown is actually a reading taken inside the instrument case in the area where the sensors are located and may not correspond with ambient air temperatures. The Cannonball3 microprocessor uses these readings to compensate for temperature changes.

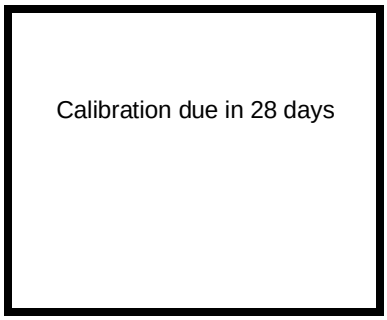
The instrument will proceed to display the current alarm settings of the sensors it detects.



Note: Cannonball3 alarm settings are adjustable by the user and may be set anywhere within the range of the specific sensor type. Factory default settings may be easily restored at any time.

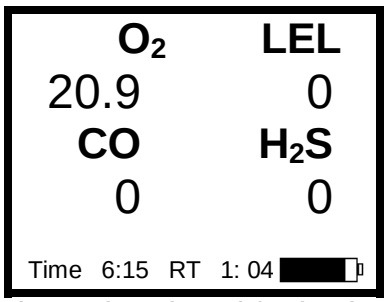
The procedure for changing alarm settings is discussed in section 3.5.2.

If the calibration due reminder is enabled, the calibration due screen will be shown with the number of days given until the next scheduled calibration.



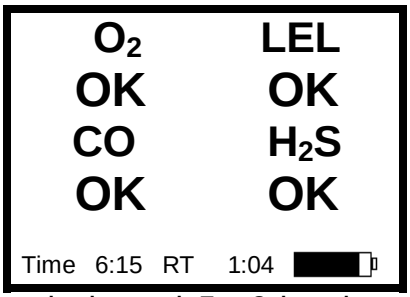
If sensors are due for calibration, the "Warning Sensor Needs Cal" message will be shown. See section 2.2.1.1.2 below for further instructions.

The final screen in the self-test and start-up sequence is the current gas level screen. This screen displays sensors currently installed and the current readings. When the instrument is operated in "Basic", "Basic/Peak" or "Technician" mode, numerical readings are shown.



Current gas level screen in Basic, Basic/Peak and Technician modes with no alarms present.

If the instrument is operated in the "Text Only" mode an "OK" message will be displayed as long as measured concentrations are below the alarm set points. If readings exceed a pre-set alarm level, the message for the affected sensor channel will change from "OK" to a numerical reading, the LED alarm lights will flash, and the audible alarm will sound.



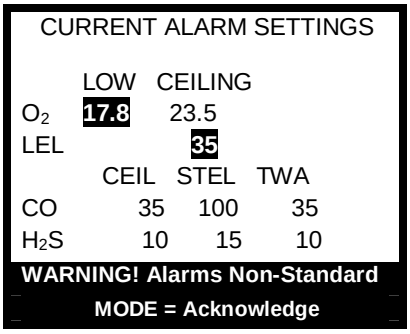
Current gas level screen in Text Only mode, no alarms present.

2.2.1.1 Other start-up screens

Several additional screens may be shown under some circumstances. Some screens may require acknowledgement by the user.

2.2.1.1.1 "Non-standard alarms"

During the start up procedure, if the instrument recognizes a low oxygen alarm setpoint of below 18.0% or an LEL ceiling alarm setpoint of higher than 30%, the LCD will display the message "WARNING! Alarms Non-Standard" at start-up and will highlight the alarm settings for the affected sensors.



Press the MODE button to acknowledge and use the non-standard settings.

Note: The definition of non-standard alarms has changed during the production span of the Cannonball3. The non-standard alarm warnings may be incurred at other levels if you are using a different version of instrument software.

Note: Factory default settings may be easily restored at any time. The procedure for restoring factory default alarm settings is covered in section 3.5.4.

2.2.1.1.2 "Warning Sensor Needs Cal"

The Cannonball3 will display the "Warning Sensor Needs Cal" message for any of the following reasons:

1. The instrument's sensor configuration has been modified since the last time the instrument was used.
2. The last calibration was not successfully completed.
3. The current date exceeds the calibration due date that has been programmed into the instrument.

⚠WARNING The Cannonball3 should not be put back into service or used until the accuracy of any affected sensor has been verified by exposure to the appropriate known concentration test gas.

The "Needs Cal" warning message may be acknowledged (and silenced) by pressing the MODE button.

2.2.2 Shut-down sequence

To turn the Cannonball3 off, hold the MODE button down for three full seconds or until the “Release Button” message appears. After the MODE button is released the display will show the message "BEGIN SHUTDOWN PLEASE WAIT”. The shutdown sequence is complete when the display blanks out.

2.3 Operating modes

The Cannonball3 offers a choice of four modes of operation: "Text Only”, "Basic”, “Basic/Peak” and "Technician”. Mode selection should be based on how much information is required, the skill level of the user, and the nature of the job.

Text Only Mode:

- Displays ‘OK’ for gas-level concentrations unless an alarm condition is present.
- Upon alarm condition, gas-level concentrations will be displayed.
- 2 screens available (toggle by pressing the MODE button):
  1. Concentration screen (see below)
  2. Information screen (see below)

Basic Mode:

- Gas-level concentrations always displayed.
- Access to calibration functions.
- 2 screens available (toggle by pressing the MODE button):
  1. Concentration screen (see below).
  2. Information screen (see below).

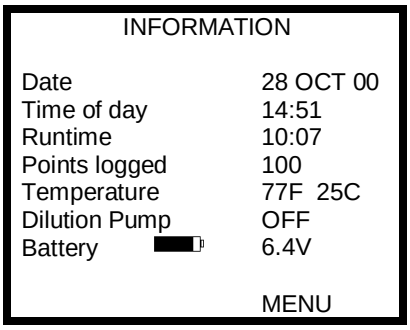
Basic/Peak Mode:

- Gas-level concentrations always displayed.
- Access to calibration functions.
- 3 screens available (toggle by pressing the MODE button):
  1. Concentration screen (see below).
  2. Peak readings screen (see below).
  3. Information screen (see below).

Technician Mode:

- Gas-level concentrations always displayed.
- Access to all advanced functions.
- 4 screens available (toggle by pressing the MODE button):
  1. Concentration readings screen (see below)
  2. Peak readings screen (see below)
  3. STEL/TWA/AVG readings screen (see below)
  4. Information screen (see below)

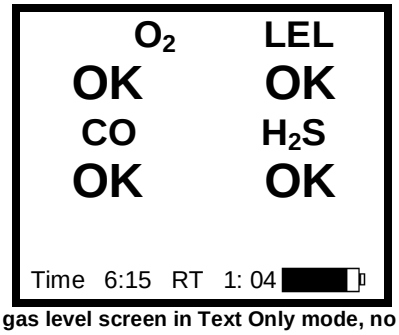
The INFORMATION screen (shown below) can be accessed from any of the four operating modes by pressing the MODE button.



Regardless of mode selection, whenever the Cannonball3 is in use it remembers the peak readings for all gases measured, and is calculating both the Time Weighted Average (TWA) and Short Term Exposure Limit (STEL) for all toxic gas sensors installed. Regardless of mode selection the Cannonball3 will go into alarm whenever any alarm set point is exceeded.

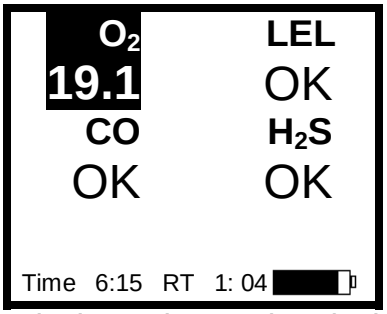
2.3.1 Text Only mode

The simplest mode of operation is the "Text Only" mode. In Text Only mode during normal operation, the LCD screen indicates "OK” unless an alarm condition is present.



Current gas level screen in Text Only mode, no alarms present.

If an alarm condition occurs the indication changes from "OK" to the numerical value, the LED alarm lights flash, and the audible alarm sounds.



Current gas level screen in Text Only mode, alarm condition.

Cannonball3 alarms are self-resetting unless the alarm latch is enabled. When the Cannonball3’s alarm latch is enabled, the audible and visible alarm will continue to sound after the atmospheric hazard has cleared. To reset the instrument, simply press the MODE button. If the Cannonball3’s alarm latch is disabled and the alarm condition is no longer present, the instrument automatically returns to normal operation, and the visible and audible alarms cease without further input from the user.

For more information on the alarm latch see section 3.5.3.1.

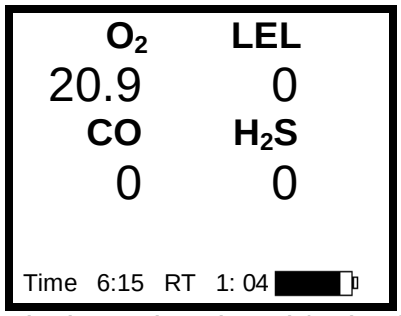
In Text Only mode, the information screen (see above) is also available to the user. Press the MODE button to toggle back and forth between the current gas level and information screens.

Note: It is not possible to initiate the "Auto- Calibration procedure while the Cannonball3 is in Text Only mode. To initiate the "Auto-Calibration" procedure, the Cannonball3 must be in Basic, Basic/Peak or Technician mode.

2.3.2 Basic mode

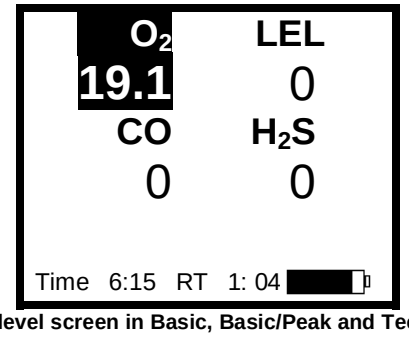
In Basic mode numerical gas level readings are always provided and it is possible to initiate "Auto-Calibration" in order to make fresh air and span calibration adjustments.

Calibration procedures are discussed in detail in Chapter 4.



Current gas level screen in Basic, Basic/Peak and Technician Modes, no alarms present.

An alarm condition occurs when one of the sensor readings exceeds the pre-set alarm level. When an alarm condition occurs, the LED alarm lights flash, and the audible alarm sounds.



Current gas level screen in Basic, Basic/Peak and Technician Modes, alarm condition.

Cannonball3 alarms are self-resetting unless the alarm latch is enabled. When the Cannonball3's alarm latch is enabled, the audible and visible alarm will continue to sound after the atmospheric hazard has cleared. To reset the instrument after the atmospheric hazard has cleared, simply press the MODE button. If the Cannonball3's alarm latch is disabled and the alarm condition is no longer present, the instrument automatically returns to normal operation, and the visible and audible alarms cease without further input from the user.

For more information on the alarm latch see section 3.5.3.1.

In Basic mode, the information screen is also available to the user. While in Basic mode the MODE button may be used to toggle back and forth between the current gas level and information screens.

2.3.3 Basic/Peak mode

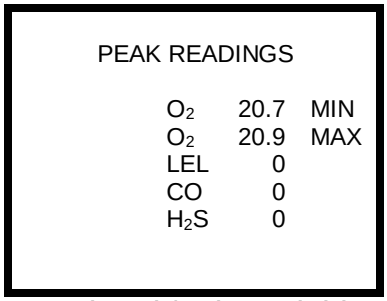
The Basic/Peak mode of operation is designed for users who need numerical sensor readings and access to the peak readings screen.

In Basic/Peak mode numerical gas level readings are always provided and it is possible initiate "Auto-Calibration" in order to make fresh air and span calibration adjustments.

Calibration procedures are discussed in detail in Chapter 4.

2.3.3.1 Peak readings

Peak readings for the accumulations of combustible gases and vapors, and for the accumulation of toxic gases represent the highest values registered by the instrument during the period of operation. Peak readings for oxygen include both the highest and lowest values registered by the instrument during the period of operation. Peak readings are updated continuously.



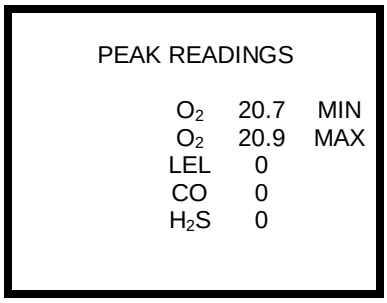
Peak Readings screen in Basic/Peak or Technician mode.

While in Basic/Peak mode the MODE button may be used to toggle back and forth between the current gas level, peak readings, and information screens.

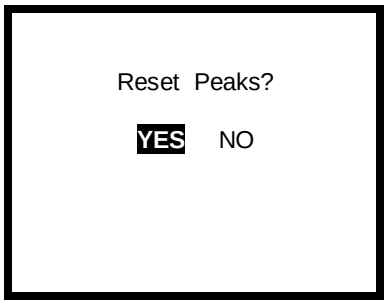
2.3.3.2 To reset peak readings

Peak readings may be reset during any period of operation. To reset the peak readings, do the following:

1. Press the MODE button until the peak readings screen appears.



2. Hold the right navigation arrow down for three seconds until the instrument instructs you to release the button. The following screen will then appear:



3. With YES highlighted, press the MODE button to reset the peak settings.

Note: Although the peak readings can be reset during any session of operation, the Cannonball3's data recorder automatically records that the peak readings have been reset.

2.3.4 Technician mode

Technician mode provides access to all advanced functions and displays of the Cannonball3.

While in Technician mode the MODE button may be used to toggle back and forth between the current gas level, peak readings, STEL/TWA/AVG and information screens.

2.3.4.1 STEL

The STEL (Short Term Exposure Limit) for a particular toxic gas is the maximum average concentration to which an unprotected worker may be exposed during any 15 minute interval. The STEL value displayed by the Cannonball3 is the average concentration for the most recently completed 15 minutes of operation.

Note: For the first 15 minutes after the Cannonball3 is initially turned on the STEL reading is a projected value. The Cannonball3 will begin projecting a STEL value after the first 30 seconds of operation. For the first 30 seconds the STEL screen will show an "X" where the reading should be.

The STEL reading is continuously updated. Audible and visible alarms will be activated immediately any time the most recent 15-minute average exceeds the STEL alarm set-point.

Appendix A discusses Permissible Exposure Limit alarm calculations in greater detail.

2.3.4.2 TWA readings

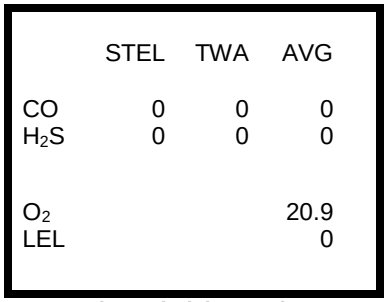
Time Weighted Average or TWA values are calculated by taking the sum of exposure to a particular toxic gas in the current operating session in terms of parts-per-million-hours and dividing by an eight-hour period.

Note: It is not possible to calculate a toxic gas TWA reading until the Cannonball3 has been operating for 15 minutes. For the first 15 minutes after start-up, the TWA screen will show an "X" in place of the calculation. After 15 minutes, the TWA calculation will be shown.

Appendix A discusses Permissible Exposure Limit alarm calculations in greater detail.

2.3.4.3 Average readings

The average readings displayed by the Cannonball3 are the simple arithmetic averages registered by the instrument during the current session of operation.

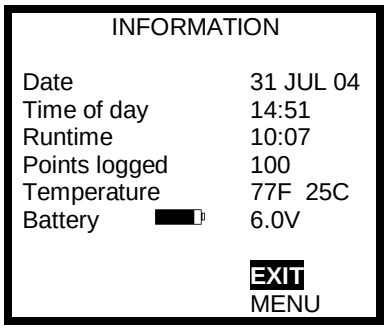


STEL/TWA/AVG screen in Technician Mode:

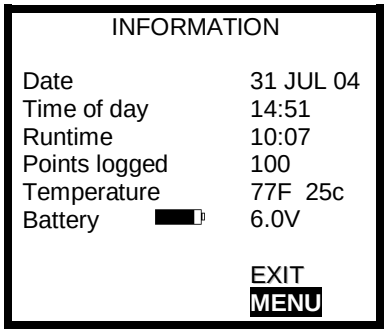
2.3.5 Changing operating modes

To change operating modes do the following:

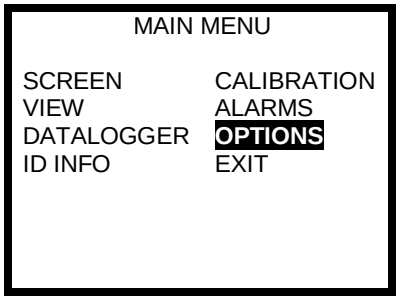
1. Press the MODE button until the information screen is displayed.



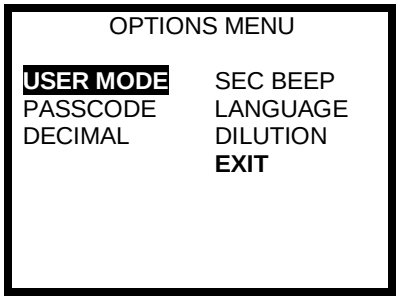
2. Hold down the left arrow key until EXIT appears and is highlighted (approximately three seconds).



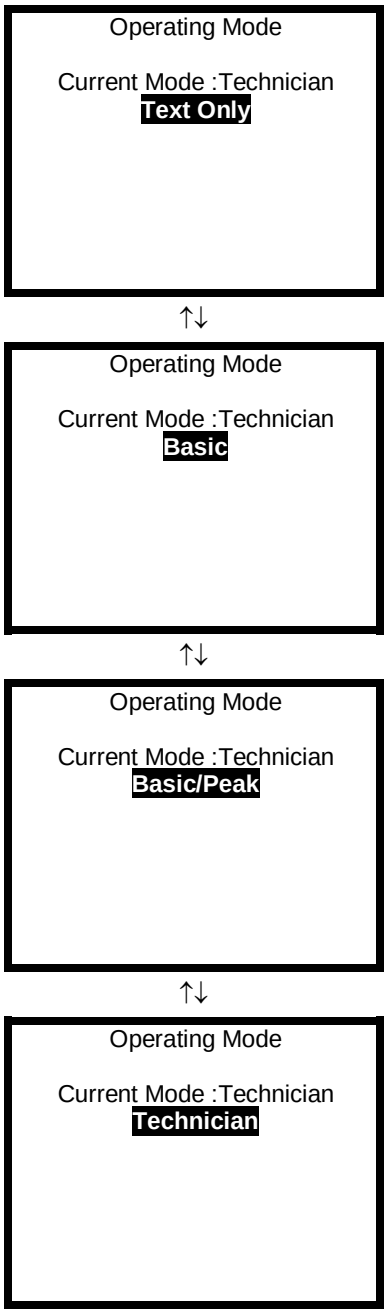
3. Press the down navigation arrow once to highlight MENU and press MODE button to enter the Main Menu.



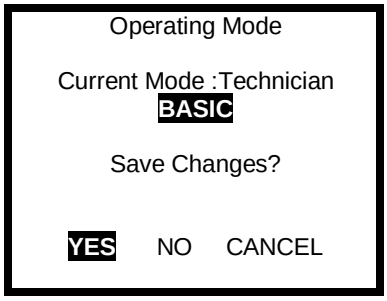
4. Press the up arrow once to highlight OPTIONS and press the MODE button to enter the Options Menu.



5. Use the navigations arrows to highlight USER MODE and press the MODE button. The up and down navigation arrows may then be used to toggle between operating modes.



6. Once the preferred operating mode is highlighted, confirm the selection by pressing the MODE button.



7. Press the MODE button with YES highlighted to save the new operating mode.

Note: Changing modes or otherwise reprogramming the instrument is reserved for authorized employees.

2.4 Batteries

The Cannonball3 can be equipped with either an alkaline battery pack or a NiMH (Nickel Metal Hydride) NiMH rechargeable battery pack.

⚠WARNING The Cannonball3 must be located in a non-hazardous location whenever the alkaline batteries are removed from the alkaline battery pack. Removing the alkaline batteries from the alkaline battery pack in a hazardous location may impair intrinsic safety.

⚠WARNING The Cannonball3 must be located in a non-hazardous location during the charging cycle. Charging the Cannonball3 in a hazardous location may impair intrinsic safety.

2.4.1 Alkaline batteries

The Cannonball3 with alkaline batteries is designed to provide at least 24 hours of continuous use with each set of 5 fresh D-cell disposable alkaline batteries.

⚠WARNING Use only Energizer E95 or EN95, Duracell MN1300, or Duracell PC1300, 1.5V D cell Alkaline batteries in the Cannonball3. Substitution of batteries may impair intrinsic safety.

2.4.1.1 Replacing alkaline batteries

1. Check that the Cannonball3 is not located in a hazardous (potentially combustible) area.
2. Make sure that the Cannonball3 is turned off.
3. Loosen the battery retention screws and remove the battery pack from the instrument.
4. Remove the screw on the top of the battery pack and open the battery pack. Remove the old batteries and install new batteries in accordance with the diagram inside the battery pack.
5. Replace the screw on the top of the battery pack and reinstall the battery pack into the instrument. Tighten the battery retention screws.

Note: Always dispose of alkaline and NiMH batteries and battery packs in accordance with local ordinances.

Note: The Cannonball3 is designed to turn itself on whenever the battery pack is removed and then replaced. This ensures that in the event of an interruption in power the instrument is not accidentally turned off. Any time the batteries are momentarily removed or replaced it will be necessary to manually turn the Cannonball3 off if the instrument is not going to be put into immediate use.

2.4.2 NiMH rechargeable battery

The Cannonball3 equipped with a rechargeable NiMH (nickel metal hydride) battery is designed to provide at least 16 hours of continuous use between charging cycles. The NiMH battery pack in the Cannonball3 is sealed and should not be disassembled in the field.

⚠WARNING The Cannonball3 must be located in a non-hazardous location during the charging cycle. Charging the Cannonball3 in a hazardous location may impair intrinsic safety.

2.4.2.1 Storage guidelines for the NiMH battery.

Never store NiMH-version Cannonball3 instruments at temperatures above 30° Celsius (86° Fahrenheit). Nickel Metal Hydride batteries may suffer deterioration resulting in damage to the internal components when stored at high

temperatures. The battery may be irretrievably damaged resulting in reduced battery capacity and voltage.

Sperian Instrumentation recommends attaching a powered Cannonball3 charger to the NiMH instruments when not in use.

2.4.2.2 Charging guidelines for NiMH battery

The NiMH battery in the Cannonball3 should never be charged at temperatures lower than 5° Celsius (40° Fahrenheit) or higher than 30° Celsius (86° Fahrenheit). Charging at temperature extremes can cause permanent damage to the battery.

⚠WARNING The Cannonball3 must be located in a non-hazardous location during the charging cycle. Charging the Cannonball3 in a hazardous location may impair intrinsic safety.

2.4.2.3 Charging procedure for NiMH battery

1. Check that the instrument is turned off. (If it is not, press the MODE button for three seconds until the message "Release Button" appears.)
2. Connect the charger to the Cannonball3.
3. Plug the power supply in and check to see that the "Power" indicator LED on the charger is lit.
4. Attach the charger to the Cannonball3. While the battery is charging the red 'Power' indicator LED and the red "Charge" indicator LED will be lit on the charger.

Note: The "Charge" LED indicator will initially light up and remain lit for the first 15 minutes regardless of battery pack voltage.

5. Charging will be completed in 5 hours or less, and will be indicated by the green ''Ready' indicator LED. Charging is complete any time after the "Ready" indicator is lit.

CAUTION To achieve optimal charge and ensure long battery life of the NIMH battery, make sure that charging takes place in an area where the ambient air temperature is between 5 ^{o} and 40^{o} Celsius (40° and 86° F). Charging the battery in temperatures above or below this range can damage the battery and will drastically effect battery life.

2.4.3 Low battery alarms

Note: The voltage figures given below are for Cannonball3 instruments with firmware version 1.55 and may be slightly different for units with other versions of instrument firmware.

The Cannonball3 includes low battery alarms that are activated whenever battery voltage approaches a level that will soon lead to instrument shut down. When the battery voltage is reduced to approximately 5.15 volts in alkaline units, or 4.82 volts in NiMH rechargeable units, an audible alarm will sound, and the display screen will indicate that a low battery condition exists. At this stage, the low battery alarms may be silenced for up to fifteen minutes by pressing the MODE button. After the first low battery alarm, the alarm will sound again every fifteen minutes until the voltage drops to the "Very Low Battery" level.

The "Very Low Battery" level occurs when the battery voltage drops to 5.06 volts in alkaline units, or 4.75 volts in NiMH rechargeable units. Due to the risk of imminent shut down, when the battery voltage reaches the "Very Low Battery" level it is no longer possible to silence the low battery alarms. At this point, it is necessary to either immediately leave the hazardous area in which the instrument is being used or to immediately install a new battery pack with a charge sufficient to avoid the low battery alarms.

When the voltage drops to 5.00 volts in alkaline units, or 4.73 volts in NiMH rechargeable units. the Cannonball3 will display a "Dead Battery" message to warn the user of imminent shut down. The instrument will then automatically turn itself off.

After any low battery alarm the batteries should be replaced if the Cannonball3 is equipped with alkaline batteries or the battery should be recharged if the Cannonball3 is equipped with a NiMH rechargeable battery.

2.5 Methods of sampling

Every Cannonball3 is equipped with a field-replaceable continuous sample draw pump. Proper use of the pump and sample probe assembly is critical to ensure proper instrument functionality. The pump and probe assemblies are automatically tested whenever the Cannonball3 is turned on.

Note: The maximum length of standard diameter tubing that can be used with the Cannonball3 is 100 feet.

The Cannonball3's sensor compartment is contained within the instrument. The gas sample must be drawn into the instrument by the pump through the probe assembly that is attached to the inlet coupling on the front of the unit.

The pump in the Cannonball3 draws the air sample into the instrument at the rate of about 1 foot per second. Once the sample reaches the sensor compartment, allow approximately 1 additional minute for readings to stabilize. This means that with the standard 10 feet of tubing between the probe and the instrument, it will take approximately 70 seconds to obtain a valid reading of the atmosphere.

⚠WARNING Use only polyester urethane (fuel-resistant) tubing to draw the sample into the Cannonball3. Use of other types of tubing may cause inaccurate and potentially dangerous readings.

The Cannonball3 is delivered with 10 feet of polyester urethane (fuel-resistant) tubing as a standard accessory. If replacement tubing is needed, Sperian Instrumentation's polyester urethane (fuel-resistant) tubing is part number 53-001.

Once turned on, the Cannonball3 monitors continuously. The Cannonball3's sensors react immediately to changes in the concentrations of the gases being measured. This type of operation monitors only the atmosphere in the immediate area of the end of the probe assembly.

CAUTION: Never operate the Cannonball3 without the sample probe assembly. The sample probe handle contains replaceable filters designed to block moisture and remove particulate contaminants. If the pump is operated without the probe assembly in place particulate contaminants may cause damage to the pump, sensors and internal components of the Cannonball3.

The sample draw pump includes a pressure sensor designed to protect the Cannonball3 from exposure to water or other liquids. If there is a change in pressure in the sample draw assembly due to fluid intake or other blockage, the pump immediately shuts down. After a few seconds audible and visual alarms indicating a low flow condition will also be activated.

CAUTION: Insertion of the sample draw tube into a fluid horizontally or at a low angle may cause fluids to be

drawn into the instrument and may cause damage to the Cannonball3's internal components.

The pressure sensor in the sample draw pump is designed to detect changes while the sample-draw probe is being held in a vertical position. If the probe is held horizontally or at a low angle while inserted into a fluid, a pressure drop sufficient to cause the pump to shut down may not be generated, and water could be drawn into the pump assembly causing damage to the pump, sensors and internal components of the Cannonball3.

To avoid potential damage, care must be taken to keep the probe vertical whenever fluids may be present.

Cannonball3 with sample probe assembly.

2.5.1 Protective "low flow" shut-downs

If a protective pump shut-down occurs, the following steps should be taken before the instrument is put back into use:

1. Turn off the Cannonball3.
2. Remove the probe assembly from the area being monitored.
3. Disconnect the probe assembly from the inlet coupling.
4. Examine the sample draw probe and hose to make sure no fluids or particles remain trapped.
5. Drain any trapped fluids and remove any trapped particles. It may be necessary to disassemble the probe assembly.
6. Replace the sample draw probe filters as needed.
7. Reattach the sample probe and hose assembly in fresh air, turn the Cannonball3 back on and wait for readings to stabilize.
8. Resume sampling.

2.5.2 Sample probe assembly

The sample probe handle contains moisture barrier and particulate filters designed to remove contaminants that might otherwise harm the instrument.

CAUTION: Never operate the Cannonball3 without the sample probe and hose assembly. The sample probe handle contains replaceable filters designed to block moisture and remove particulate contaminants. If the pump is operated without the probe assembly in place particulate contaminants may cause damage to the pump, sensors and internal components of the Cannonball3.

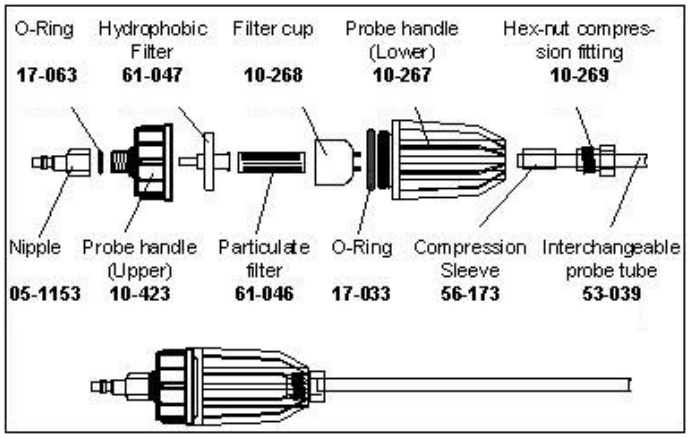


Figure 2.5.2. Cannonball3 sample draw probe.

Particulate contaminants are removed by means of a cellulose filter. The hydrophobic filter includes a 0.1 μm Teflon™ barrier which blocks the flow of moisture as well as any remaining particulate contaminants.

Sample probe filters should be replaced whenever visibly discolored due to contamination. A spare filter replacement kit (Sperian Instrumentation part number 54-05-K0401) is included with every Cannonball3.

2.5.2.1 Changing sample probe filters

The threaded sample probe handle is unscrewed (as shown in Figure 2.5.2 above) to provide access to the filters. The particulate filter is held in place by a clear filter bowl. To replace the particulate filter, remove the old filter and bowl, insert a new filter into the bowl, and slide the bowl back into place in the probe handle. The hydrophobic barrier filter fits into a socket in the rear section of the probe handle. (The narrow end of the hydrophobic barrier filter is inserted towards the rear of the handle.)

2.5.2.2 Changing sample probe tubes

The standard 11.5" long butyrate probe tube is held in place by means of a hex-nut compression fitting and compression sleeve. The standard probe tube is designed to be easily interchangeable with other custom length sections of 1/4" OD tubing, or probe tubes made of other materials (such as stainless steel).

To exchange probe tubes, loosen the hex-nut compression fitting, remove the old tube, slide the compression sleeve into place around the new tube, insert the new tube into the probe handle, and replace and tighten the hex-nut.

Note: When connected to the Cannonball3, the sample probe and hose assembly will be automatically checked for leakage whenever the Cannonball3 is turned on.

2.5.3 Pump modules

The continuous sample draw pump assembly in the Cannonball3 is contained in an easily replaceable pump module that is accessed from the bottom of the instrument.

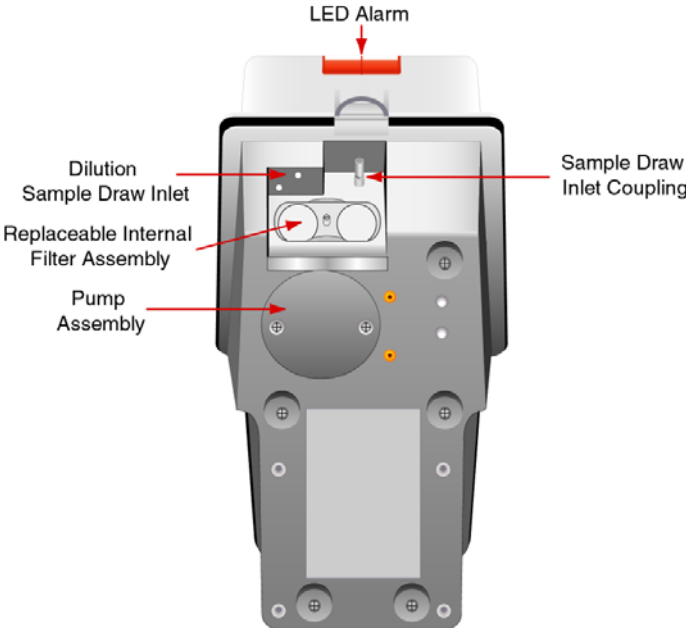


Figure 2.5.3 Bottom of lower case assembly.

2.5.3.1 Replacing the pump module

To replace the pump module, simply loosen the two pump module retention screws on the bottom of the lower case assembly and remove the pump module from the instrument. Install the new pump module, tighten the retention screws and restart the instrument.

CAUTION: Be sure to properly seat the o-ring on the base of the new pump module before installation. Failure to properly seat the o-ring will compromise the Cannonball3's resistance to water and dust.

2.6 EEPROM equipped "Smart Sensors"

Each sensor installed in a Cannonball3 detector is equipped with its own non-volatile memory storage device or "EEPROM". The contents of the sensor's memory device are designed to be read and updated directly by the Cannonball3. The fact that each Cannonball3 Smart Sensor is capable of remembering and communicating important information about itself to the instrument allows for a number of important Cannonball3 operating benefits.

2.6.1 Identification of sensor type

Any sensor installed in the Cannonball3 automatically identifies itself to the instrument microprocessor. The Cannonball3 automatically displays the sensor readings on the liquid crystal display (LCD) and assigns the alarm settings that are programmed into the sensor's EEPROM.

2.6.2 Other information stored in the sensor EEPROM

The Cannonball3 automatically updates the sensor serial number, the most recent calibration settings, temperature compensation curves, and the most recent alarm settings whenever the instrument is turned on, whenever a change is made during operation, and whenever the instrument is turned off.

If a sensor is changed or replaced the Cannonball3 recognizes that a change has occurred, displays a "Needs Cal" message the next time the instrument is turned back on, and identifies the affected sensors. Even if the change is only to replace one sensor with another of the same kind, the Cannonball3 will still note the change in serial numbers of the sensors installed, and display the "Needs Cal" message.

⚠WARNING Accuracy of the Cannonball3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.

⚠WARNING The accuracy of sensors identified as "Needing Calibration" must be verified by exposure to known concentration calibration gas before the Cannonball3 is put back into service. Failure to do so may result in inaccurate and potentially dangerous readings.

2.6.3 Sensor removal and replacement

To remove or replace sensors in the Cannonball3, do the following:

1. Make sure the Cannonball3 is turned off.
2. Remove the battery pack.
3. Remove the six Phillips head screws from the bottom of the instrument and separate the upper and lower case assemblies. Take special care not to disconnect any of the hoses connecting the sensor compartment, pump and inlet fittings. In the event of a hose disconnection, see the pump tubing assembly diagram (figure 6.2.3) in chapter 6.
4. Remove the two screws from the top of the sensor compartment.
5. Lift the sensor compartment cover up to expose the sensors.
6. Identify the sensor that you wish to replace and gently pull the sensor out of its socket.
7. Press the replacement sensor into place.
8. Replace the sensor compartment cover and secure with two screws removed in step 3.
9. Rejoin the upper and lower case assemblies and secure with the six screws removed in step 2.
10. The new sensor must be allowed to stabilize prior to use. The following chart gives a breakdown by sensor type with the required stabilization period for current Cannonball3 sensors. The instrument does not need to be turned on while new sensors are stabilizing, but functioning batteries must be installed in the instrument. If the instrument is a NiMH unit, a powered charger should be attached to the instrument for the duration of the stabilization period.

Sensor	Stabilization Period
Oxygen (54-25-90)	1 hour
LEL (54-25-80(all versions))	5 minutes
All Toxic sensors except those shown below	15 minutes
54-25-04 NH_3 Sensor	24 hours

11. The Cannonball3 will automatically recognize the changes that have been made upon turn on and display the "Needs Cal" message.

12. Recalibrate the Cannonball3 with calibration gas appropriate for the new sensor before the instrument is put back into service.

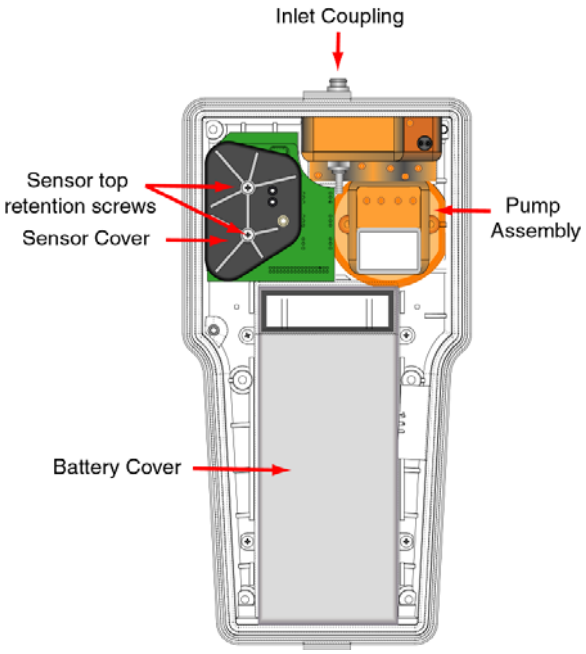


Figure 2.6.3 Internal assembly diagram

Cannonball3 programming includes safeguards to recognize maladjusted sensors. If the settings on the new sensor are significantly different from those of the old sensor it will trigger a message that the sensor is reading "Too Low" or "Too High" for One-Button Auto-Calibration fresh air adjustment.

Once the new sensor has been fresh air calibrated using the "manual" calibration procedures, it will then be possible to do subsequent fresh air and span calibrations by using the mode button and One-Button Auto-Calibration procedures.

Note: The first fresh air calibration adjustment after installation of a new sensor should be done using the "manual" calibration procedure as discussed in section 4.6 of this manual.

2.6.4 Missing sensor

The Cannonball3 is able to recognize when a sensor is removed or becomes disconnected while the instrument is in normal operation. Disconnection of a sensor while the instrument is turned on will trigger a missing sensor alarm, the corresponding channel of the display will show an "X" in place of the normal sensor readings and the audible and visible alarms will be activated.

2.6.5 "Sensor not found"

If the Cannonball3 is suddenly unable to read the EEPROM of a smart sensor currently installed the channel will "X" out and the audible and visual alarms for the affected sensor channel will be activated.

If a smart sensor is removed while the instrument is turned off without being replaced with another sensor, a message will be displayed during the start-up sequence indicating that the sensor is missing. Pressing the MODE button acknowledges the condition, and allows the use of the instrument for those sensors that have been successfully detected.

Chapter 3. Advanced Functions

The microprocessor circuitry in the Cannonball3 makes modifications to the operational set-up parameters easy. By using the MODE button and four navigation arrows located on the instrument keypad, the user can reach the Main Menu, which provides access to the operational set-up choices for the instrument.

Note: This chapter covers advanced functions in units without the datalogger upgrade. Some menu items may be slightly different for instruments with the datalogger upgrade. Chapter 5 covers datalogging options in detail.

Caution: Reprogramming the Cannonball3 is reserved for authorized personnel.

3.1 The Main Menu

The Main Menu provides access to all user-configurable functions of the Cannonball3.

3.1.1 Entering the Main Menu

1. Turn the instrument on and wait until the gas readings screen appears.
2. Press the MODE button until the information screen is displayed.

```
INFORMATION

Date            31 JUL 04
Time of day     14:51
Runtime         0:00
Points logged   0
Temperature     77F  25C
Battery         6.6V

                EXIT
                MENU
```

3. Hold down the left navigation arrow for 3 seconds or until EXIT appears and is highlighted.

```
INFORMATION

Date            31 JUL 04
Time of day     14:51
Runtime         10:07
Points logged   100
Temperature     77F  25C
Battery         6.6V

                EXIT
                MENU
```

4. Press the down navigation arrow once to highlight MENU and press the MODE button.

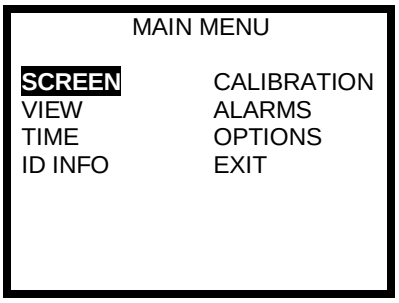
```
MAIN MENU

SCREEN          CALIBRATION
VIEW            ALARMS
TIME            OPTIONS
ID INFO         EXIT
```

3.2 The Screen Menu

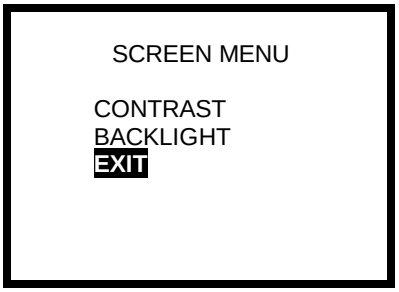
The Screen Menu provides access to the Cannonball3's adjustable contrast and backlight settings.

3.2.1 Entering the Screen Menu

1. Enter the Main Menu as described above in section 3.1.1.



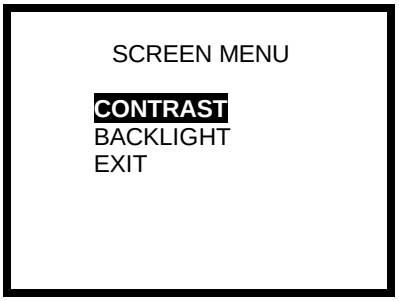
2. Use the navigation arrows highlight SCREEN and then press the MODE button to enter the Screen Menu.



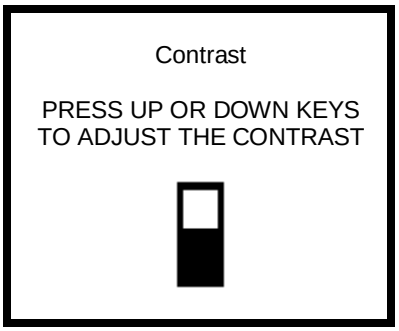
3.2.2 Adjusting the contrast

Adjustments to the screen contrast are made as follows:

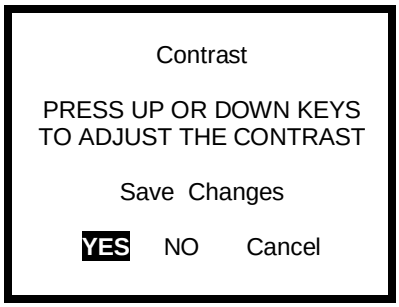
1. Enter the Screen Menu as described above in section 3.2.1.



2. Use the up navigation arrow to highlight CONTRAST and press the MODE button.



3. Adjust the contrast with the up and down navigation arrows. When the contrast reaches the desired level press the MODE button.

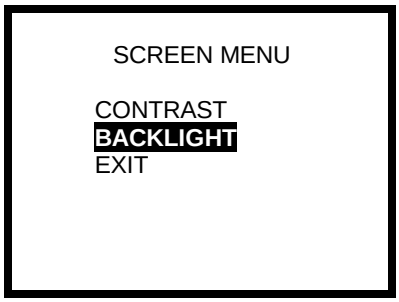


4. Press the MODE button once the Contrast has been properly adjusted.

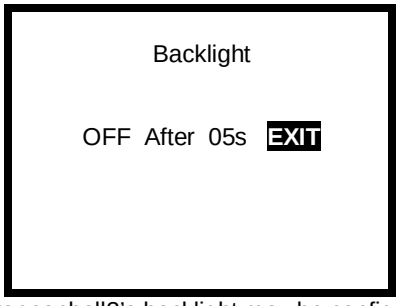
3.2.3 Adjusting the backlight

The backlight settings control the length of time that the backlight will remain on after the instrument recognizes a low light condition. The backlight may also be set to remain on always. To adjust the backlight settings:

1. Enter the Screen Menu as described above in section 3.2.1.



2. Use the up navigation arrow to highlight BACKLIGHT and press the MODE button.

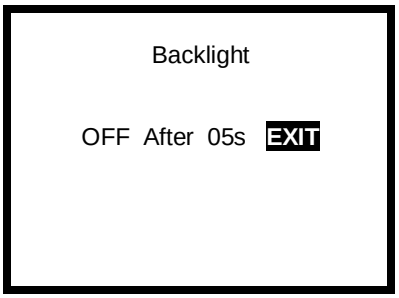


The Cannonball3's backlight may be configured to either be "ON Always" or to automatically turn off after an interval of between 5 and 90 seconds.

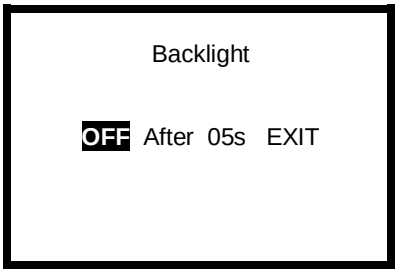
3.2.3.1 Backlight ON Always

To turn the Cannonball3's backlight "ON Always", perform the following steps:

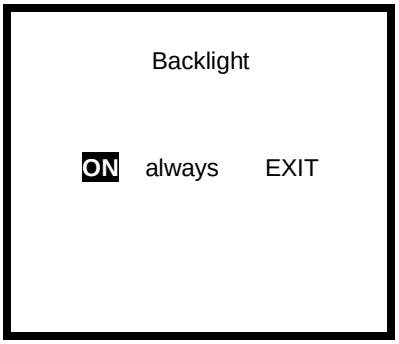
1. Follow the instructions above in section 3.2.3 to reach the Backlight settings.



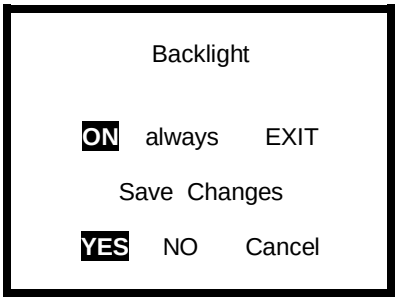
2. Use the right and left navigation arrows to highlight OFF.



3. The up and down navigation arrows are used to toggle between “OFF After” to “ON always.



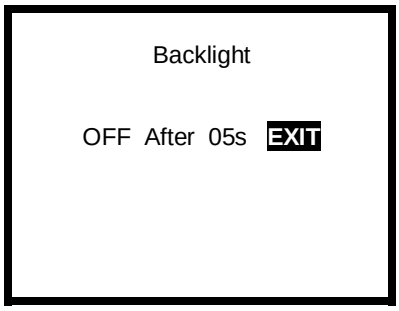
4. Press the MODE button with ON highlighted to confirm the new setting



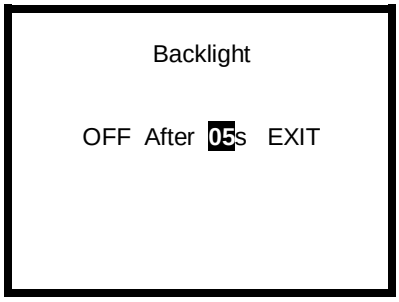
5. Press the mode button with YES highlighted to save the new backlight setting.

3.2.3.2 Adjusting the backlight interval

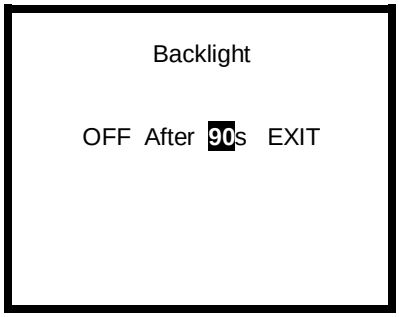
1. Follow the instructions above in section 3.2.3 to reach the backlight settings.



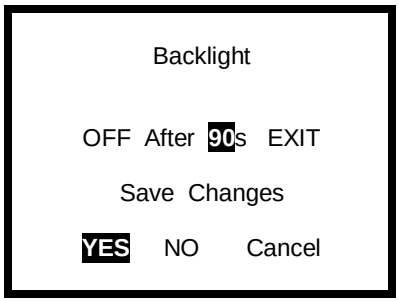
2. Use the right and left navigation arrows to highlight the time interval in seconds.



3. Use the up and down navigation arrows to adjust the interval to any length of time between 5 and 90 seconds.



4. Once the appropriate interval is reached, press the MODE button.



5. Press the mode button with YES highlighted to save the new interval setting.

3.3 The Calibration Menu

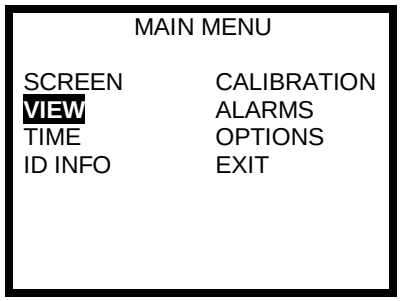
All calibration functions are covered in detail in Chapter 4.

3.4 The View Menu

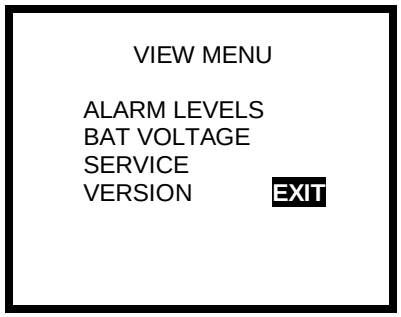
Many of the Cannonball3’s user-adjustable settings may be seen, but not adjusted through the View Menu.

3.4.1 Entering the View Menu

1. Enter the Main Menu as described above in section 3.1.1.

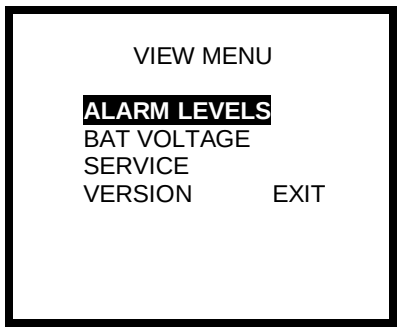


2. Use the navigation arrows to highlight VIEW and press the MODE button. The View Menu will then be shown.

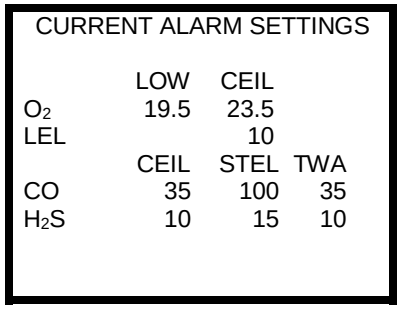


3.4.2 View alarm levels

1. Enter the View Menu as discussed above in Section 3.4.1.



2. Use the navigation arrows to highlight ALARM LEVELS and press the MODE button. The current alarm settings screen will then be shown.

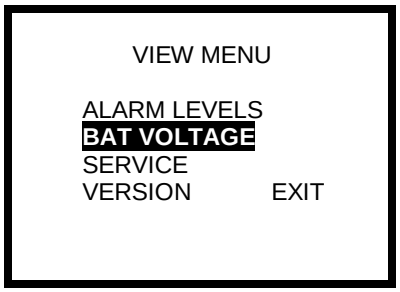


3. Press the MODE button to return to the Main Menu.

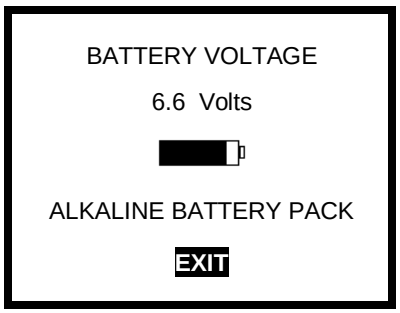
Note: The Cannonball3 will automatically return to the Main Menu approximately 5 seconds after reaching the view current alarm settings screen.

3.4.3 View battery voltage

1. Enter the View Menu as discussed above in section 3.4.1



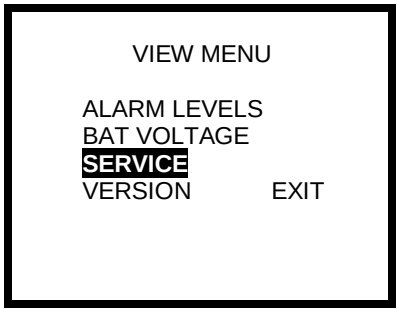
2. Use the navigation arrows to highlight BAT VOLTAGE and press the MODE button. The battery voltage screen will be shown.



3. Press the MODE button to return to the Main Menu.

3.4.4 View service information

1. Enter the View Menu as discussed above in section 3.4.1.

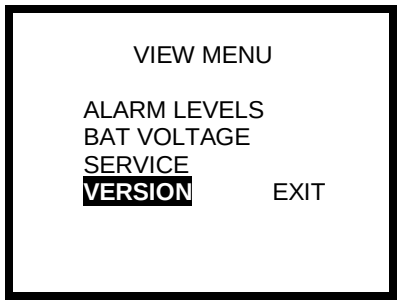


2. Use the navigation arrows to highlight SERVICE and press the MODE button. The service information screen will be shown.

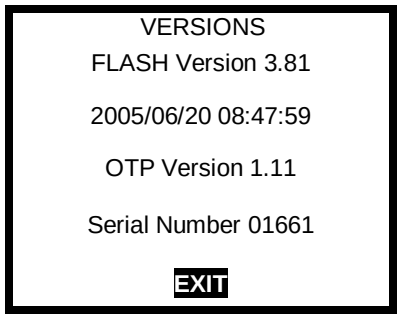
3. Press the MODE button to return to the Main Menu.

3.4.5 View software version

1. Enter the View Menu as discussed above in section 3.4.1



2. Use the navigation arrows to highlight VERSION and press the MODE button. The software version screen then be shown.



3. Press the MODE button to return to the Main Menu.

3.5 The Alarms Menu

Cannonball3 gas alarms are user-adjustable and may be set anywhere within the range of the sensor channel. When an alarm set point is exceeded for a sensor, a loud audible alarm sounds, and the three bright red LED alarm lights blink.

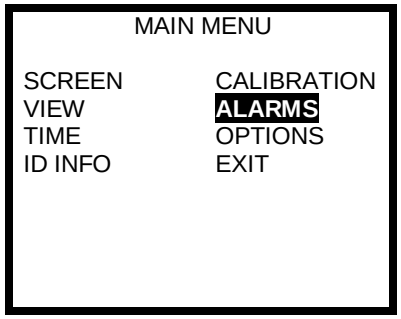
Cannonball3 alarms are self-resetting unless the alarm latch is enabled. With the alarm latch disabled, visible and audible alarms cease when readings drop back below the pre-set alarm levels. With the alarm latch enabled, visible and audible alarms continue to sound after the atmospheric hazard has cleared. The user must then manually reset them by pressing the MODE button.

Alarm latch procedures are discussed in section 3.5.3.

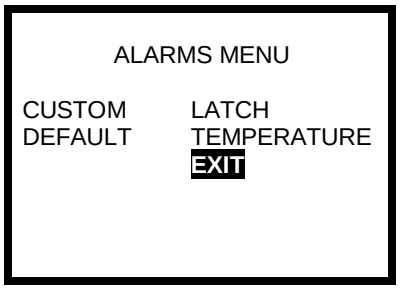
Factory default settings can be restored at any time during normal operation by using the procedures discussed in section 3.5.4.

3.5.1 Entering the Alarms Menu

1. Enter the Main Menu as discussed above in section 3.1.1.



2. Use the navigation arrows to highlight ALARMS and press the MODE button. The Alarms Menu will then be shown.

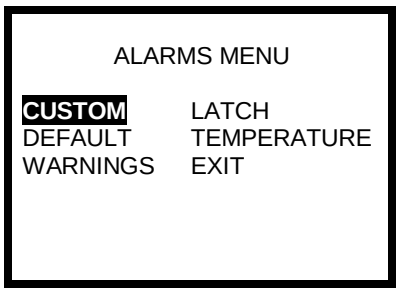


3.5.2 Custom alarm settings

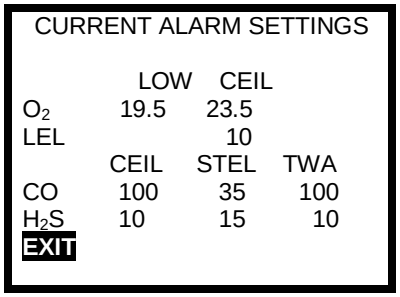
Cannonball3 gas alarms are user-adjustable and may be set anywhere within the range of the sensor channel.

To customize alarm settings:

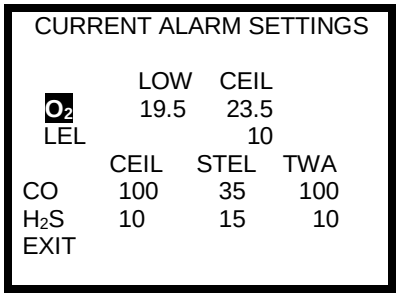
1. Enter the Alarm Menu as described above in section 3.5.1.



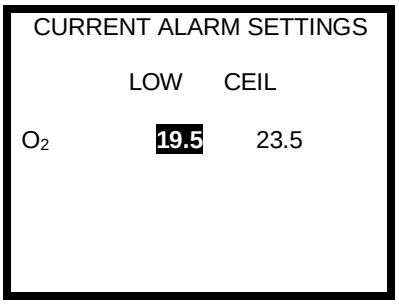
2. Use the navigation arrows to highlight CUSTOM and press the MODE button. The current alarm settings screen will then be shown.



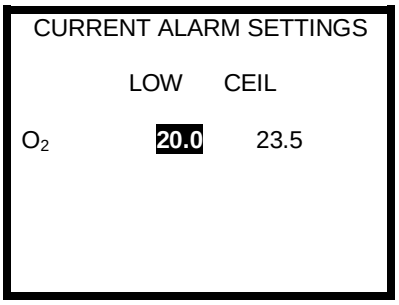
3. To modify alarm settings, use the up and down navigation arrows to select the specific sensor channel that requires adjustment.



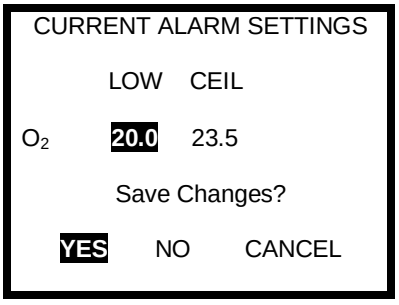
4. Press the MODE button to confirm the selection.



5. Use the right and left navigation arrows to select the specific alarm for modification. Once the specific alarm is selected, use the up and down navigation arrows to modify the current alarm setting.



6. When the alarm adjustment for a particular sensor is complete, press the MODE button to enter the new setting.



7. Press the MODE button with YES highlighted to save the new alarm settings. The instrument will then return to the current alarm settings screen.

3.5.3 Alarm and OK latches

The Cannonball3 includes alarm latch and OK latch functions that can be enabled or disabled according to the user's requirements.

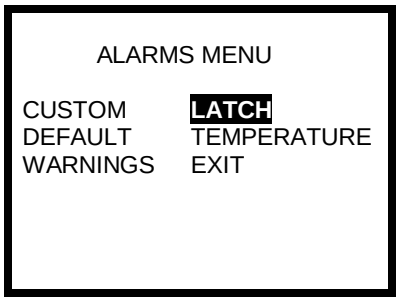
3.5.3.1 Alarm latch settings

When the Cannonball3's alarm latch is enabled, the audible and visible alarms will continue to sound after the atmospheric hazard has cleared. To reset the instrument, simply press the MODE button.

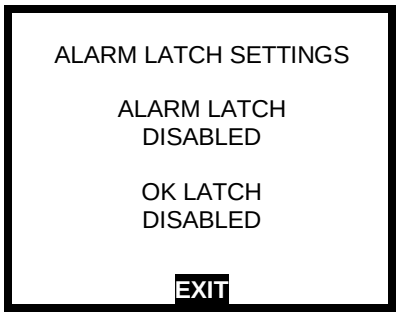
When the Cannonball3's alarm latch is disabled and the alarm condition is no longer present, the instrument automatically returns to normal operation, and the visible and audible alarms cease without further input from the user.

To adjust the alarm latch settings do the following:

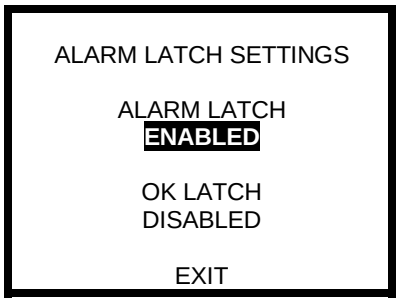
1. Enter the Alarm Menu as described above in section 3.5.1.



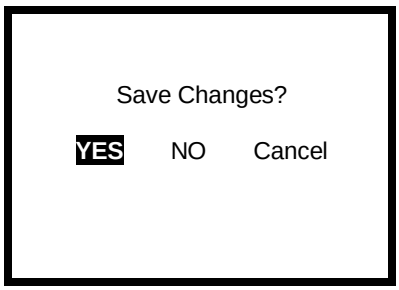
2. Use the navigation arrows to highlight LATCH and press the MODE button. The alarm latch settings screen will then appear.



3. Use the up and down navigation arrows to select the ENABLED/DISABLED setting for the alarm latch.



4. Use the left and right navigation arrows to toggle between ENABLED and DISABLED. Once the desired setting is reached, press the MODE button to confirm the selection.



5. Press the MODE button with YES highlighted to save the new alarm latch setting.

3.5.3.2 OK latch settings

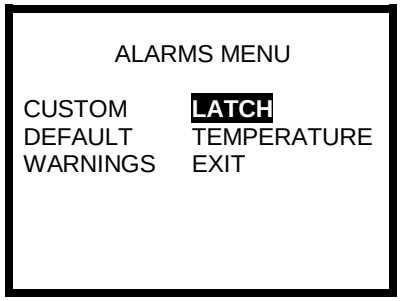
The OK latch is only operational while the Cannonball3 is Text Only mode.

While in Text Only mode with the OK latch enabled, once an alarm condition clears, the instrument will continue to display numeric readings for the sensor that was in alarm. This allows the user to know that an alarm condition was present during the current operating session.

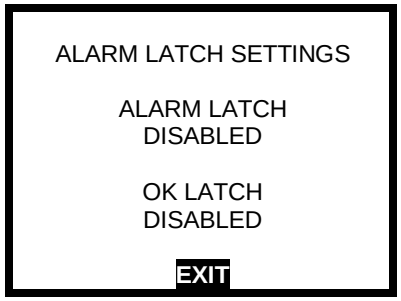
With the OK latch disabled, after an alarm condition, the Cannonball3 will again display OK for the sensor that was in alarm.

To adjust the OK latch settings:

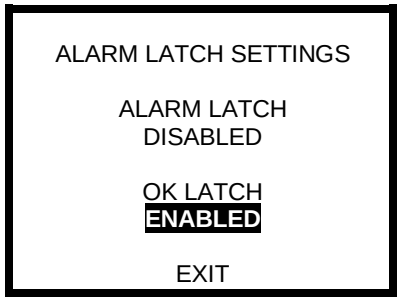
1. Enter the Alarms Menu as described above in section 3.5.1.



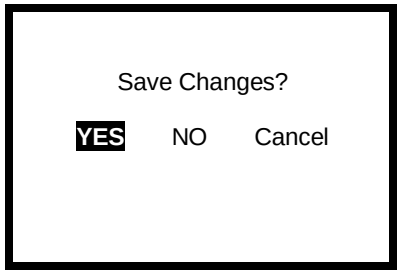
2. Use the navigation arrows to highlight LATCH and press the MODE button. The alarm latch settings screen will then be shown.



3. Use the up and down navigation arrows to select the ENABLED/DISABLED setting for the OK latch.



4. Use the left and right navigation arrows to toggle between ENABLED and DISABLED. Once the appropriate setting is reached, press the MODE button to confirm your selection.



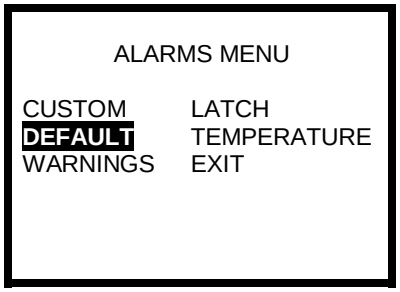
5. Press the MODE button with YES highlighted to save the new alarm latch settings.

3.5.4 Default alarm settings

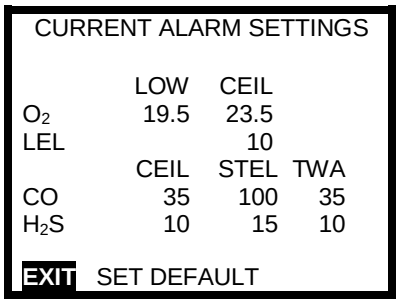
Cannonball3 alarm settings are set at the factory and may be restored at any time while the instrument is being operated in Basic, Basic/Peak or Technician mode.

3.5.4.1 Restore factory default alarm settings

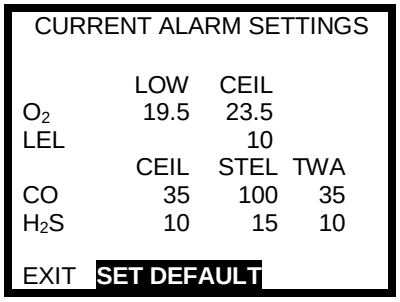
1. Enter the Alarm Menu as described above in section 3.5.1.



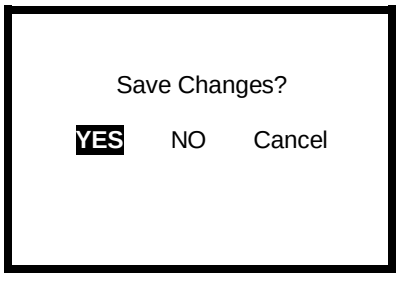
2. Use the navigation arrows to highlight DEFAULT and press the MODE button. The current alarm settings screen will then be shown.



3. Press the right navigation arrow once to highlight SET DEFAULT as shown below.



4. Press the MODE button with SET DEFAULT highlighted to restore factory default alarm settings.



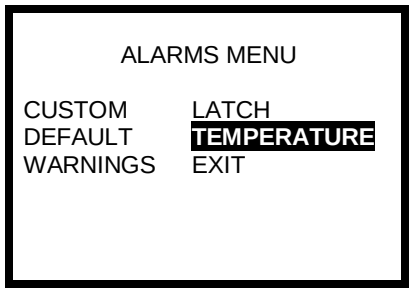
5. Press the mode button with YES highlighted to restore the default alarm settings.

3.5.5 Temperature alarm

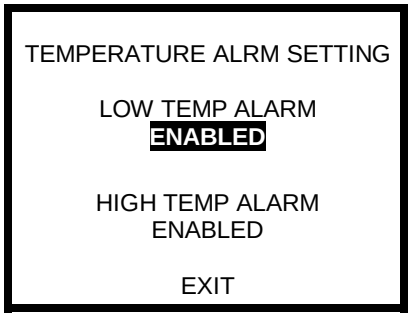
The Cannonball3 includes both high and low temperature alarms for all sensors recognized by the instrument. The temperature alarm setpoints are pre-programmed into the individual sensor EE-proms and may not be modified in any way, but the alarms can be enabled or disabled depending on the needs of the user.

To enable or disable the temperature alarms:

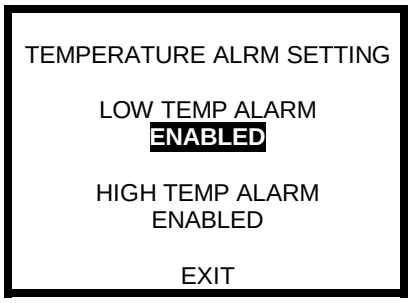
1. Enter the Alarm Menu as described above in section 3.5.1.



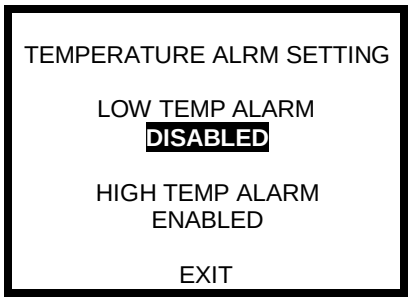
2. Use the navigation arrows to highlight TEMPERATURE and press the MODE button. The temperature alarms settings screen will then be shown.



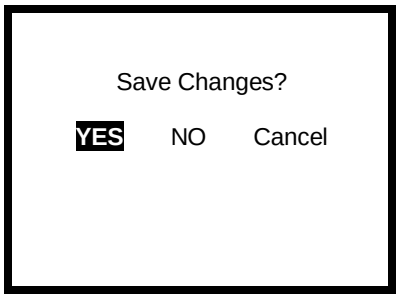
3. Use the up and down navigation arrows to select the high or low temperature alarm.



4. Once the enabled or disabled setting is selected, the right and left navigation arrows are used to toggle between ENABLED and DISABLED.



5. Once appropriate setting is shown, press the MODE button to enter the new setting.



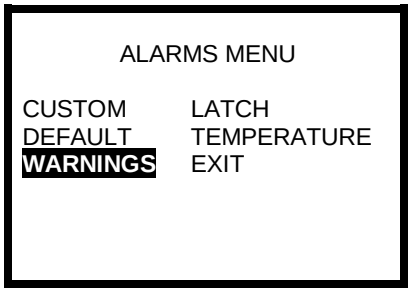
6. Press the MODE button with YES highlighted to save the new temperature alarm settings.

3.5.6 Warning Alarms

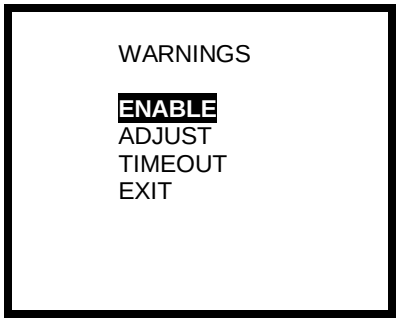
The Cannonball3 includes warning alarms for each sensor channel. The warning alarms are typically set at 50% of the level of the standard alarms.

3.5.6.1 Enable/disable warning alarms

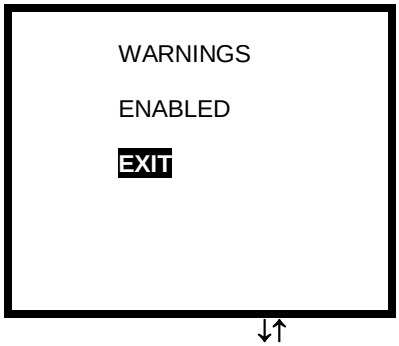
1. Enter the Alarm Menu as described above in section 3.5.1.



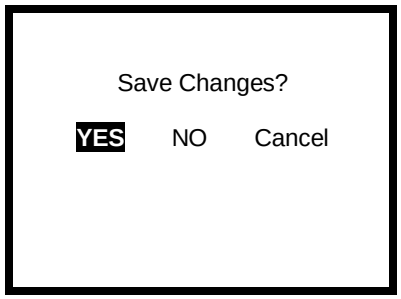
2. Use the navigation arrows to highlight WARNINGS and press the MODE button. The warning alarm settings screen will then be shown.



3. Use the up and down navigation arrows to highlight ENABLE and press the MODE button. The enabled or disabled setting for the warning alarms will be shown between WARNINGS and EXIT. Use the up and down navigation arrows to change the setting.



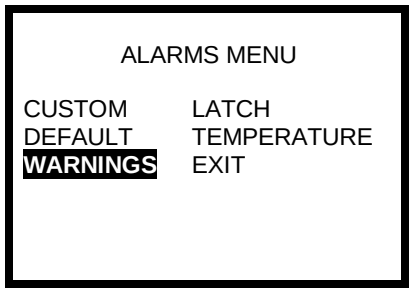
4. Once the correct setting is shown, press the MODE button.



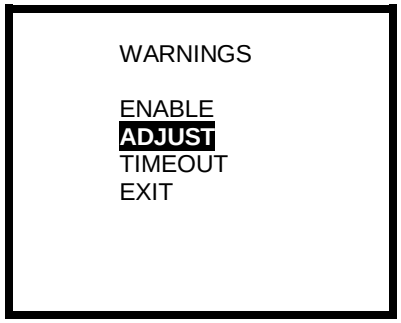
5. Press the MODE button with YES highlighted to save the new warning alarm setting.

3.5.6.2 Adjust warning alarm levels

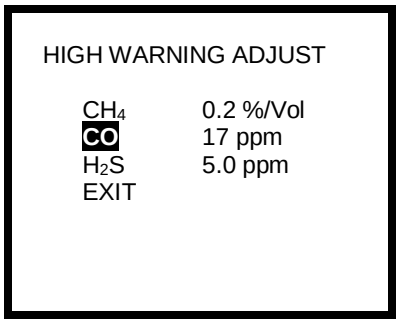
1. Enter the Alarm Menu as described above in section 3.5.1.



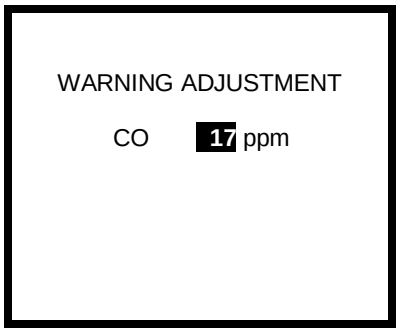
2. Use the navigation arrows to highlight WARNINGS and press the MODE button. The warning alarm settings screen will then be shown.



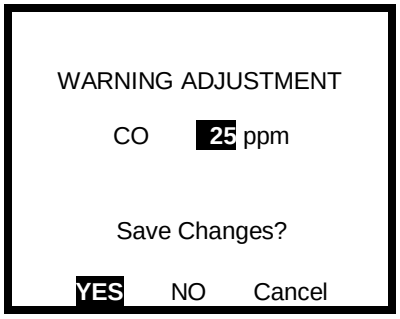
3. Use the up and down navigation arrows to highlight ADJUST and press the MODE button. The High Warning Adjust screen will then be shown.



4. Use the up and down navigation arrows to highlight the alarm for adjustment and press the MODE button.



5. Use the up and down navigation arrows to make the adjustment. Once the warning alarm level has been adjusted as needed, press the MODE button to enter the new setting.



6. Press the MODE button with YES highlighted to save the new warning alarm setting.

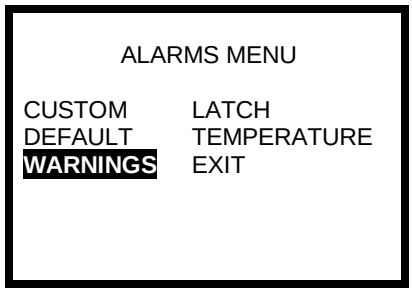
3.5.6.3 Timeout adjustment

The warning alarm can be silenced for a designated amount of time by pressing the MODE button. The timeout adjustment controls the length of time that the warning alarm will remain silent before it will again become audible. The timeout can be set to any whole minute interval between 1 and 60 minutes, or it can be disabled by setting the interval to 0.

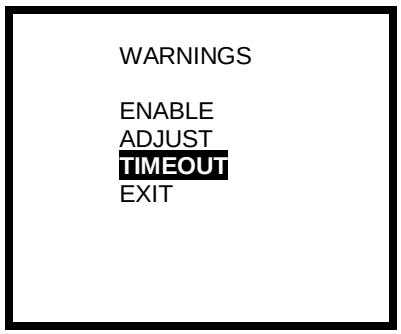
Note: The warning alarm timeout function disables the audible alarm only. The Cannonball3 display will still indicate that a warning alarm is present.

To adjust the timeout interval:

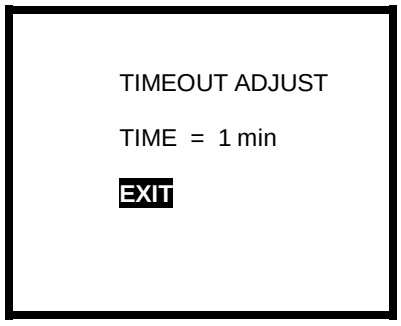
1. Enter the Alarm Menu as described above in section 3.5.1.



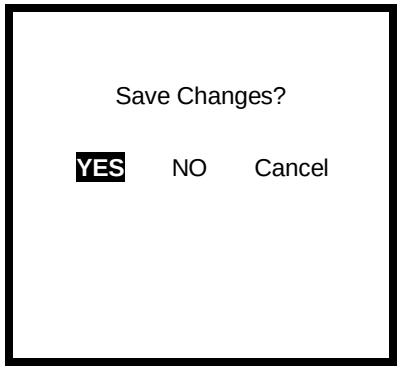
2. Use the navigation arrows to highlight WARNINGS and press the MODE button. The warning alarm settings screen will then be shown.



3. Use the up and down navigation arrows to highlight TIMEOUT and press the MODE button.



4. Use the up and down navigation arrows to adjust the interval as needed. Once the interval has been set as needed, press the MODE button to enter the new setting.



5 Press the MODE button with YES highlighted to save the new warning alarm setting.

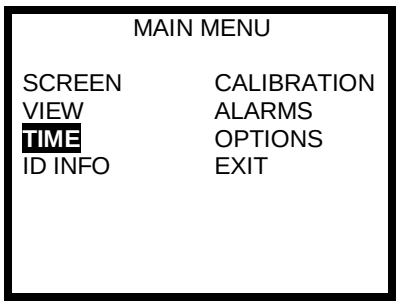
3.6 The Time Menu

For Cannonball3 instruments that do not include the datalogger upgrade, the Time Menu provides access to date and time-related functions.

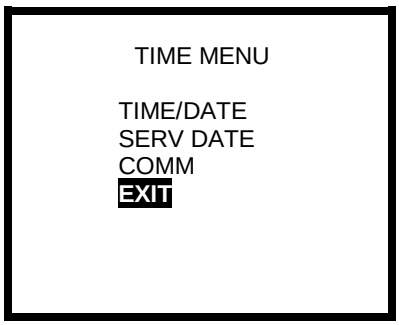
Note: If your Cannonball3 shows DATALOGGER in place of TIME in the Options Menu, proceed to Chapter 5.

3.6.1 Entering the Time Menu

1. Enter the Main Menu as described above in section 3.1.1.



2. Use the navigation arrows to highlight TIME and press the MODE button. The Time Menu will then be shown.

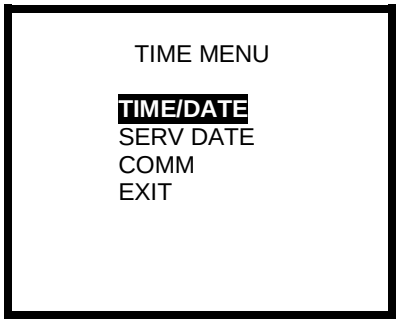


3.6.2 Time and date settings

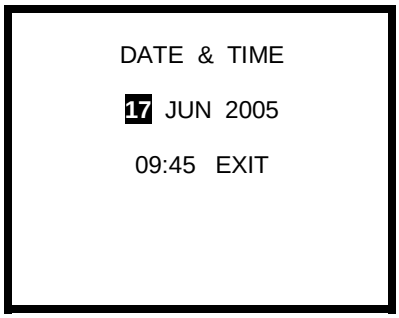
Since the Cannonball3 records instrument data that may be used at a later date, it is important that the time and date be accurate.

To change the time and date:

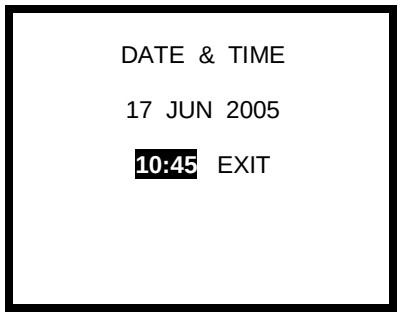
1. Enter the Time Menu as described above in section 3.6.1.



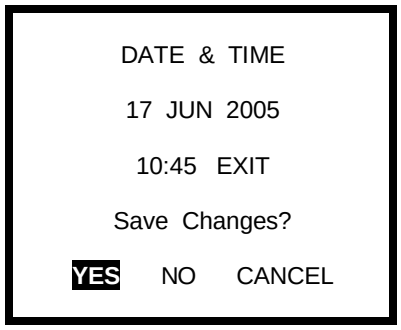
2. Use the navigation arrows to highlight TIME/DATE and press the MODE button.



3. The right and left navigation arrows are used to move back and forth between the day, month, year, and time settings and the EXIT option. Once the time setting that needs to be adjusted is highlighted, the up and down navigation arrows are used to adjust the setting.



4. The MODE button may be pressed at any time to confirm the new time settings.

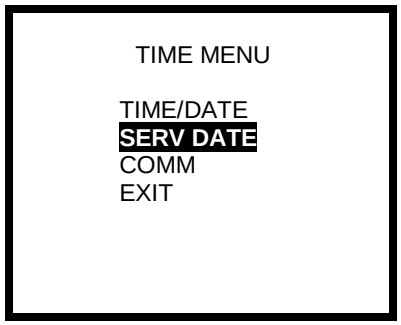


5. Press the MODE button with YES highlighted to confirm the new time and date settings.

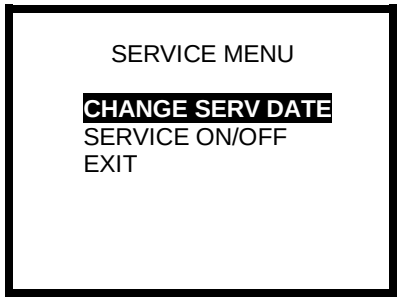
3.6.3 Service date settings

The Cannonball3 can be programmed to automatically remind the user to service the sensors in the unit. To reach the service due date settings for the individual sensors:

1. Enter the Time Menu as described above in section 3.6.1.

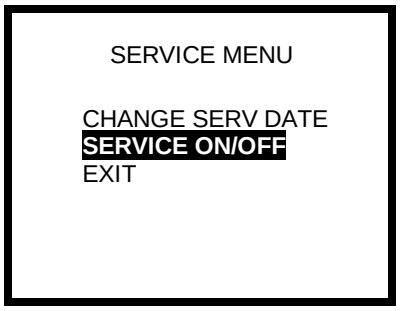


2. Use the navigational arrows to highlight SERV DATE and press the MODE button.

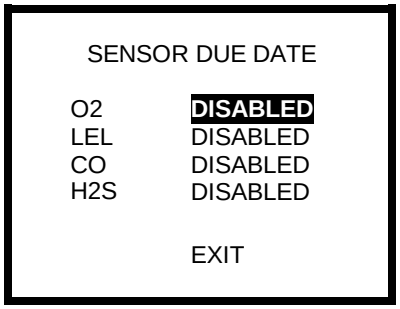


3.6.3.1 Enable/Disable sensor service due date settings

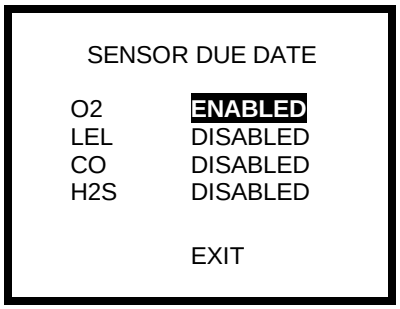
1. Enter the Service Menu screen as described above.



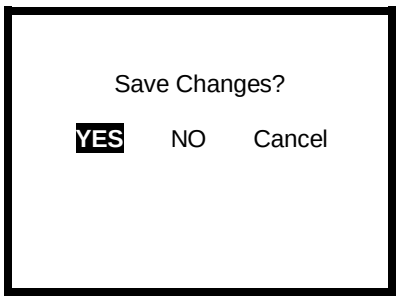
2. Use the up navigation arrows to highlight SERVICE ON/OFF and press the MODE button.



3. To change the service due setting for an individual sensor, use the up and down navigation arrows to highlight the setting adjacent to the sensor, the right or left navigation arrows may then be used to toggle back and forth between “enabled” and “disabled”.



4. Once the sensor due date settings are enabled or disabled as required, press the MODE button to enter the settings.

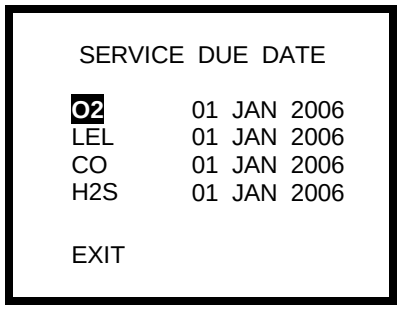


5. Press the MODE button with YES highlighted to confirm the new settings.

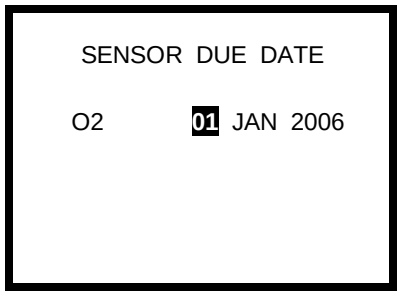
3.6.3.2 Change sensor service due dates

1. Enter the Service Menu as described above.

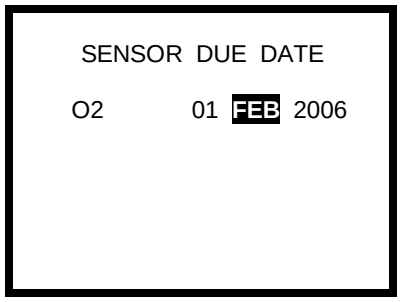
2. Use the up navigation arrows to highlight CHANGE SERV DATE and press the MODE button.



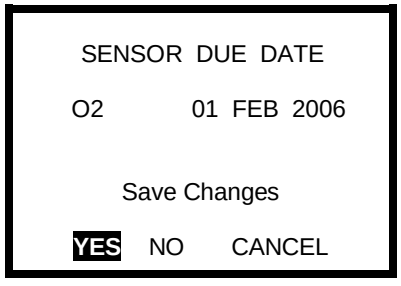
3. Use the up and down navigation arrows to highlight the sensor that requires due date adjustment and press the MODE button.



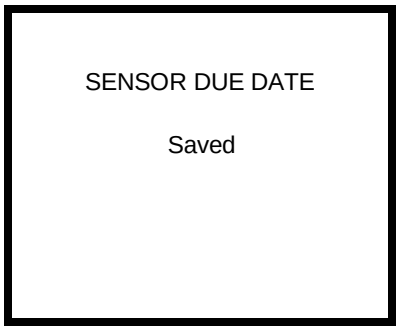
4. Use the right and left navigation arrows to highlight the day, month or year. Then use the up and down navigation arrows to adjust the setting.



5. Once the date has been set, press the MODE button to enter the new date.



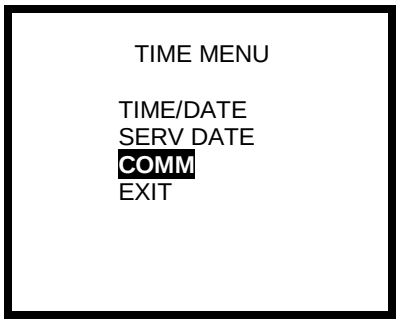
6. Press the MODE button with YES highlighted to confirm the new service due date settings.



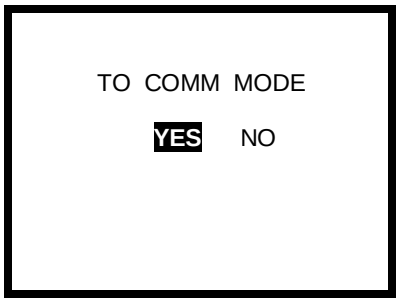
3.6.4 Communications

Communications mode enables the Cannonball3's IrDA port for downloading to or uploading from a personal computer. To enter communications mode, do the following:

1. Enter the Time Menu as described above in section 3.6.1.



2. Use the navigation arrows to highlight COMM and press the MODE button.



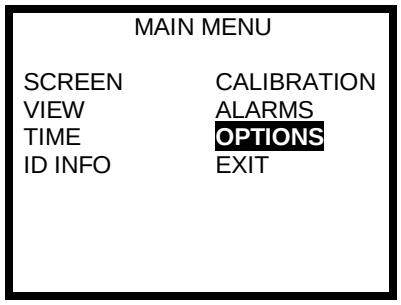
3. Press the MODE button with YES highlighted to enter communications mode and enable the IrDA port.

3.7 The Options Menu

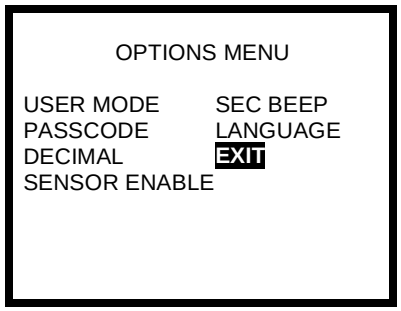
Many of the Cannonball3's higher functions are controlled through the Options Menu, including operating mode selection, and security beep, language, passcode and toxic decimal settings. Each of these options is described in greater detail below.

3.7.1 Entering the Options Menu

1. Enter the Main Menu as described above in section 3.1.1.



2. Use the navigation arrows to highlight OPTIONS and press the MODE button. The Options Menu will then be shown.



3.7.2 User modes

The Cannonball3 offers a choice of four modes of operation: "Text Only", "Basic", "Basic/Peak" and "Technician". Mode selection should be based on how much information is required, the skill level of the user, and the nature of the job.

3.7.2.1 Overview of user modes

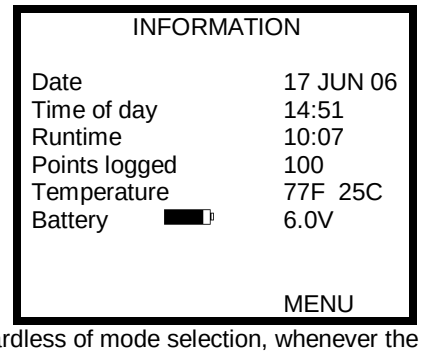
Text Only Mode:
- Displays 'OK' for gas-level concentrations unless an alarm condition is present.
- Upon alarm condition, gas-level concentrations will be displayed.
- 2 screens available (toggle by pressing the MODE button):
  1. Concentration screen (see below)
  2. Information screen (see below)

Basic Mode:
- Gas-level concentrations always displayed.
- Access to calibration functions.
- 2 screens available (toggle by pressing the MODE button):
  1. Concentration screen (see below).
  2. Information screen (see below).

Basic/Peak Mode:
- Gas-level concentrations always displayed.
- Access to calibration functions.
- 3 screens available (toggle by pressing the MODE button):
  1. Concentration screen (see below).
  2. Peak readings screen (see below).
  3. Information screen (see below).

Technician Mode:
- Gas-level concentrations always displayed.
- Access to all advanced functions.
- 4 screens available (toggle by pressing the MODE button):
  1. Concentration readings screen (see below)
  2. Peak readings screen (see below)
  3. STEL/TWA/AVG readings screen (see below)
  4. Information screen (see below)

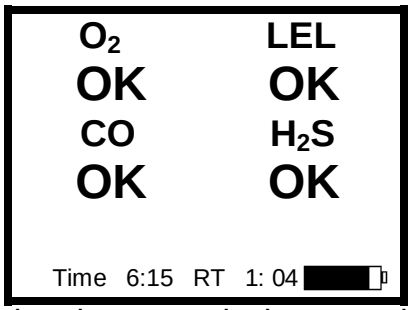
The information screen can be accessed from any of the four operating modes by pressing the MODE button.



Regardless of mode selection, whenever the Cannonball3 is in use it remembers the peak readings of all gases measured, and is calculating both Time Weighted Averages (TWA) and Short Term Exposure Levels (STEL) for any toxic gas sensors installed. Regardless of mode selection, the Cannonball3 will go into alarm whenever any alarm set point is exceeded.

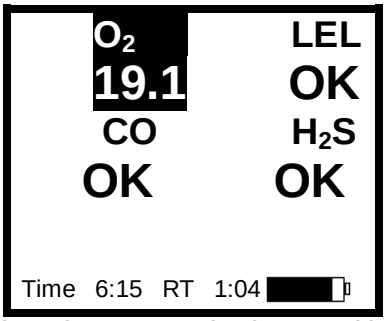
3.7.2.2 Text Only mode

The simplest mode of operation is "Text Only" mode. In Text Only mode during normal operation, the LCD screen does not display numerical readings, only the indication "OK" unless an alarm condition is present.



Text Only mode current gas level screen, no alarms present.

If an alarm condition occurs the indication changes from "OK" to the numerical value, the LED alarm light flashes, and the audible alarm sounds.



Text Only mode current gas level screen with alarm condition.

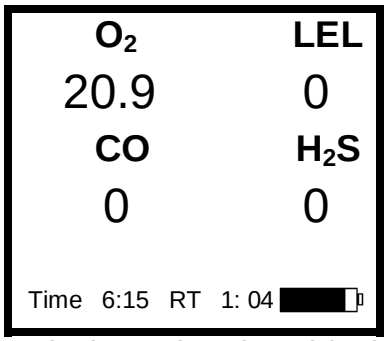
In Text Only mode, the information screen (see above) is also available to the user. Press the MODE button to toggle back and forth between the current gas level and information screens.

Note: It is <u>not</u> possible to initiate the "Auto- Calibration" procedure while the Cannonball3 is operated in the Text Only mode. To initiate Auto-Calibration, the Cannonball3 must be in Basic, Basic/Peak or Technician mode.

3.7.2.3 Basic mode

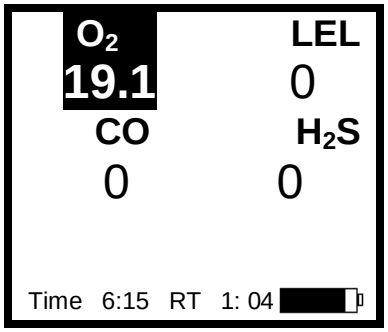
In Basic mode numerical gas level readings are always provided and it is possible to initiate "Auto-Calibration" in order to make fresh air and span calibration adjustments.

Calibration procedures are discussed in detail in Chapter 4.



Current gas level screen in Basic, Basic/Peak and Technician Modes.

An alarm condition occurs when one of the sensor readings exceeds the pre-set alarm level. When an alarm condition occurs, the numerical reading changes to reflect the new value, the LED alarm lights flash, and the audible alarm sounds.



Current gas level screen in alarm condition in Basic, Basic/Peak and Technician Modes.

In Basic mode, the Information screen (see above) is also available to the user. While in Basic mode, press the MODE button to toggle back and forth between the current gas level and information screens.

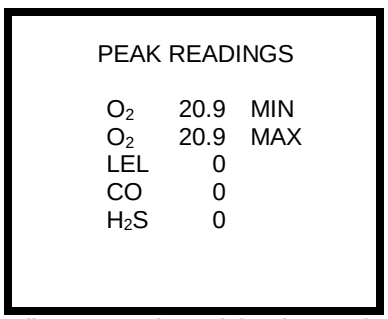
3.7.2.4 Basic/Peak mode

In Basic/Peak mode, numerical gas level readings are always provided and the peak readings screen is available. It is also possible to initiate Auto-Calibration in order to make fresh air and span calibration adjustments.

Calibration procedures are discussed in detail in Chapter 4.

3.7.2.4.1 Peak readings

Peak readings represent the highest and lowest values registered by the instrument during any period of operation. Peak readings are updated continuously.



Peak Readings screen in Basic/Peak or Technician mode.

In Basic/Peak mode, the MODE button is used to toggle back and forth between the current gas level, peak readings, and information screens.

3.7.2.5 Technician Mode

Technician Mode provides access to all advanced functions and displays, including Auto-Calibration.

In Technician mode, the MODE button is used to toggle back and forth between the current gas level, peak readings, STEL/TWA/AVG and information screens.

3.7.2.5.1 STEL Readings

The STEL (Short Term Exposure Limit) for a particular toxic gas is the maximum average concentration to which an unprotected worker may be exposed during any 15 minute interval. The STEL value displayed by the Cannonball3 is the average concentration for the most recently completed 15 minutes of operation.

Note: For the first 15 minutes after the Cannonball3 is initially turned on the STEL reading is a projected value. The Cannonball3 will begin projecting a STEL value after the first 30 seconds of operation. For the first 30 seconds the STEL screen will show an "X" where the reading should be.

The STEL reading is continuously updated. Audible and visible gas alarms will be activated immediately any time the most recent 15 minute average exceeds the STEL alarm set-point.

3.7.2.5.2 TWA readings

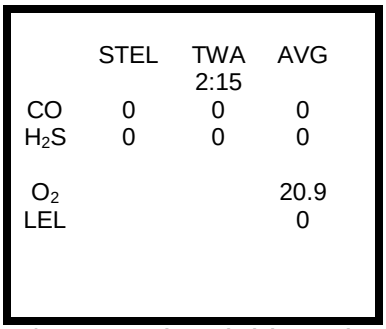
Time Weighted Average or TWA values are calculated by taking the sum of exposure to a particular toxic gas in the current operating session in terms of parts-per-million-hours and dividing by an eight-hour period.

Note: It is not possible to calculate a toxic gas TWA reading until the Cannonball3 has been operating for 15 minutes. For the first 15 minutes after start-up, the TWA screen will show an "X" in place of the calculation. After 15 minutes, the TWA calculation will be shown.

Appendix A discusses Permissible Exposure Limit alarm calculations in greater detail.

3.7.2.5.3 Average readings

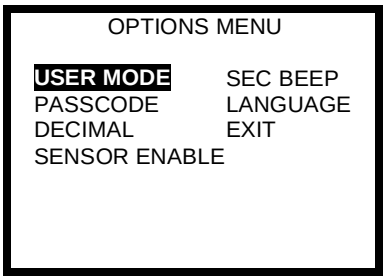
Average readings (AVG) are not projected values. They are the simple arithmetic average values registered by the instrument during any period of operation.



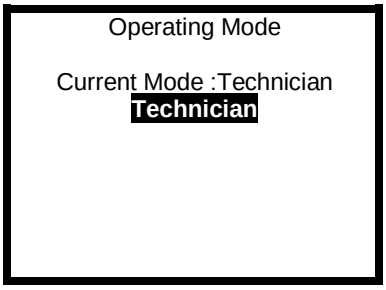
STEL/TWA/AVG screen in Technician mode.

3.7.2.6 Changing the user mode

1. Enter the Options Menu as discussed in section 3.7.1.



2. From the Options Menu use the navigation arrows to highlight USER MODE and press the MODE button. The up and down arrows may then be used to toggle between operating modes.



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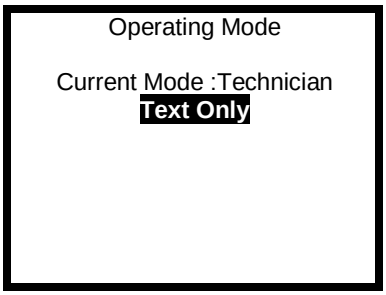

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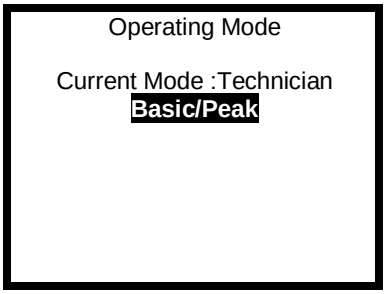

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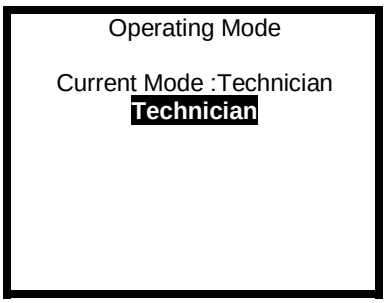
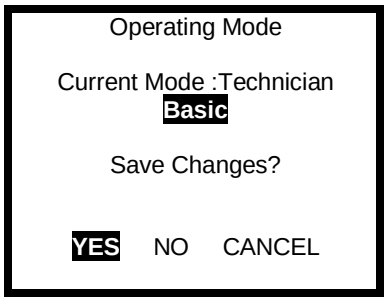


3. Once the preferred operating mode is highlighted, confirm the selection by pressing the MODE button.



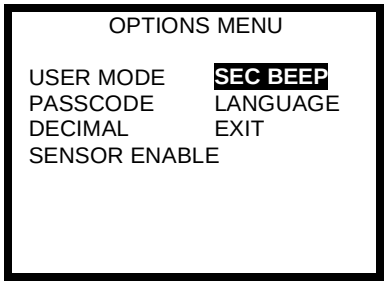
4. Press the MODE button with YES highlighted to accept the new operating mode

3.7.3 Security beep

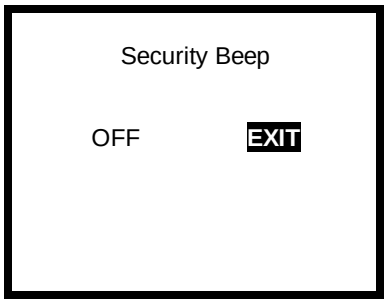
The security beep is an audible alarm that “beeps” on a regular basis while the Cannonball3 is in normal operation. This periodic beep serves as a reminder that the instrument is turned on.

3.7.3.1 Adjusting the security beep

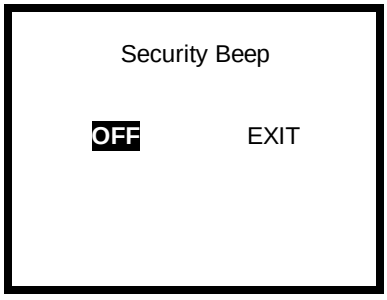
1. Enter the Options Menu as covered above in section 3.7.1.



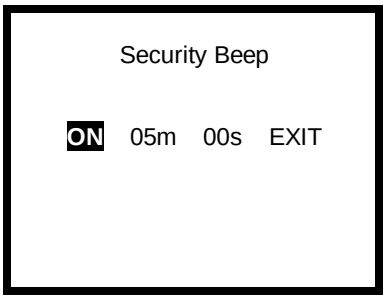
2. Use the navigation arrows to highlight SEC BEEP and press the MODE button.



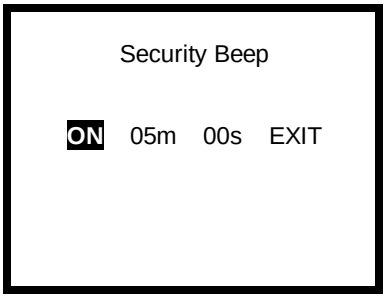
3. Press the left navigation arrow key once to highlight OFF (or ON).



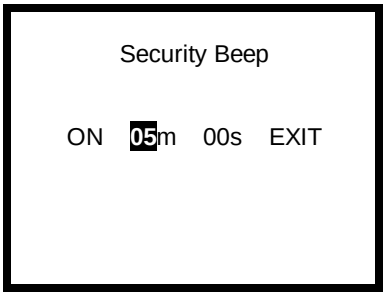
or



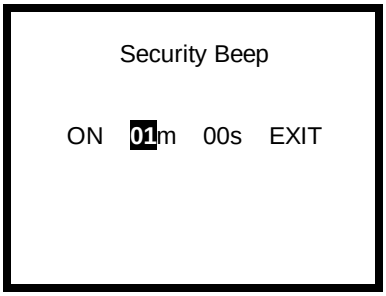
4. With ON or OFF highlighted, the up and down navigation arrows allow the user to toggle between security beep on and security beep off.



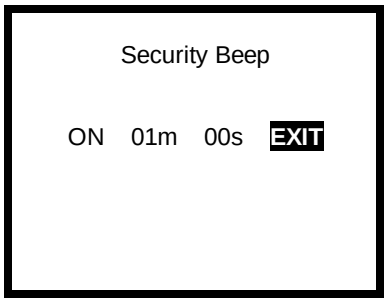
5. The interval setting will appear when the security beep is turned ON (as above). Use the right and left navigation arrows to highlight the interval if it requires adjustment.



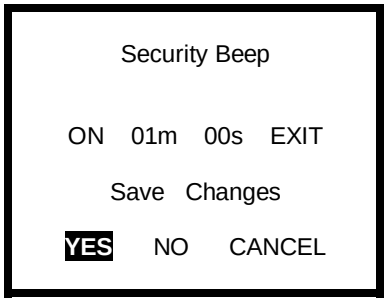
6. Once the interval is highlighted, use the up and down navigation keys to adjust the interval.



7. Once the desired interval is reached use the right and left navigation arrows to highlight EXIT.



8. Press the MODE button with EXIT highlighted to exit the security beep option.



9. Press the MODE button with YES highlighted to save the new security beep settings.

3.7.4 Passcode

Access to the following Main Menu items can be restricted through the Cannonball3's passcode feature: SCREEN, CALIBRATION, ALARMS, DATALOGGER and OPTIONS. With the passcode enabled, access is also restricted to the automatic span calibration.

The Cannonball3 has three passcode settings:

Not Required means that a passcode does not need to be entered to access the subdirectories listed above or to initiate a calibration subroutine.

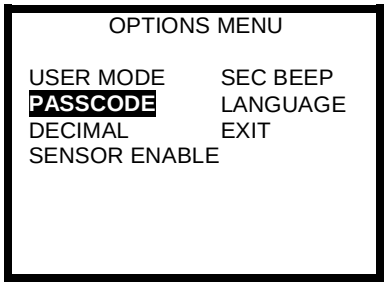
Required Including Fresh Air Cal means that a passcode must be entered to access the subdirectories listed above and to initiate any calibration subroutine.

Required Except For Fresh Air Cal means that a passcode must be entered to access the subdirectories listed above and to initiate a span calibration, but a fresh air calibration may be performed without entering a passcode.

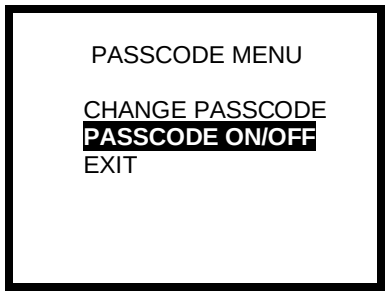
3.7.4.1 Change passcode setting

To enable or disable the passcode option, perform the following steps:

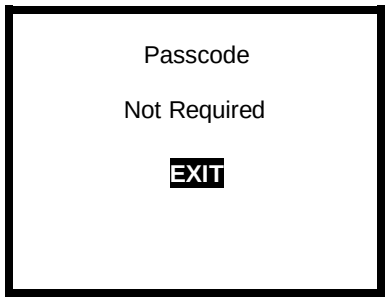
1. Enter the Options Menu as covered above in section 3.7.1.



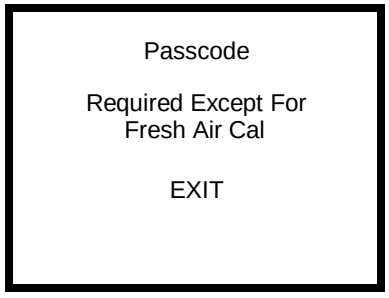
2. Use the navigation arrows to highlight PASSCODE and press the MODE button. The Passcode Menu will then be shown.



3. Use the navigation arrows to highlight PASSCODE ON/OFF and press the MODE button. The current passcode setting will be shown as either “Not Required”,”Required Except For Fresh Air Cal” or ”Required Including Fresh Air Cal”



4. Use the up navigational arrow to change the setting.



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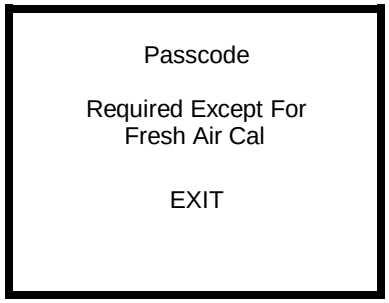
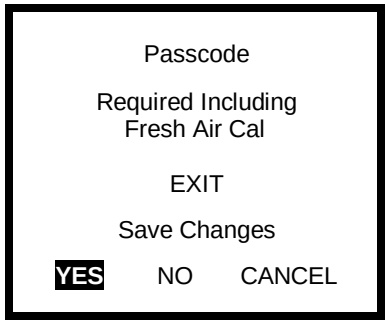


5. Once the desired passcode setting is displayed, press the MODE button to enter the setting.

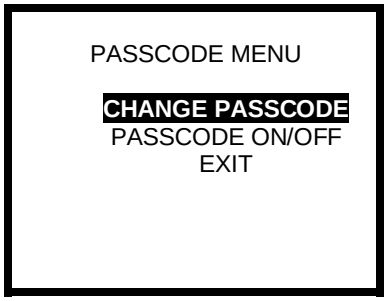


6. Press the MODE button with YES highlighted to save the new passcode setting.

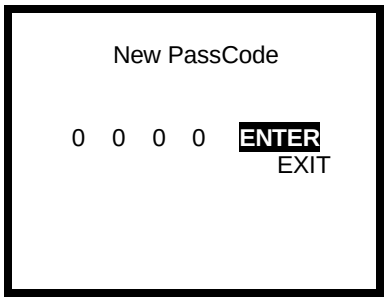
3.7.4.2 Changing the passcode

To change the passcode, perform the following steps:

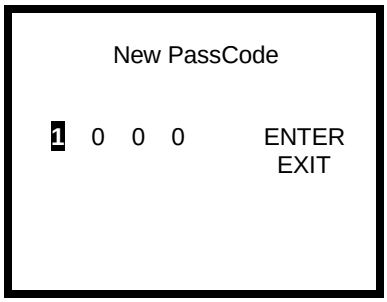
1. Follow steps 1 through 3 above in section 3.7.4.1 to reach the Passcode Menu.



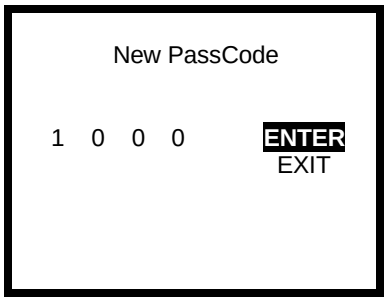
2. Use the up navigation arrow to highlight CHANGE PASSCODE and press the MODE button. The new passcode screen will then be shown:



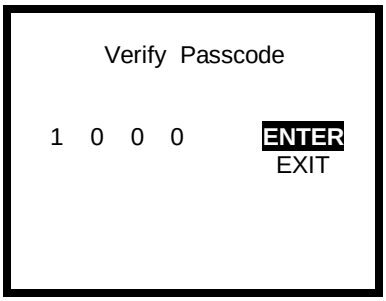
3. Use the right and left navigation arrows to select the digit for change and then use the up and down navigational arrows to change the digit itself.



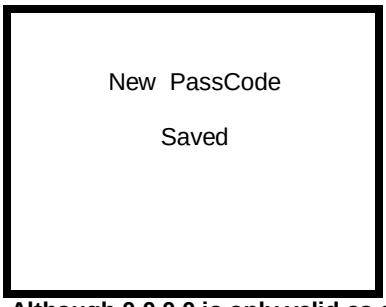
4. Once the desired passcode is shown, use the navigation keys to highlight ENTER.



5. Press the MODE button to enter the new passcode. The Cannonball3 will then proceed to the verification screen where the new passcode will have to be entered in again.



6. Press the MODE button with ENTER highlighted to confirm the new passcode.



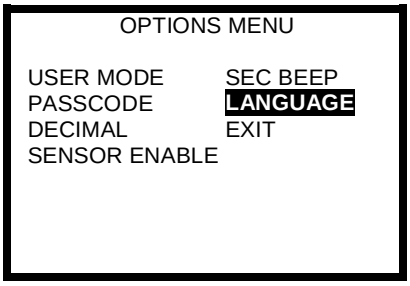
Note: Although 0 0 0 0 is only valid as an initial passcode , once the passcode has been changed, 0 0 0 0 becomes invalid and may never be used as a passcode again.

3.7.5 Language

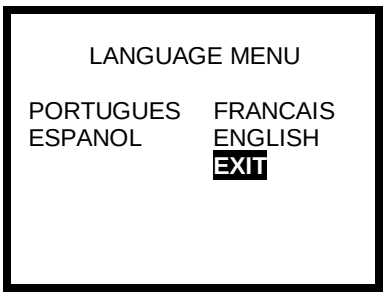
The Cannonball3 can be set to display messages and readings in a variety of languages. The languages currently available are English, French, Portuguese and Spanish.

3.7.5.1 Entering the Language Menu

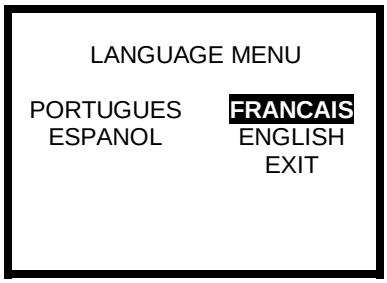
1. Follow the instructions in 3.7.1 to reach the Options Menu.



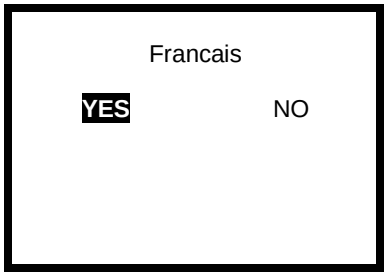
2. Use the navigation arrows to highlight LANGUAGE and press the MODE button.



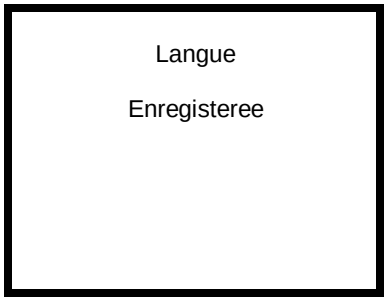
3. Use the navigation arrows to highlight the language that is to be used.



4. Press the MODE button with the appropriate language highlighted enter the new language setting.



5. Press the MODE button with YES highlighted to save the new language settings.



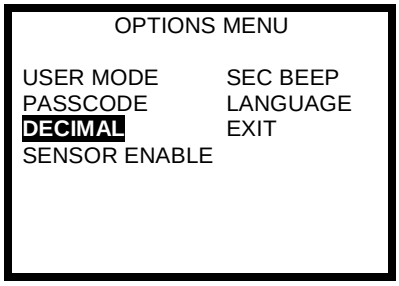
3.7.6 DECIMAL: Changing the precision of the toxic sensor readout

Toxic gas readings may be given in full parts-per-million (PPM) increments, or in tenths of parts-per-million (0.1PPM) increments for some sensors. If the decimal point is enabled, 0.1PPM increments will be shown during normal operation of the toxic sensor. If the decimal point is disabled readings will be shown in full part-per-million increments.

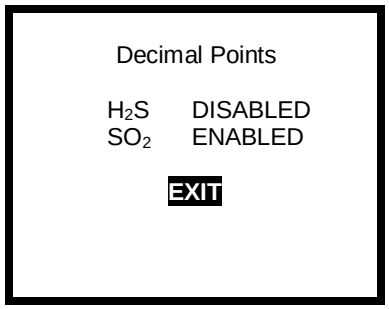
Note: The decimal point for the CO, CO Minus and CO Plus sensors can not be enabled. All CO sensor readings are displayed in full parts-per-million (PPM).

Note: In the event that the Cannonball3 does not have a sensor with a decimal point setting, the instrument will briefly show "Nothing to Adjust" and return to the main menu.

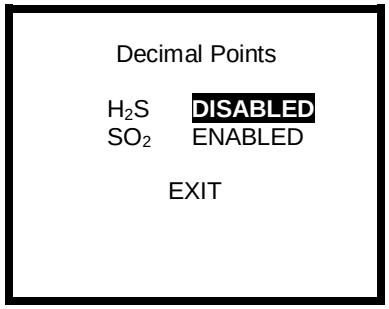
1. Follow the instructions in 3.7.1 to reach the Options Menu.



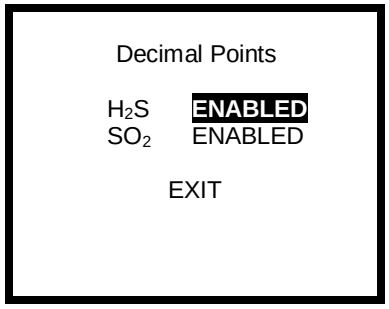
2. Use the navigation arrows to highlight DECIMAL and press the MODE button.



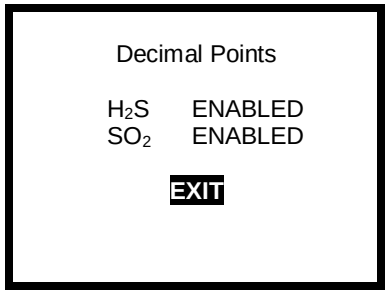
3. Use the up and down navigation arrows to highlight the enabled or disabled setting for the sensor whose decimal point setting requires adjustment.



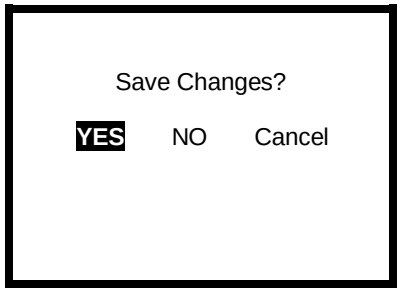
4. Press the left or right navigation button to change the toxic sensor's decimal point setting.



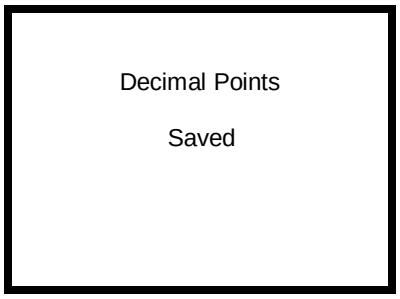
5. If necessary, use the navigation arrows to proceed to other decimal point settings and repeat steps 3 and 4.



6. Once the appropriate decimal point settings have been entered, use the navigation arrows to highlight EXIT and press the MODE button to enter the new settings.



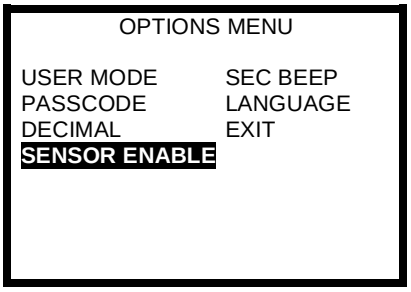
7. Press the mode button with YES highlighted to save the new decimal settings.



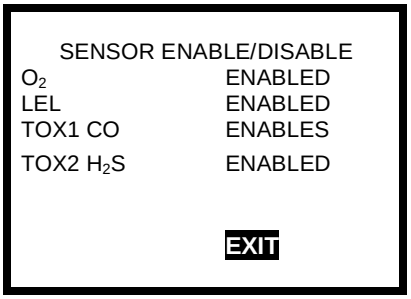
3.7.7 Sensor enable/disable

Sensors in the Cannonball3 can be enabled or disabled as needed. To enable or disable a sensor:

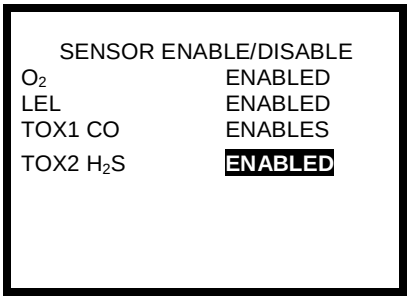
1. Follow the instructions in 3.7.1 to reach the Options Menu.



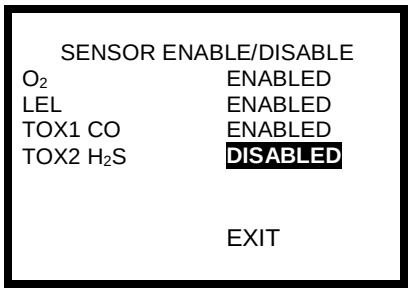
2. Use the navigation arrows to highlight SENSOR ENABLE and press the MODE button.



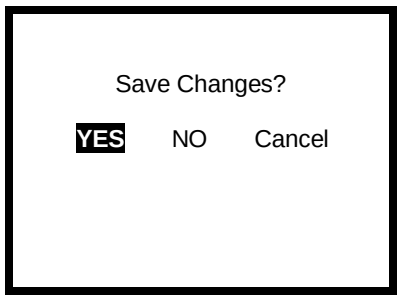
3. Use the up and down navigation arrows to highlight the enabled or disabled setting for the sensor.



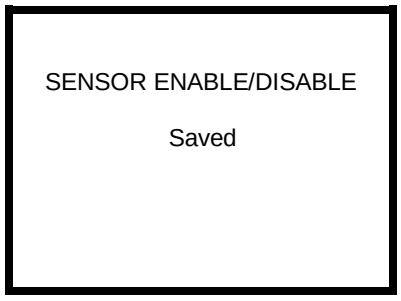
4. Once ENABLED or DISABLED is highlighted, use the right and left navigation arrows to change the setting.



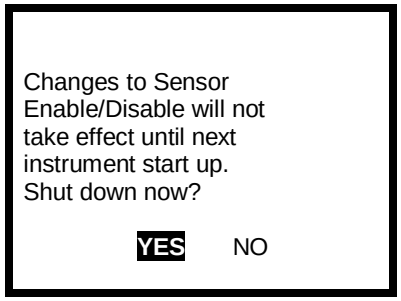
5. Once the correct setting is shown press the MODE button.



6. Click the MODE button with YES highlighted to save the changes.



The changes to the sensor enabled/disabled settings will take effect upon next instrument turn on.



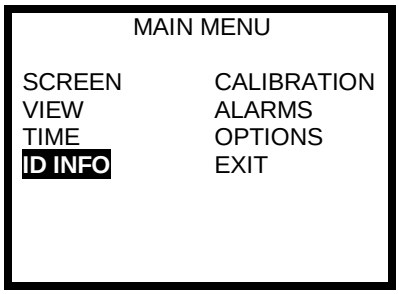
7. Click the MODE button with YES highlighted to shut the Cannonball3 down. Upon turn on the new sensor settings will go into effect.

3.8 ID Info

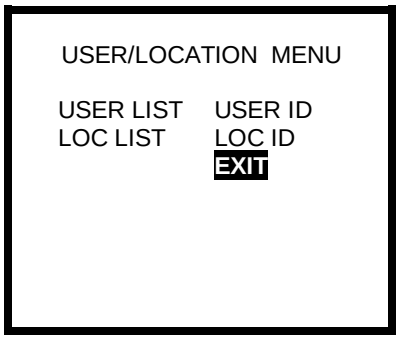
The Cannonball3 can store up to 20 different names and 20 different locations for use in the session memory.

3.8.1 Entering the ID Info Menu

1. Enter the Main Menu as described above in section 3.1.1.
2. Use the navigation arrows to highlight ID INFO as shown below.



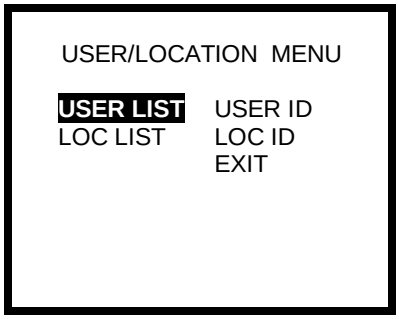
3. Press the MODE button to confirm your selection. The User/Location Menu will then appear:

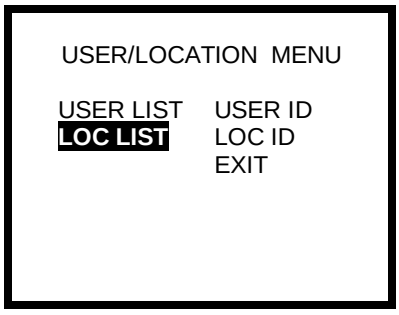


3.8.2 User and location list settings

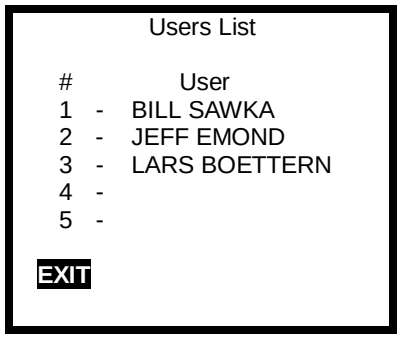
User and location names may be manually entered into the Cannonball3 through the USER LIST and LOC LIST subdirectories.

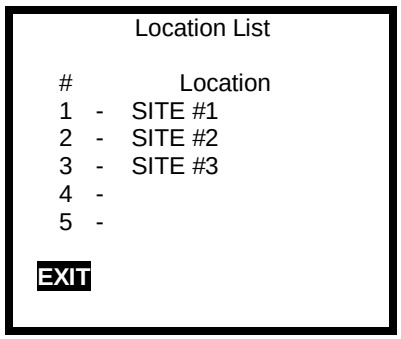
1. Enter the ID INFO subdirectory to reach the USER/LOCATION MENU as described in section 3.8.1. Use the navigation arrows to highlight USER LIST or LOC LIST as shown below.



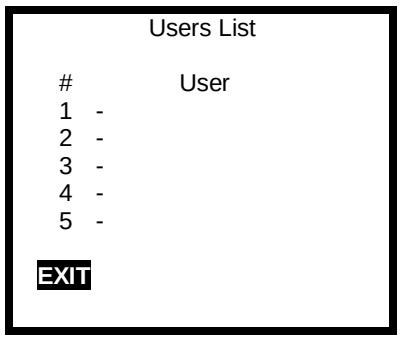


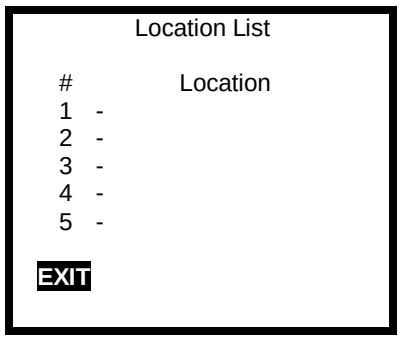
2. Press the MODE button to confirm the selection. The User List or Location List will then be shown.



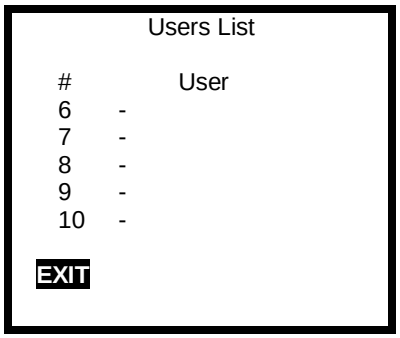


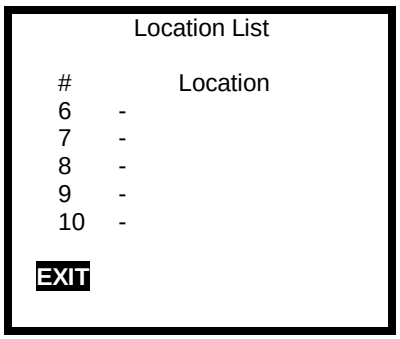
The names that appear in the lists are those that have already been programmed into the instrument. If no names have been added, then the list will be blank as shown below.



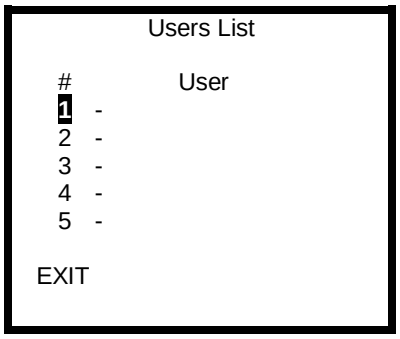


3. The User and Location lists each consist of 4 screens containing 5 names each. With EXIT or a user number highlighted, the right and left navigation arrows are used to scroll though the 4 available screens for each list.

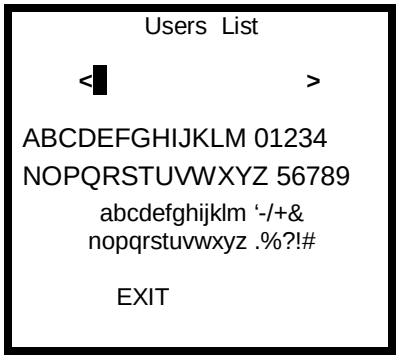




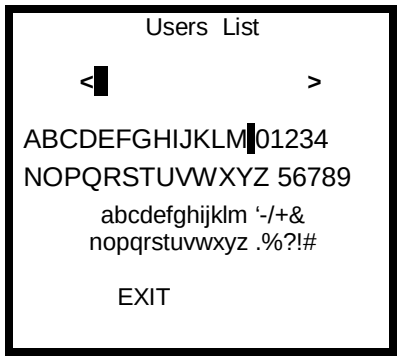
4. Changes to both the Users List and the Location List follow the same procedure. To change a record, use the up and down navigation arrows to highlight the record number as shown below.



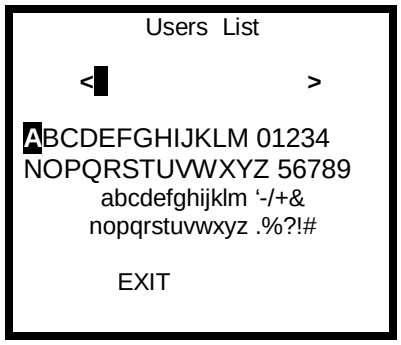
5. Press the MODE button with the user or location number highlighted to access the manual entry features for that particular memory location.



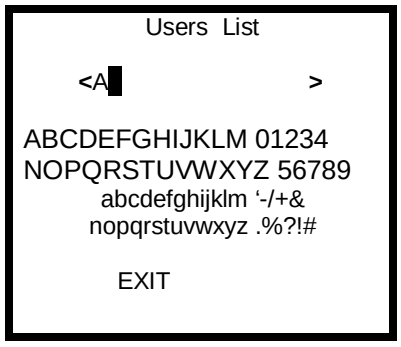
6. There are 14 spaces located between the arrows. Press the MODE button to change the character in the first space. A highlighted cursor will appear between the letter M and the number 0 as shown below.



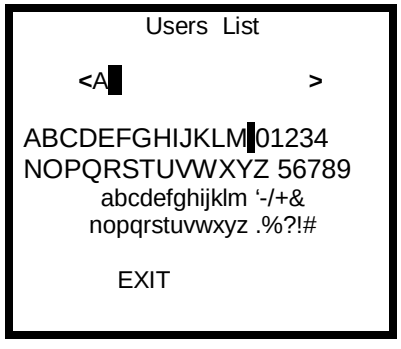
7. Use the navigation arrows to highlight the character required for the space.



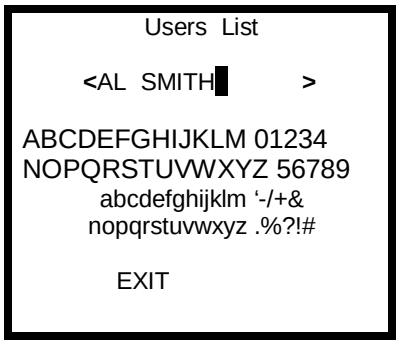
8. With the appropriate character highlighted, press the MODE button to enter the highlighted character into the highlighted space. The cursor will automatically move to the next available space.



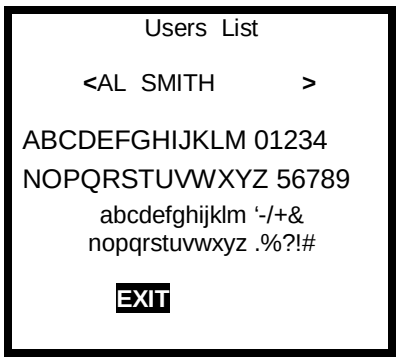
9. Press the MODE button to change the character in the next space. A highlighted cursor will then appear between the letter M and the number 0.



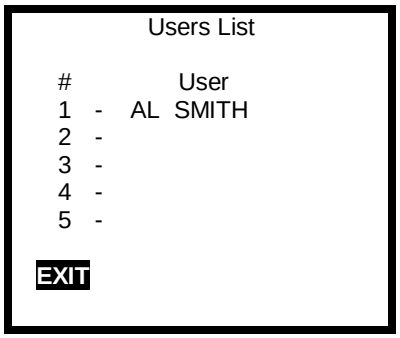
10. Repeat steps 7-9 until the desired entry appears between the arrows.



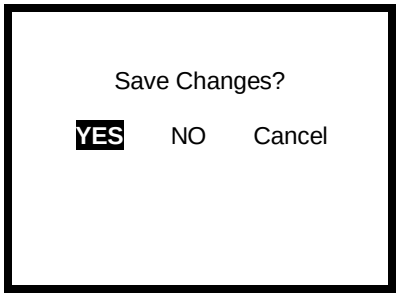
11. When finished use the right and left navigation arrows to move the cursor to EXIT.



12. Press the MODE button with EXIT highlighted to return to the users list screen.



13. Press the MODE button with EXIT highlighted to exit the users list screen.

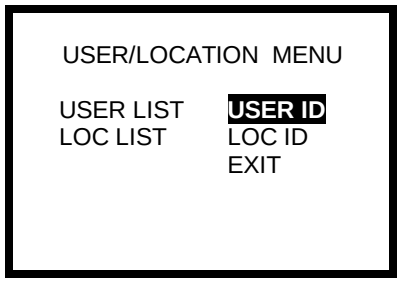


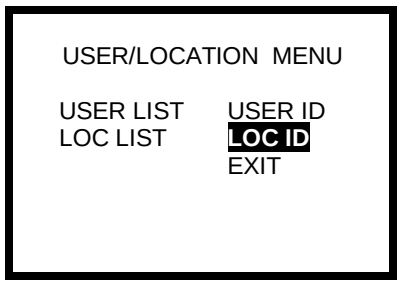
14. Press the MODE button with YES highlighted to save the changes to the user or location list.

3.8.3 Selecting a user or location ID

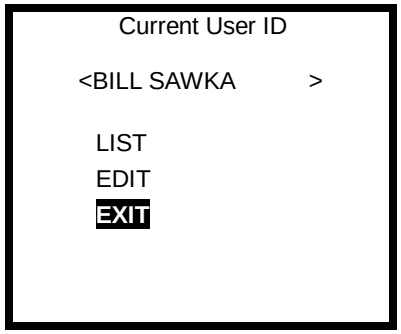
To select a specific name or location from the user or location list for use in the session memory, do the following:

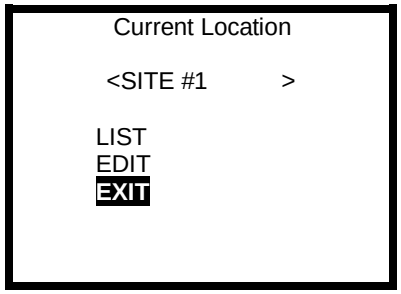
1. From the Main Menu, enter the ID INFO subdirectory to enter reach the USER/LOCATION MENU as described in section 3.8.1. Use the navigation arrows to highlight USER ID or LOC ID as shown below.



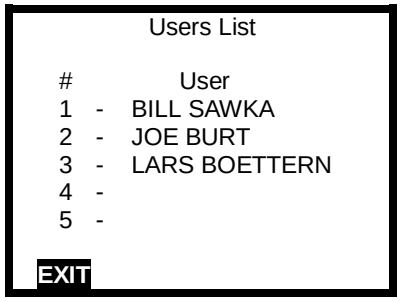


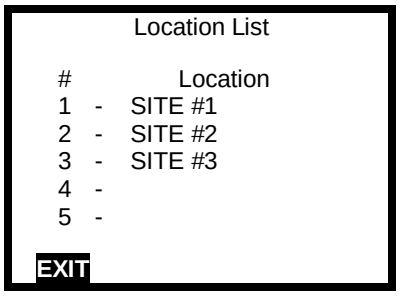
2. Press the MODE button to confirm the selection. The current user or location ID will then be shown.



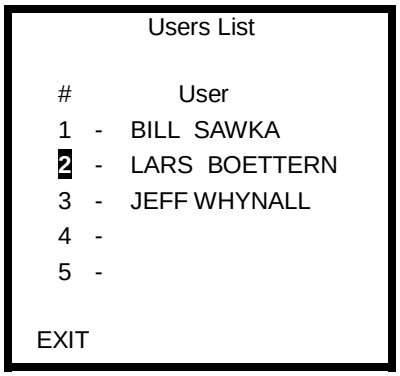


3. To select a different user or location ID for the current operating session, use the up and down navigation arrows to highlight LIST and press the MODE button. The users list or locations list will then be shown.

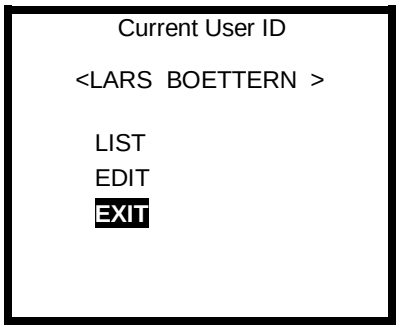




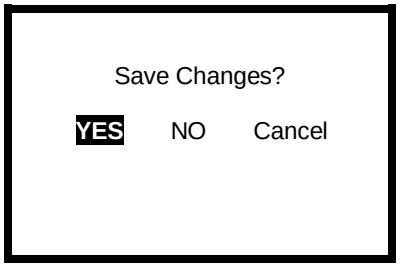
4. To select a new user or location ID, use the up and down navigation arrows to highlight the correct ID number.



5. Press the MODE button with the appropriate user number highlighted to enter the new user ID into the session memory.



6. To accept the new ID, press the MODE button with EXIT highlighted.



7. Press the MODE button with yes highlighted to save the new user or location ID for the current session.

Note: A new datalogging session is automatically started whenever a change is made to the current user or location ID.

Note: User and location ID settings may also be modified through the EDIT choice in step 2 of section 3.8.3 above. Simply select EDIT and follow the instructions in section 3.8.2 beginning with step 4.

Chapter 4. Calibration

The Cannonball3 multi-gas detector has been designed for easy calibration. A single control, the on/off MODE button, can be used to both enter “Auto-Calibration” mode and to automatically make calibration adjustments.

Manual and single-sensor calibration procedures can also be initiated by using the navigation arrows located on the instrument.

Sperian Instrumentation’s calibration frequency recommendations are discussed in Appendix E.

Note: If a sensor has just been replaced, it must be allowed to stabilize prior to initiating any of the calibration subroutines detailed below. See section 6.1.1 for further details concerning sensor stabilization requirements.

Note: Chapter 4 covers calibration of Cannonball3 instruments without dilution capability and without the HC/LEL sensor.

For calibration instructions for instruments with dilution capability, proceed to the Cannonball3 Dilution Manual. The part number for the Dilution Manual is 13-186.

For specific calibration instructions concerning the HC/LEL sensor, see the HC/LEL Sensor Addendum to the Cannonball3 Reference Manual. The part number for the addendum is 13-236.

4.1 Verification of accuracy

⚠WARNING Accuracy of the Cannonball3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.

Verification of accuracy is a two step procedure.

Step one is to take the Cannonball3 to an area where the atmosphere is known to be fresh and check the readings. If the readings differ from those expected in fresh air, then a fresh air calibration adjustment must be made.

Step two is to make sure the sensors are accurate by exposing them to an appropriate test gas of known concentration and noting the sensor response. This procedure is known as a functional (bump) test and is described in detail in section 4.4. During the bump test, each of the sensors is challenged with calibration gas sufficient to cause the alarms to activate (when the alarms and calibration gas values are set at the default levels).

Note: Cannonball3 instruments equipped with the ClO2 specific sensor require a chlorine dioxide generator as a calibration gas source.

Sperian Instrumentation offers calibration kits and long lasting cylinders of test gas specifically developed for easy Cannonball3 calibration.

⚠WARNING Use of non-standard calibration gas and/or calibration kit components when calibrating the Cannonball3 can lead to inaccurate and potentially dangerous readings, and may void the standard Sperian Instrumentation warranty.

Customers are strongly urged to use only Sperian Instrumentation calibration materials when calibrating the Cannonball3.

4.2 Effect of contaminants on Cannonball3 sensors

The atmosphere in which the Cannonball3 is used can have lasting effects on the sensors. Sensors may suffer losses in sensitivity leading to degraded performance if exposed to certain substances.

There are three basic types of sensors that may be installed in the Cannonball3 detector: galvanic oxygen, catalytic hot-bead combustible gas, and electrochemical toxic. Each type of sensor uses a slightly different detection principle, so the kinds of conditions that affect the accuracy of the sensors vary from one type of sensor to the next.

⚠WARNING Accuracy of the Cannonball3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.

4.2.1 Effects of contaminants on oxygen sensors

Oxygen sensors may be affected by prolonged exposure to "acid" gases such as carbon dioxide. The oxygen sensors used in Sperian Gas Detectors are not recommended for continuous use in atmospheres containing more than 25% CO_2.

4.2.2 Effects of contaminants on combustible sensors

Combustible sensors will be adversely affected by exposure to substances containing volatile silicone, which is found in many commercial formulations such as spray lubricants, plastic mold(ing) release agents, waterproofing agents, heat transfer fluids, and is released during the cure of silicone-based caulks and rubbers (RTV). Other combustible gas sensor poisons and inhibitors include, but are not limited to: tetraethyl lead as in "leaded" gasoline grades (aviation "low-lead" fuel), halogenated hydrocarbons such as Freons™, other such refrigerants and solvents such as 1,1,1-trichloroethane, perchloroethylene and methylene chloride. Chronic exposures to high concentrations (above human health and safety levels) of hydrogen sulfide (H_2S) and phosphine (PH_3) can also impair combustible sensor performance.

Note: Damage to combustible gas sensors incurred by exposure to known sensor poisons such as silicones, tetra-ethyl lead, and/or other substances may (at the discretion of Sperian Instrumentation’s Instrument Service Department) void Sperian Instrumentation’s Standard Warranty as it applies to the replacement of combustible gas sensors. For a more complete list of known sensor poisons see Sperian Instrumentation’s Standard Warranty in Appendix G.

After any detector exposure to a suspected or known poison/inhibitor source, combustible sensor accuracy should be verified immediately by exposure to calibration gas of known percent LEL concentration.

Note: If the combustible sensor in the Cannonball3 suffers a loss of sensitivity, it tends to be lost first with regards to methane.

As described above, combustible gas sensors may become desensitized if exposed to certain substances. In some cases a desensitized combustible sensor may still respond accurately to propane and other hydrocarbons while showing a dangerously reduced response to methane.

Sperian Instrumentation’s “Equivalent” calibration gas mixtures have been developed to eliminate this potentially dangerous source of calibration error. Sperian Instrumentation’s “Equivalent” mixtures are based on methane, so any loss of sensitivity to methane is detected (and can be corrected) immediately.

Using Sperian Instrumentation brand calibration gas and regularly verifying accuracy ensures that proper sensitivity is maintained for the life of the sensor.

4.2.3 Effects of high concentrations of combustible gas on the combustible sensor

The accuracy of combustible sensors may also be affected by exposure to high concentrations of combustible gas. To minimize the chance for damage or loss of sensitivity to the combustible sensor, the Cannonball3 is designed to "alarm latch" whenever the concentration of combustible gas exceeds 100 percent LEL for units without a dilution pump, or approximately 200 percent LEL for units with a dilution pump. Under these conditions an "X" will appear in place of the combustible gas reading to indicate that an over-limit condition has occurred, and "LEL OVERRANGE" will be displayed at the bottom of the LCD.

During an "LEL OVERRRANGE" condition, the audible and visible alarms will be activated until the instrument is manually reset by turning it off.

⚠WARNING A combustible sensor overrange alarm indicates a potentially explosive atmosphere. Failure to leave the area immediately may result in serious injury or death!

⚠WARNING In the event of a combustible sensor overrange alarm the Cannonball3 must be turned off, brought to an area that is known to be safe and then turned on again to reset the alarm.

⚠WARNING Make sure that the Cannonball3 is located in fresh air before turning the instrument back on after a combustible sensor alarm latch condition has occurred. Fresh air calibration adjustments may only be made when the Cannonball3 is located in air that is known to be fresh. After a combustible sensor alarm-latch condition occurs, the accuracy of the combustible gas sensor must be verified by exposure to known percentage LEL concentration test gas before further use.

Note: The combustible sensor used in the Cannonball3 design requires the presence of oxygen in order to detect combustible gas. The accuracy of the combustible sensor may be affected if the instrument is used in oxygen-deficient atmospheres.

⚠WARNING A rapid up-scale reading followed by a declining or erratic reading may indicate a hazardous combustible gas concentration that exceeds the Cannonball3's zero to 100 percent LEL detection range for units without a dilution pump, or zero to approximately 200 percent detection range for units with a dilution pump. The safest course of action is to immediately leave the affected area, and to return only after further testing determines that the area is once again safe for entry.

4.2.4 Effects of contaminants on toxic gas sensors

Sperian Instrumentation's "substance-specific" electrochemical "smart sensors" used to measure CO, H_2S, PH_3, SO_2, NH_3, Cl_2, ClO_2, HCN and NO_2 have been carefully designed to minimize the effects of common interfering gases. "Substance-specific" sensors are designed to respond only to the gases that they are supposed to measure. The higher the specificity of the sensor, the less likely the sensor will react to other gases, which may be incidentally present in the environment. For instance, a "substance-specific" carbon monoxide sensor is deliberately designed not to respond to other gases that may be present at the same time, such as hydrogen sulfide and methane.

Although great care has been taken to reduce cross-sensitivity, some interfering gases may still have an effect on toxic sensor readings. In some cases the interfering effect may be positive and result in readings that are higher than actual. In other cases the interference may be negative and produce readings that are lower than actual.

4.3 Single sensors capable of monitoring for two different gases

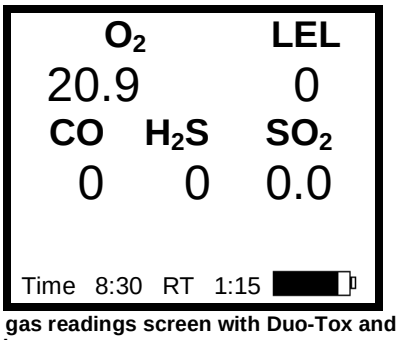
The OSHA standard for permit-required confined space entry (29 CFR 1910.146) explicitly requires the use of a direct-reading, substance-specific sensor whenever a particular toxic hazard is likely to be present. For example, if hydrogen sulfide is likely to be present, one of the toxic sensors selected should be specifically designed for the detection of H_2S, and should be directly calibrated for the measurement of H_2S.

4.3.1 Using one sensor to monitor for carbon monoxide and hydrogen sulfide

Carbon monoxide and hydrogen sulfide are the two most common toxic gases associated with confined space entry. Sperian Instrumentation offers two different sensors, the Duo-Tox and the CO Plus, which allow the user to monitor for both of these hazards while utilizing only one sensor port.

4.3.1.1 Duo-Tox dual purpose carbon monoxide / hydrogen sulfide sensor

The Duo-Tox sensor is a substance-specific, dual-channel, electrochemical sensor designed to simultaneously and discriminately detect both carbon monoxide and hydrogen sulfide without cross interference. When the Duo-Tox sensor is installed in the Cannonball3, it provides two independent channels of monitoring information while using only one sensor port. This allows the instrument to provide five channels of detection with only four sensors installed. A Cannonball3 equipped with a Duo-Tox sensor will show both CO and H_2S on the current gas readings screen.



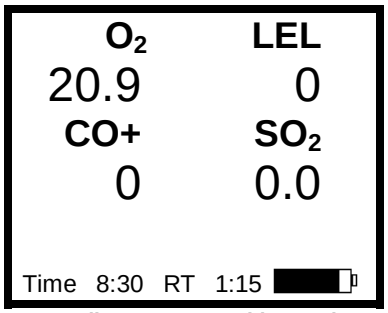
Current gas readings screen with Duo-Tox and SO_2 toxic sensors installed.

Calibration gas containing known concentrations of both CO and H_2S must be used to properly calibrate the Duo-Tox sensor.

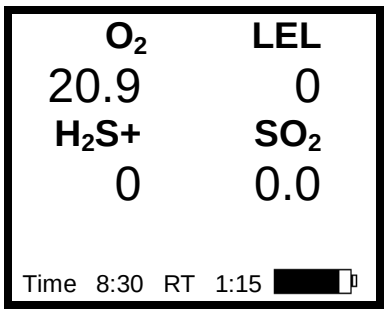
4.3.1.2 "CO Plus" dual purpose carbon monoxide/hydrogen sulfide sensor

The "CO Plus" sensor is ideal for situations requiring the use of a single sensor to monitor simultaneously for both CO and H_2S, in which the user does not need to definitively know which hazard is being encountered. While the "CO Plus" sensor is designed for the simultaneous detection of both carbon monoxide and hydrogen sulfide, it can only be calibrated for the direct detection of one of these hazards.

The Cannonball3 offers a choice of two different calibration gas settings for the CO Plus sensor. Calibration gas settings determine whether the Cannonball3 is configured for the direct detection of CO or H_2S. When the calibration gas value is set to CO, the Cannonball3 will show CO+ on the current gas readings screen. Alternately, when the calibration gas value is set to H_2S, the Cannonball3 will show H_2S+ on the current gas readings screen.



Current gas readings screens with CO Plus sensor; calibration gas value set to CO.



Current gas readings screens with CO Plus sensor; calibration gas value set to H_2S.

Note: The procedure for changing the calibration gas value setting for the CO Plus sensor is covered below in section 4.7.2.2.

4.3.1.2.1 Relative response of the CO Plus sensor to carbon monoxide and hydrogen sulfide

The "CO Plus" sensor will accurately and directly measure the gas type to which it has been successfully calibrated. OSHA has assigned an 8-hour TWA of 35 PPM as the permissible exposure limit for carbon monoxide. If the "CO Plus" sensor is successfully calibrated to carbon monoxide, and then exposed to 35 PPM carbon monoxide, the display will show 35 PPM.

Appendix A discusses Permissible Exposure Limit alarm calculations in greater detail.

The "CO Plus" sensor will also show a "relative response" to other interfering gases. When calibrated with carbon monoxide, the "CO Plus" sensor responds to hydrogen sulfide in a ratio of about 3.5 to 1.0. This means a concentration of about 10 PPM hydrogen sulfide would produce a reading of 10 X 3.5 or 35 PPM in an instrument that has been calibrated to CO.

This is a very convenient relative response. The 8-hour TWA permissible exposure limit for hydrogen sulfide is 10 PPM. This means that the CO Plus gas alarms will be tripped any time the concentration of hydrogen sulfide exceeds the permissible exposure limit.

Note: The procedure for changing the calibration gas value setting for the CO Plus sensor is covered below in section 4.7.2.2.

4.3.2 Cl_2 and ClO_2 sensors

Four different sensors are currently available for the PhD5 for the detection of chlorine (Cl_2) and chlorine dioxide (ClO_2). The non-specific versions of the Cl_2 and ClO_2 (part numbers 54-25-08 and 54-25-12) have built-in cross-sensitivity as follows:

The Cl_2 (non-specific) and ClO_2 (non-specific) sensors are actually the same sensor. When calibrated to Cl_2 the sensor will respond to ClO_2 in a ratio of 1:3.1. As an example, if a Cl_2 non-specific sensor is exposed to 1 PPM ClO_2 the readout on the gas detector will be 3.1 PPM.

The OSHA short term exposure limits (STEL) for Cl_2 and ClO_2 relate to each other in approximately the same ratio. The OSHA permissible exposure limits (PEL) for an 8-hour time weighted average (TWA) for Cl_2 and ClO_2 relate to each other in a ratio of 1:5. The table below details the OSHA alarm setpoints for Cl_2 and ClO_2.

Substance	STEL	TWA
Cl_2	1.0 PPM	0.5 PPM
ClO_2	0.3 PPM	0.1 PPM

Based on the relationships between the OSHA alarm set points and the relative response, one benefit of the Cl_2 (non-specific) / ClO_2 (non-specific) sensor is that the same sensor (with a limited degree of accuracy) can be used for the detection of both gases.

Note: For more information on cross sensitivity for any of the sensors available in the PhD5, see Appendix B.

The specific version of the Cl_2 sensor is not cross sensitive to ClO_2. The specific version of the ClO_2 sensor is not cross sensitive to Cl_2.

Note: Cannonball3 instruments equipped with a chlorine dioxide (ClO2) specific sensor (54-25-20) require a chlorine dioxide generator as a calibration gas source.

4.4 Functional (bump) test

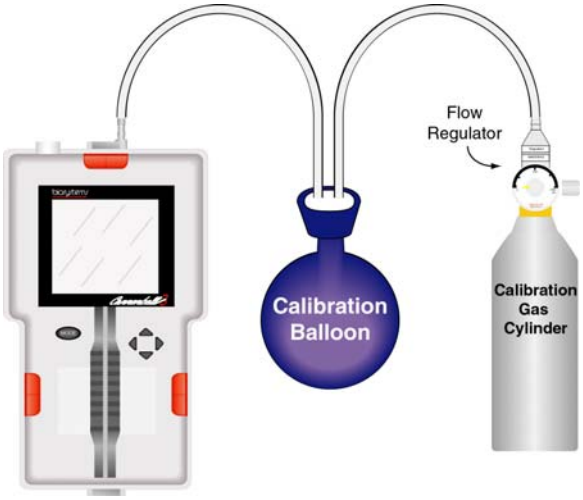
The accuracy of the Cannonball3 may be verified at any time by a simple functional (bump) test. During the bump test, each of the sensors is challenged with calibration gas sufficient to cause the alarms to activate (when the alarms and calibration gas levels are set at the default levels).

The Cannonball3 includes a built-in continuous sample draw pump that draws the gas sample into the sensor compartment. As such, there are two viable methods for delivering the gas to the sensor chamber for the bump test. Either use a standard 1 liter/minute regulator with the calibration balloon that is included with every Cannonball3, or use a demand flow regulator and a small piece of tubing to deliver the calibration gas directly into the inlet coupling on the front of the instrument.

To perform a functional (bump) test, do the following:

1. Turn the Cannonball3 on and wait at least three minutes to allow the readings to fully stabilize.
2. Make sure the instrument is located in fresh air.
3. Verify that the current gas readings match the concentrations present in fresh air. If the Cannonball3 is operated in Basic, Basic/Peak or Technician operating mode the fresh air readings should equal 20.9% O_2, 0% LEL or 0.0% CH_4, and 0 or 0.0 PPM for any toxic sensors installed. If the instrument is operated in the Text Only mode all readings should indicate that conditions are "OK". If necessary, perform a fresh air calibration as discussed in section 4.5.1.

4.a. If using a calibration balloon, fill the empty balloon with calibration gas until it is full. Connect the calibration balloon assembly to the inlet coupling on the Cannonball3. Continue to flow gas to the balloon throughout the bump-test procedure.



Cannonball3 with calibration balloon and calibration gas cylinder.

4.b. If using a demand flow regulator, attach the regulator to the gas cylinder and then connect it the inlet coupling on the front of the instrument with a short piece of tubing. The Cannonball3's continuous sample pump will automatically draw the appropriate amount of calibration gas throughout the span calibration procedure.

5. Wait for the readings to stabilize. (Forty-five seconds to one minute is usually sufficient. Exotic sensors may take longer.)

6. Note the readings.

   Sperian Instrumentation's multi-calibration gas mixtures contain approximately 18% oxygen by volume, which is a level sufficient to verify that the oxygen sensor is functioning properly. When the bump test is performed with calibration gas containing approximately 18.0% oxygen, the oxygen sensor is considered accurate when it reads within +/-0.5% of the level given on the calibration cylinder. If your calibration gas contains more than 19.0% oxygen, or if the Cannonball3 fails to register a drop in oxygen level during the bump test proceed to step 6a.

   LEL and toxic readings are considered accurate when the readings fall between 90% and 120% of the expected concentration as given on the calibration gas cylinder.

   If readings are accurate during the bump test, there is no need to adjust your gas detector.

   If the gas readings are inaccurate, the instrument must be span calibrated before further use.

6.a If the oxygen sensor fails to register a drop in oxygen level during a bump test or calibration, the oxygen sensor may also be challenged in the following manner: First remove the calibration materials and allow the current gas readings to return to fresh air levels (20.9% O_2, 0% LEL or 0.0% CH_4, and 0 or 0.0 PPM for any toxic sensors). Then hold your breath for 10 seconds or more and slowly exhale in the area of the inlet coupling on the front of the Cannonball3 so that the sample is drawn into the instrument. If the descending oxygen alarm is set to 19.5%, the instrument should go into alarm after a few seconds. If the instrument fails to go into alarm while performing this test, stop using the sensor immediately and contact Sperian Instrumentation.

7. Depending on the sensor configuration of the Cannonball3, it will sometimes be necessary to use more than one source of calibration gas to complete the bump test. If this is the case, return to step three and follow the instructions given to challenge the remaining sensor(s) with calibration gas. If using a calibration balloon, be sure to completely purge the calibration balloon during cylinder changes and always continue to flow calibration gas into the calibration balloon until the calibration is complete.

If readings are found to be accurate during the bump test, there is no need to adjust your gas detector. If the readings are inaccurate, the instrument must be span calibrated before further use.

Note: If toxic or LEL gas concentration readings are not between 90% and 120% of expected values during a functional (bump) test, then the instrument must be adjusted using the "span" calibration procedures discussed in section 4.5 before further use.

4.5 Automatic calibration

Sperian Instrumentation's one-button auto-calibration procedure may be used to verify accuracy at any time during normal operation in all modes except Text-Only Mode.

Auto-calibration is a two-step procedure. In the first step the Cannonball3 is taken to an area where the atmosphere is known to be fresh and a fresh air adjustment is made as detailed below.

The second step is the sensor response or "span" calibration adjustment. In this step the accuracy of the Cannonball3 sensors is established by exposing them to known concentration calibration gas. Once again, the sensitivity or "span" is automatically adjusted by the instrument.

Note: If a sensor has just been replaced, it must be allowed to stabilize prior to initiating any of the calibration subroutines detailed below. See section 6.1.1 for further details concerning sensor stabilization requirements.

Note: For instruments with dilution capability, proceed to the Dilution Manual for calibration instructions.

4.5.1 Automatic fresh air calibration sequence

The automatic fresh air calibration procedure may only be performed while the instrument is operating in Technician, Basic/Peak or Basic operating modes.

⚠WARNING Wait at least 3 minutes after turning the instrument on to allow sensor readings to stabilize fully before initiating any calibration procedures. Failure to wait three minutes before initiating calibration procedures may lead to inaccurate and potentially dangerous readings.

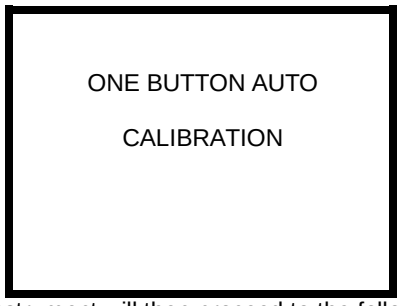
Note: If a sensor has just been replaced, it must be allowed to stabilize prior to calibration. See section 6.1.1 for further details concerning sensor stabilization requirements.

1. Turn the instrument on and make sure gas readings are given in numbers. (This is an indication that the Cannonball3 is currently in Basic, Basic/Peak or Technician Mode).

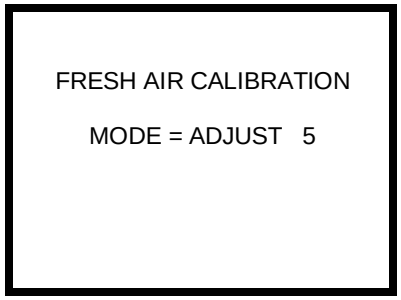
If sensor readings are displayed in the form of "OK" text messages, the instrument is currently in Text-Only mode. It will be necessary to change the operating mode to Basic,

Basic/Peak or Technician mode as explained in section 2.3.5 before proceeding with the calibration.

2. Wait at least three minutes after turning the instrument on to allow sensor readings to stabilize fully before initiating any calibration procedures. If a sensor has just been replaced, see section 6.1.1 for sensor stabilization requirements.
3. Make sure the instrument is located in an area where the air is known to be fresh.
4. Press the MODE button three times within two seconds. This will "wake up" the instrument from normal operation, and initiate the auto-calibration sequence. A screen will briefly display the message “One Button Auto-Calibration”.



The instrument will then proceed to the following screen and begin a 5-second countdown.



5. To initiate the fresh air calibration, press the MODE button before the unit finishes the countdown.

Upon successful completion of the fresh air calibration, the instrument will automatically proceed to the automatic span calibration sequence.

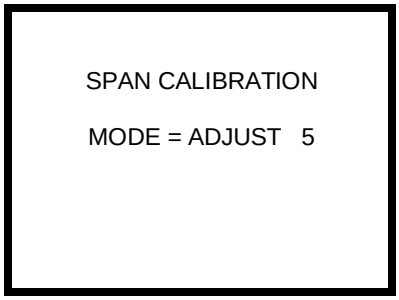
4.5.1.1 Reading “Too High” or “Too Low” for zero adjust

To reduce the chances of the Cannonball3 being inadvertently fresh air calibrated in contaminated air, only small adjustments are allowed in the automatic fresh air calibration sequence. If the necessary adjustments are too large, the display will indicate the sensor (or sensors) affected, and a message screen will indicate that the reading is “Too Low” or “Too High” for zero adjustment. In this case the instrument must be fresh air calibrated using the manual calibration procedures as discussed in section 4.6.1 of this manual.

Once the instrument has been successfully fresh air calibrated using the manual fresh air calibration procedure, subsequent calibration adjustments may be made using the MODE button and automatic calibration logic discussed in this section.

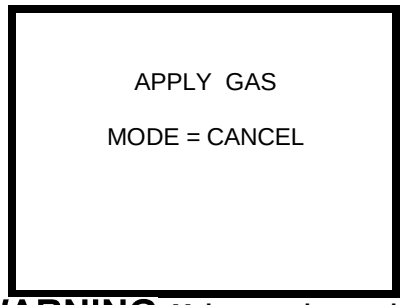
4.5.2 Automatic span calibration sequence

After completion of the automatic fresh air calibration, the unit will display the countdown for the automatic span calibration:



If span calibration is not required, allow the unit to complete the 5-second countdown without pressing any buttons.

Press MODE before the before the end of the 5-second countdown to initiate the automatic span calibration sequence. The Cannonball3 will then display:



⚠WARNING Make sure the regulator, cylinder seating surfaces and threads are clean and dry before attaching the regulator to the cylinder of gas. Introduction of contaminants through the regulator fittings may alter or degrade the concentration of the gas contained in the cylinder and may lead to inaccurate and potentially dangerous gas readings.

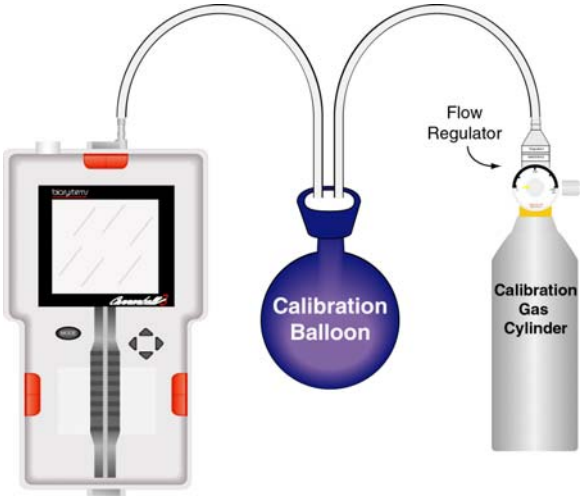
Note: Cannonball3 instruments equipped with a chlorine dioxide (ClO_2) specific sensor (54-25-20) require a chlorine dioxide generator as a calibration gas source.

The Cannonball3 includes a built-in continuous sample draw pump that draws the gas sample into the sensor compartment. As such, there are two viable methods for delivering the gas to the sensor chamber for span calibration: a standard 1 liter/minute regulator with the calibration balloon that is included with every Cannonball3, or with a demand flow regulator and a small piece of tubing.

If using a calibration balloon, fill the empty balloon with calibration gas until it is full. Connect the calibration balloon assembly to the inlet coupling on the Cannonball3. Continue

to flow gas to the balloon throughout the span calibration procedure.

If using a demand flow regulator, the Cannonball3's continuous sample pump will draw the appropriate amount of calibration gas throughout the span calibration procedure.



Cannonball3 with calibration balloon and calibration gas cylinder.

⚠WARNING Failure to purge the calibration balloon of all gas prior to inflation with calibration gas may result in inaccurate and potentially dangerous readings.

⚠WARNING Make sure the calibration balloon is completely filled with the appropriate calibration gas before attempting to calibrate the Cannonball3. Use of improper calibration gas or failure to fill the calibration balloon before calibration may lead to inaccurate and potentially dangerous gas readings.

The Cannonball3 automatically recognizes the type of gas supplied and displays the current reading for each sensor that may be calibrated using the current gas mixture. The span adjustment process from this point on is automatic and requires no user input.

LEL Sensor Reading	49
CO Sensor Reading	51
H_2S Sensor Reading	24

Multi Cal Gas Detected

Once the readings stabilize, the Cannonball will automatically adjust itself so that the sensor readings match the expected gas concentration values as they appear in the gas values subdirectory of the calibration menu.

LEL Calibrated to	50
CO Calibrated to	50
H_2S Calibrated to	25

The Cannonball3 will then display the final calibration values for the current span calibration, as well as the maximum adjustment values possible for the LEL sensor and any toxic sensors that are currently recognized. As a sensor loses sensitivity, the maximum possible adjustment will decrease to approach the expected concentration of the calibration gas.

LEL Adjusted to	50
Max Possible to	221
CO Adjusted to	50
Max Possible to	281
H_2S Adjusted to	25
Max Possible to	138

During the span calibration, the Cannonball3 will automatically test the oxygen sensor. Sperian Instrumentation's multi-calibration gas mixtures contain approximately 18% oxygen by volume, which is a level sufficient to challenge the oxygen sensor. The Cannonball3 must register an oxygen sensor reading of below 19.0% oxygen in order to fully pass the span calibration. If the instrument does not register a sufficient drop in the oxygen sensor reading, the following screen will be shown:

Low Response
Check O2 Sensor

MODE=Acknowledge

Press MODE to acknowledge the warning.

If the Low O2 Response warning is shown, proceed to section section 4.4 step 6a for further instructions on verifying oxygen sensor performance.

Once the span-calibration is completed, the instrument will turn itself off.

AUTO CALIBRATION

COMPLETED

↓

After shut down, remove all fittings from the Cannonball3. Press the MODE button to turn the instrument back on and resume normal operation.

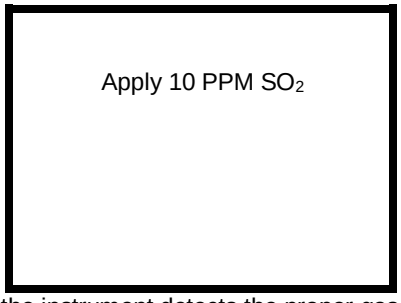
Note: If the MODE button is pressed at any time prior to completion of the calibration, the calibration procedure will be cancelled and the instrument will return to normal operation.

⚠WARNING Use of non-standard calibration gas and/or calibration kit components when calibrating the Cannonball3 may lead to dangerously inaccurate readings and may void the standard Sperian Instrumentation warranty.

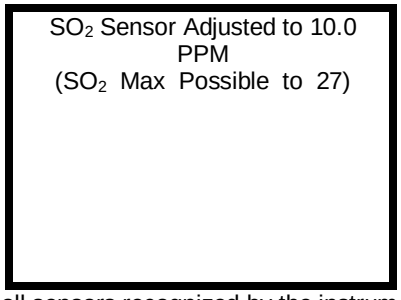
4.5.3 Automatic span calibration with more than one gas source

Depending on the sensor configuration of the Cannonball3, it will sometimes be necessary to use more than one source of calibration gas to complete the calibration of the Cannonball3. If using a calibration balloon, be sure to completely purge the calibration balloon during cylinder changes and always continue to flow calibration gas into the calibration balloon until the calibration is complete.

Note: If multiple cylinders of calibration gas are used during calibration, it will be necessary to completely purge the calibration balloon and then completely refill it with new calibration gas between span adjustments. In this case the display will indicate the type and concentration of the next cylinder of calibration gas to be applied.



Once the instrument detects the proper gas, the instrument will proceed to automatically calibrate the appropriate sensor channel.



Once all sensors recognized by the instrument have been successfully span-calibrated, the instrument will display "Auto Calibration Completed" and proceed to shut itself off.

Remove all fittings from the Cannonball3 before turning the instrument back on.

Note: It is possible to exit the automatic span calibration sequence at any time prior to completion by pressing and holding down the MODE button to turn the instrument off. The instrument will retain the updated settings for those sensors whose span adjustments have been successfully completed. Sensors that were not successfully adjusted at the time the auto-calibration sequence was terminated will trigger a "Needs Cal" message at the time the instrument is next turned on. The accuracy of those remaining sensors should be verified by exposure to known concentration test gas before the instrument is put back into service.

4.6 Manual calibration

It is possible to calibrate the Cannonball3 manually by using the navigation arrows to enter the Calibration Menu and select the desired calibration procedure.

Note: For instruments with dilution capability, proceed to the Dilution Manual for calibration instructions.

Note: For instruments equipped with the HC/LEL sensor, proceed to the HC/LEL Manual Addendum to the Cannonball3 Reference Manual.

4.6.1 Manual fresh air calibration procedure

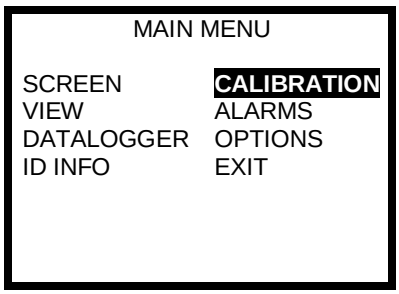
In some cases, it will be necessary to manually fresh air calibrate the Cannonball3. Manual fresh air calibrations are performed as follows:

1. Turn the instrument on and wait at least three minutes to allow sensor readings to stabilize fully before initiating any calibration procedures.

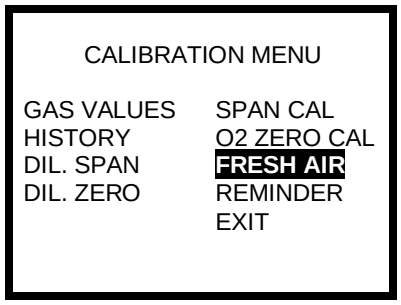
⚠WARNING Wait at least 3 minutes after turning the instrument on to allow sensor readings to stabilize fully before initiating any calibration procedures. Failure to wait three minutes before initiating calibration procedures may lead to inaccurate and potentially dangerous readings.

Note: If a sensor has just been replaced, it must be allowed to stabilize prior to calibration. See section 6.1.1 for further details concerning sensor stabilization requirements.

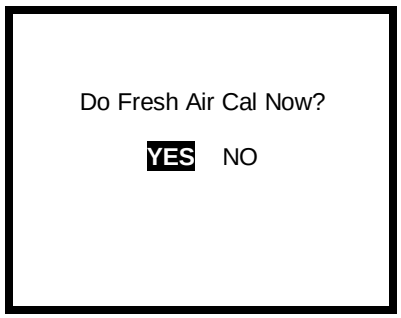
2. Make sure the instrument is located in an area where the air is known to be fresh.
3. Enter the Main Menu. For instructions on how to enter the Main Menu, see section 3.1 above.



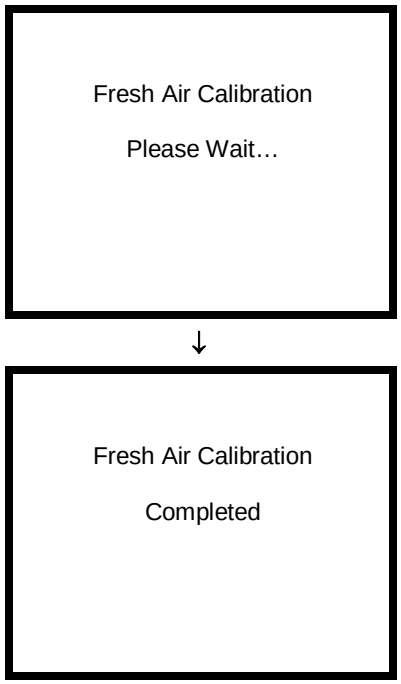
4. Use the navigation arrows to select CALIBRATION and then press the MODE button.



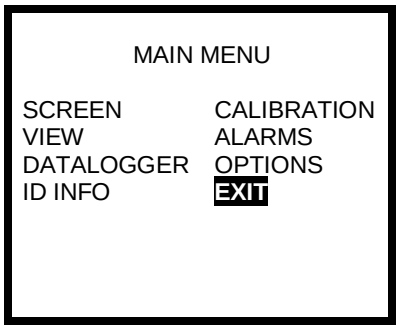
5. Use the navigation arrows to highlight FRESH AIR and press the MODE button.



6. Press the MODE button with YES highlighted to initiate the fresh air calibration.



7. After the completion of the fresh air calibration the Cannonball3 will automatically return to the Main Menu.



8. Press the MODE button with EXIT highlighted to return to the current gas readings screen.

4.6.1.1 Shortcuts to the manual fresh air calibration procedures

There are two additional ways to reach the manual fresh air calibration procedure detailed above.

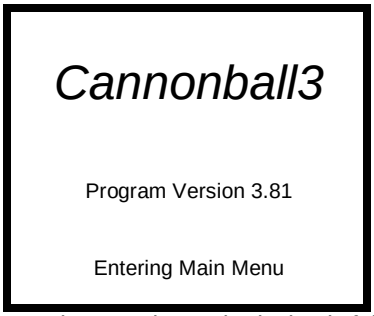
4.6.1.1.1 Shortcut to fresh air calibration while in normal operation

At the current gas readings screen in Basic, Basic/Peak or Technician mode, press and hold the left navigation arrow for six seconds until the Cannonball3 instructs you to release it. The instrument will then proceed directly to the manual fresh air calibration as detailed above in section 4.6.1.

Note: If no action is taken within fifteen seconds of entering the "Do Fresh Air Cal Now?" screen, the instrument will return to the current gas readings screen.

4.6.1.1.2 Shortcut to Main Menu while turning the Cannonball3 on

Turn on the Cannonball3 while holding down the left navigation arrow. After the initial start up sequence the Main Menu screen will be displayed.



Once the Main Menu is reached, simply follow the directions above in section 4.6.1 starting at step 4.

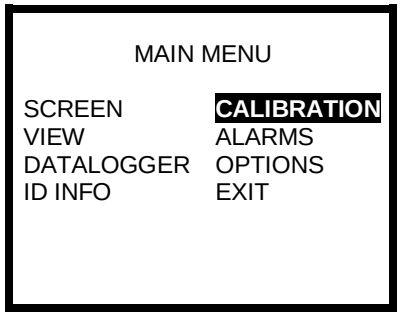
4.6.2 Manual span calibration procedures

Manual span calibration procedures are useful when the calibration of a single sensor is required. Manual span calibrations are performed as follows:

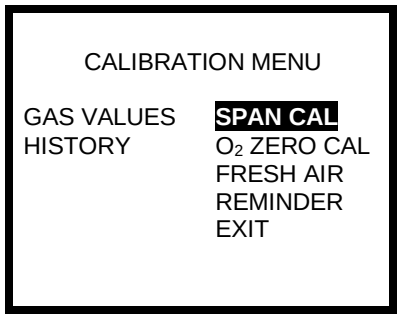
1. Turn the instrument on and wait at least three minutes to allow sensor readings to stabilize fully before initiating any calibration procedures.

⚠WARNING Wait at least 3 minutes after turning the instrument on to allow sensor readings to stabilize fully before initiating any calibration procedures. Failure to wait three minutes before initiating calibration procedures may lead to inaccurate and potentially dangerous readings.

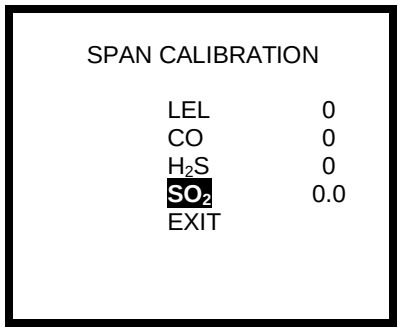
2. Enter the Main Menu as described above in section 3.1.



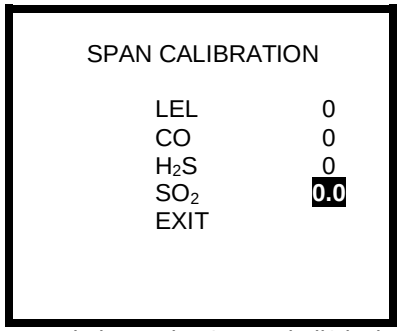
3. Use the navigation arrows to highlight CALIBRATION and press the MODE button.



4. Use the navigation arrows to highlight SPAN CAL and press the MODE button.



5. Use the up and down navigation arrows to highlight the sensor that requires calibration. Confirm the sensor selection by pressing the MODE button.



As discussed above, the Cannonball3 includes a built-in continuous sample draw pump that draws the gas sample into the sensor compartment. As such, there are two viable methods for delivering the gas to the sensor chamber for span calibration: a standard 1 liter/minute regulator with the calibration balloon that is included with every Cannonball3, or with a demand flow regulator and a small piece of tubing.

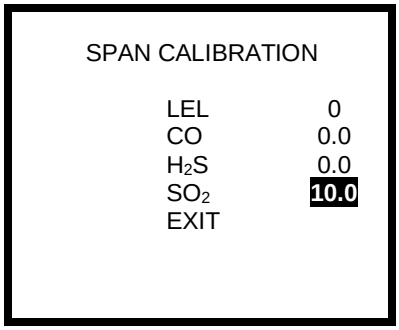
6.a If using a calibration balloon, fill the empty balloon with calibration gas until it is full. Connect the calibration balloon assembly to the inlet coupling on the Cannonball3. Continue to flow gas to the balloon throughout the span calibration procedure.

6.b. If using a demand flow regulator, attach the regulator to the gas cylinder and then connect it to end of the sample probe assembly with a short piece of tubing. The Cannonball3's continuous sample pump will draw the appropriate amount of calibration gas throughout the span calibration procedure.

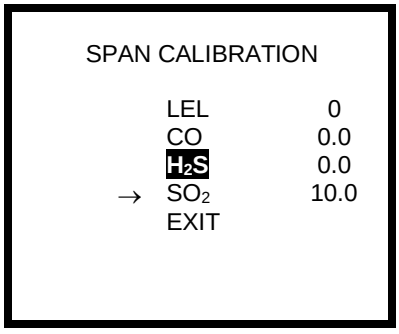
⚠WARNING Make sure the regulator, cylinder seating surfaces and threads are clean and dry before attaching the regulator to the cylinder of gas. Introduction of contaminants through the regulator fittings may alter or degrade the concentration of the gas contained in the cylinder and may lead to inaccurate and potentially dangerous gas readings.

⚠WARNING Make sure the calibration balloon is filled with the appropriate calibration gas before attempting to calibrate the Cannonball3. Use of improper calibration gas or failure to fill the calibration balloon before calibration may lead to inaccurate and potentially dangerous gas readings.

7. When the readings stabilize, use the up and down navigation arrows to raise or lower the readings to match the level of the gas concentration printed on the calibration cylinder label.



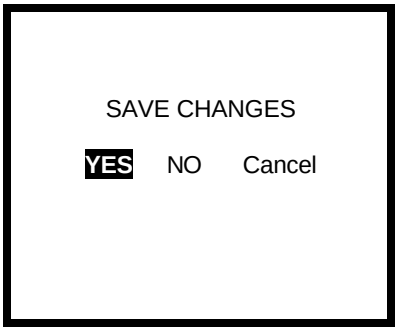
8. When the span calibration for a particular sensor is completed, press the MODE button to confirm the calibration and then use the navigation arrows to advance to the next sensor channel to be span adjusted. The sensor that was just span calibrated will then be marked with an arrow as shown below.



⚠WARNING If using the calibration balloon and the calibration of more than one sensor is required, deflate the calibration balloon fully before filling it with new gas for subsequent calibrations. Failure to fully deflate the calibration balloon between calibrations may lead to inaccurate and potentially dangerous readings.

Note: Remember to continue to flow calibration gas into the calibration balloon throughout the span calibration procedure.

9. When finished, use the navigation arrows to highlight EXIT and press the MODE button to exit and save the new calibration settings.



10. Press the MODE button with yes highlighted to save changes. Remove all fittings before turning the instrument back on and returning to normal operation.

Note: The calibration reminder is only reset when all toxic and LEL sensors have been successfully span calibrated.

4.6.3 O_2 zero calibration

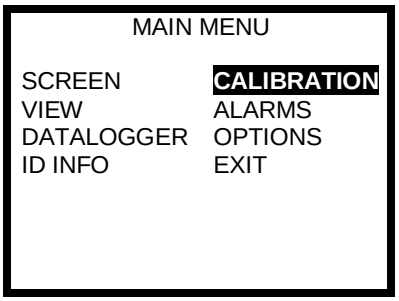
The Cannonball3 includes a "real" zero calibration adjustment for the oxygen sensor. The O_2 zero calibration should not be confused with the fresh air calibration adjustment. The O_2 zero calibration adjustment is used to calibrate the oxygen sensor in an atmosphere containing no oxygen, while the fresh air zero calibration adjustment is used to calibrate the oxygen sensor in an atmosphere containing 20.9% oxygen.

Note: The O_2 zero calibration adjustment for the Cannonball3 must be performed using calibration gas containing 99.9% N_2 (nitrogen) or better.

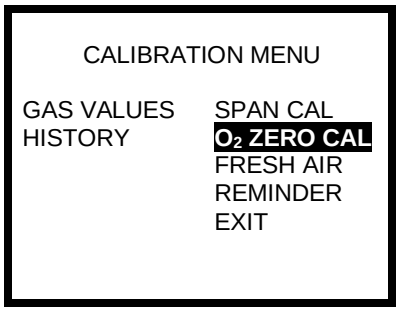
To complete the O_2 zero calibration:

1. Turn the instrument on and wait at least three minutes to allow sensor readings to stabilize fully before initiating any calibration procedures.

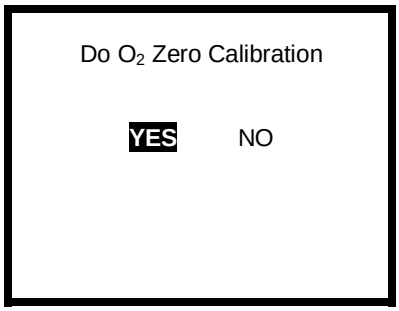
2. Enter the Main Menu as described above in section 3.1.



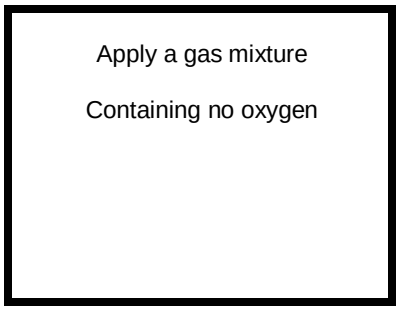
3. Use the navigation arrows to select CALIBRATION and press the MODE button.



4. Use the navigation arrows to highlight O_2 ZERO CAL and press the MODE button.



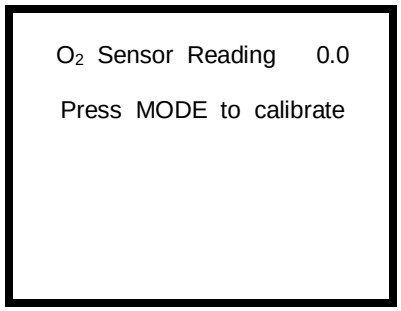
5. Press the MODE button with YES highlighted to begin the O_2 zero calibration.



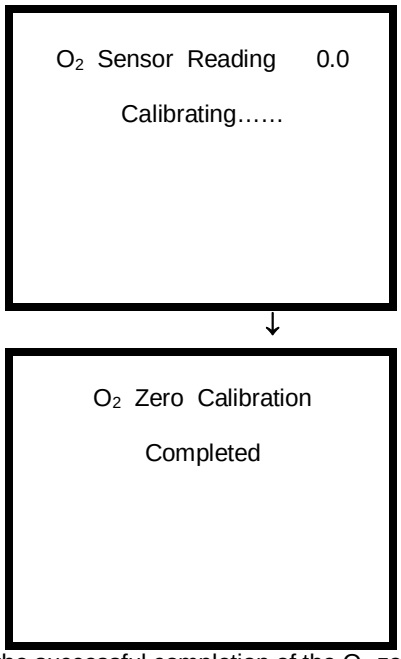
As discussed above, the Cannonball3 includes a built-in continuous sample draw pump that draws the gas sample into the sensor compartment. As such, there are two viable methods for delivering the gas to the sensor chamber for span calibration: a standard 1 liter/minute regulator with the calibration balloon that is included with every Cannonball3, or with a demand flow regulator and a small piece of tubing.

6.a If using a calibration balloon, fill the empty balloon with calibration gas until it is full. Connect the calibration balloon assembly to the inlet coupling on the Cannonball3. Continue to flow gas to the balloon throughout the span calibration procedure.

6.b. If using a demand flow regulator, attach the regulator to the gas cylinder and then connect it to end of the sample probe assembly with a short piece of tubing. The Cannonball3's continuous sample pump will draw the appropriate amount of calibration gas throughout the span calibration procedure.



7. The oxygen reading will drop immediately and should approach a reading of 0.0 percent oxygen, but may not actually stabilize at 0.0. Press the MODE button when the oxygen reading stabilizes to calibrate the sensor.



After the successful completion of the O_2 zero calibration, the instrument will return to the Main Menu. Disconnect the calibration gas cylinder immediately.

4.7 The Calibration Menu

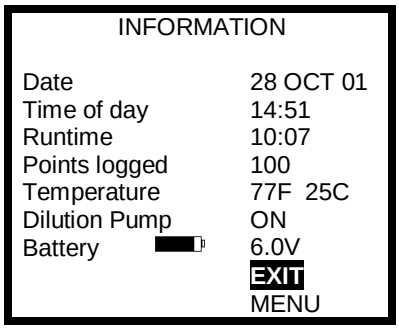
The Calibration Menu is an immediate subdirectory of the Main Menu and provides access to all manual calibration functions and controls.

Note: For instruments with dilution capability, proceed to the Dilution Manual for calibration instructions.

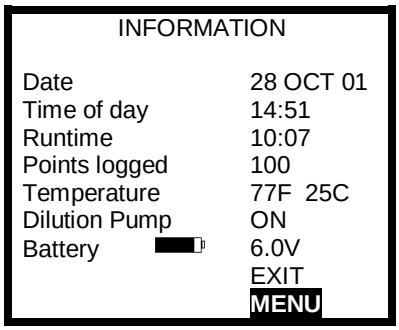
4.7.1 Entering the Calibration Menu

To enter the Calibration Menu:

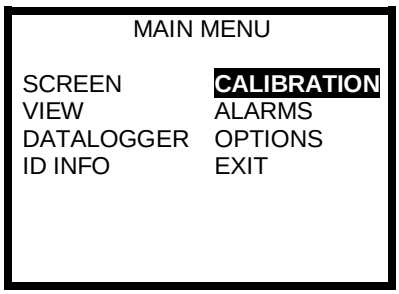
1. Turn the instrument on and wait until gas readings appear.
2. Press the MODE button until the information screen is displayed (shown below).
3. At the INFORMATION screen hold down the left navigation arrow for 3 seconds or until EXIT appears and is highlighted.



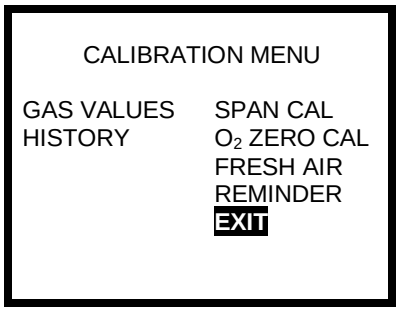
4. Press the down navigation arrow once to move the cursor and highlight MENU.



5. Press the MODE button once with MENU highlighted to enter the MAIN MENU.



6. Use the navigation arrows to highlight CALIBRATION and press the MODE button.

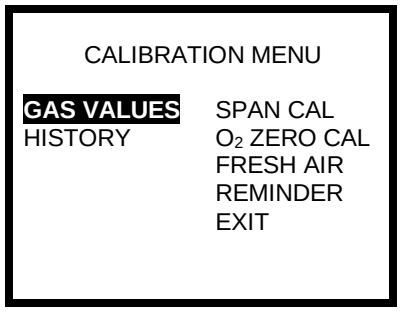


4.7.2 Gas values

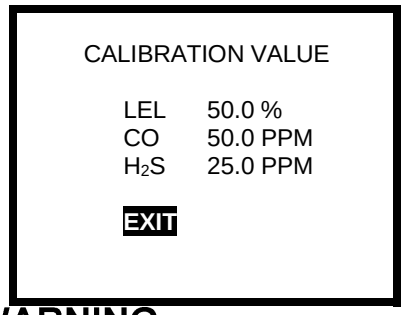
Calibration gas concentration values may be viewed and adjusted through the gas values screen.

To view the gas values screen:

1. Enter the Calibration Menu as described above in section 4.7.1.

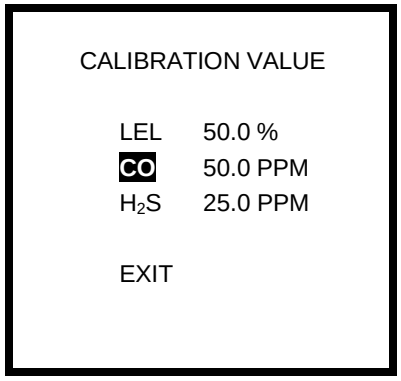


2. Use the navigation arrows to highlight GAS VALUES and press the MODE button.

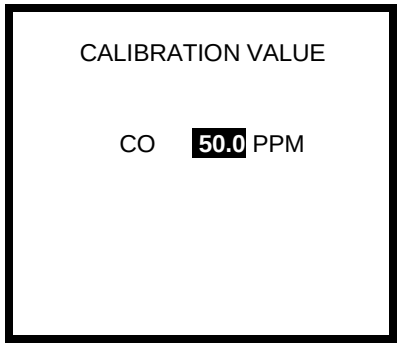


⚠WARNING Calibration values shown in the calibration value table must match those appearing on the calibration gas cylinder(s) that will be used to calibrate the Cannonball3. Non-matching calibration gas and calibration gas value settings will lead to inaccurate and potentially dangerous readings.

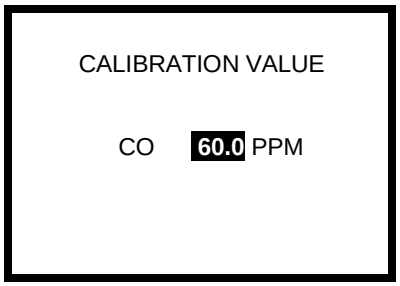
3. Use the up and down navigation arrows to highlight the gas concentration value that requires adjustment.



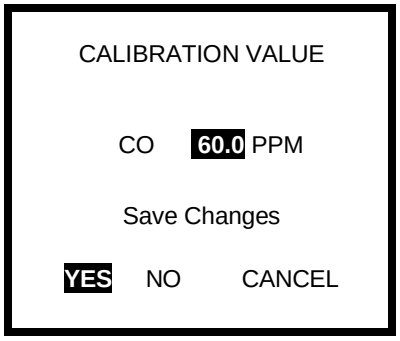
4. Press the MODE button to confirm the selection. The concentration will then be highlighted.



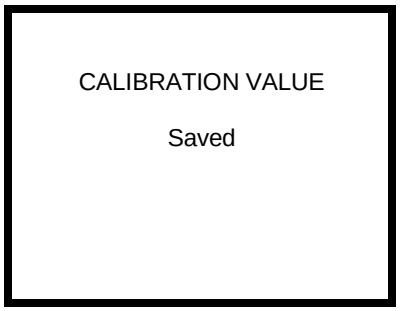
5. Use the up and down navigation arrows to adjust the calibration value.



6. Once the concentration matches the value listed on the calibration gas cylinder, press the MODE button.



7. Press the MODE button with YES highlighted to save the new settings.



4.7.2.1 Changing the combustible gas readout from LEL to CH_4 (or vice-versa)

The Cannonball3 may be configured to show combustible gas readings in terms of percent of LEL (Lower Explosive Limit) or in terms of the percent by volume of Methane (CH_4).

With the Cannonball3 configured to read in the percent by volume of Methane (CH_4) mode, the LEL sensor must be calibrated to the actual percent by volume of Methane used in Sperian Instrumentation's calibration gas cylinders, not to the %LEL value given on the label. The actual percentage by volume of CH_4 will be stamped in indelible black ink on the side on the cylinder body. For example, Sperian Instrumentation's popular all-in-one mix, part number 54-9044E, with 50% LEL propane equivalent will list 1.62% CH_4 on the side of the cylinder body. In this case, the percent by volume CH_4 calibration gas value should be set to 1.62%.

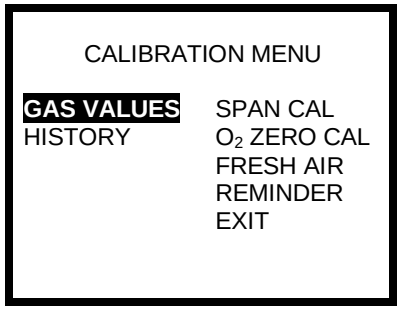
For easy reference, the actual percent by volume of CH_4 for the following Sperian Instrumentation's LEL component mixtures is listed in the following table.

LEL Component Description	Volume % Methane (CH4)
50% LEL Methane	2.50
50% LEL Propane Equivalent	1.62
50% LEL Pentane Equivalent	1.25

Table 4.7.2.1 Percent LEL versus percent by volume of methane for common Sperian Instrumentation calibration gas cylinders.

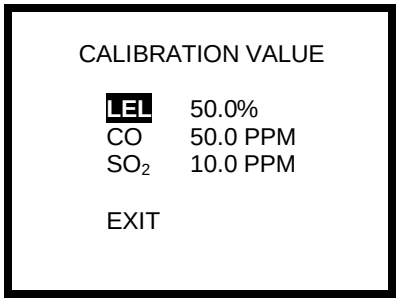
To change the calibration gas value setting from percentage of LEL to percent by volume of methane or vice versa:

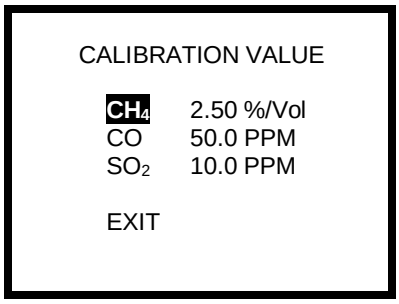
1. Enter the Calibration Menu as described above in section 4.7.1.



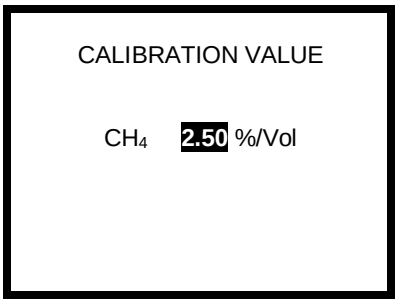
2. Use the navigation arrows to highlight GAS VALUES and press the MODE button.

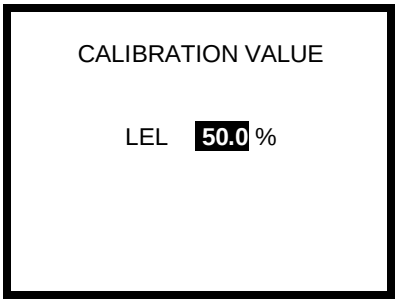
Depending on the existing calibration gas value setting, the instrument will display the calibration value either as percentage of LEL or as percent by volume of Methane (CH_4).



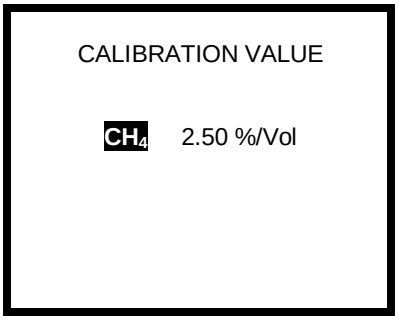


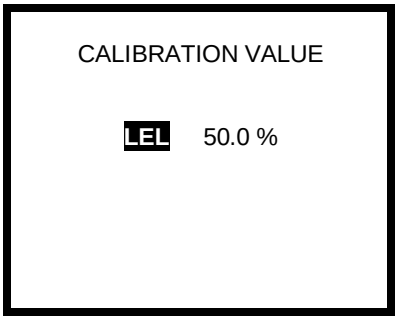
3. Use the up and down navigation arrows to select LEL or CH_4 and press the MODE button.



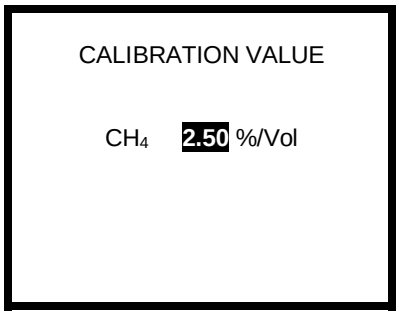


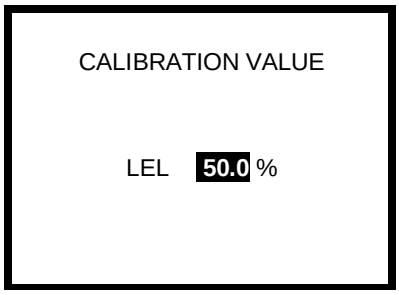
4. The right and left navigation arrows may be used to move back and forth between the calibration gas setting (LEL or CH_4) and the calibration gas concentration. To change the calibration gas setting, press the left navigation arrow once to highlight LEL or CH_4.



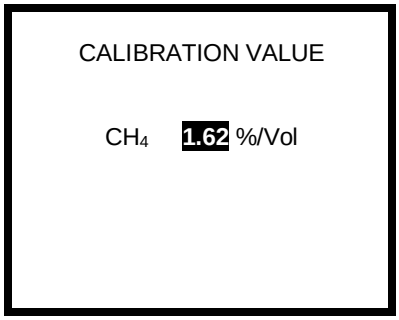


5. With LEL or CH_4 highlighted, the up and down navigation arrows are used to change the setting. Once the desired setting is shown, press the MODE button to save the setting or move on to step 6 to adjust the concentration of the calibration gas.

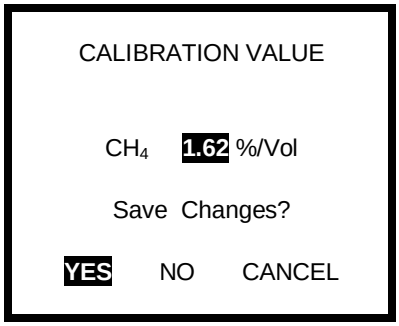




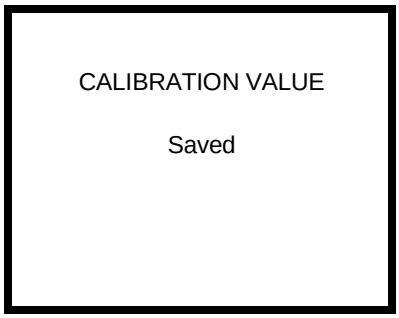
6. To change the concentration of LEL or CH_4 used in calibration, use the right navigation arrow to highlight the calibration gas concentration. With the concentration value highlighted, adjustments to the gas concentration may then be made using the up and down navigation arrows.



7. Once the appropriate calibration gas concentration is reached, press the MODE button to confirm the setting.



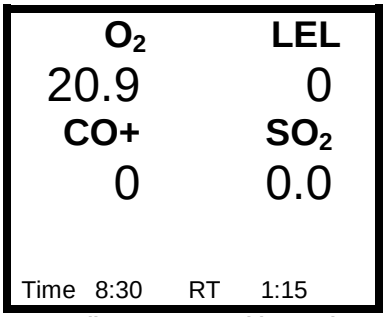
8. Press the MODE button with YES highlighted to save the new settings.



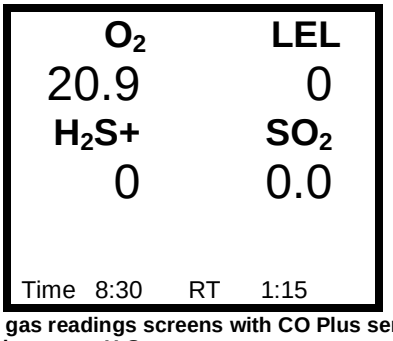
4.7.2.2 Changing the direct reading setting of the CO Plus sensor from CO to H_2S

Sperian Instrumentation's CO Plus sensor is designed for the simultaneous detection of both carbon monoxide and hydrogen sulfide, but it can only be calibrated for the direct detection of one of these hazards.

Calibration gas settings determine whether the Cannonball3 is configured for the direct detection of CO or H_2S. When the calibration gas selected is CO, the Cannonball3 will show CO+ on the current gas readings screen. Alternately, when the calibration gas selected is H_2S, the Cannonball3 will show H_2S+ on the current gas readings screen.



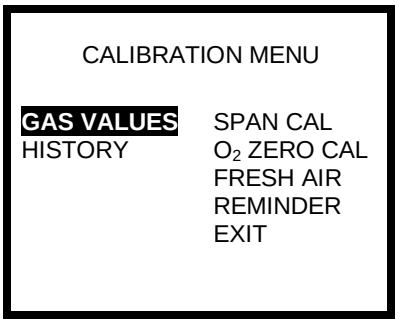
Current gas readings screens with CO Plus sensor; calibration gas setting set to CO.



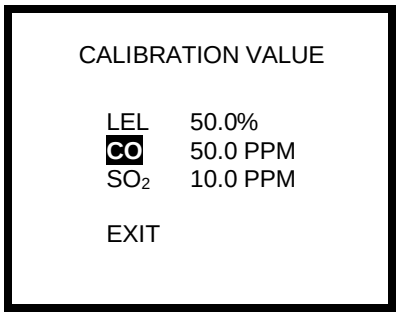
Current gas readings screens with CO Plus sensor; calibration gas setting set to H_2S.

To change the direct reading selection of the CO Plus sensor through the calibration gas value settings:

1. Enter the Calibration Menu as detailed above in section 4.7.1.

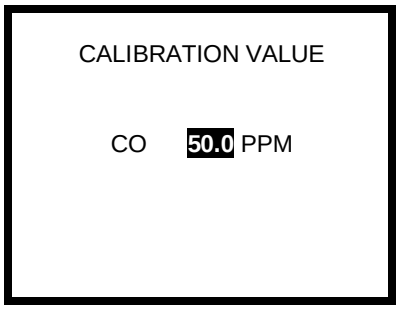


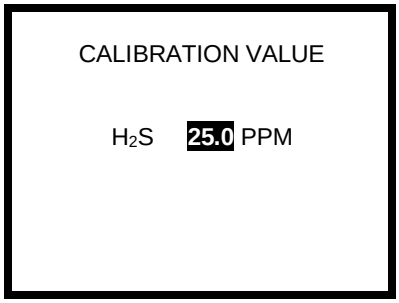
2. Use the navigation arrows to highlight GAS VALUES and press the MODE button to enter the gas values screen.



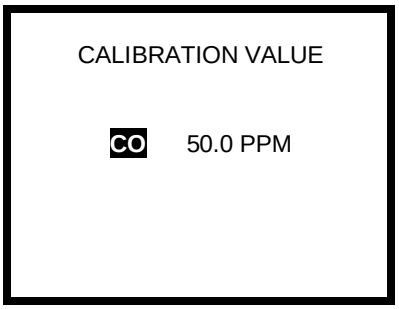
Depending on the existing calibration gas setting for the CO Plus sensor, the calibration gas value will appear as either CO or H_2S.

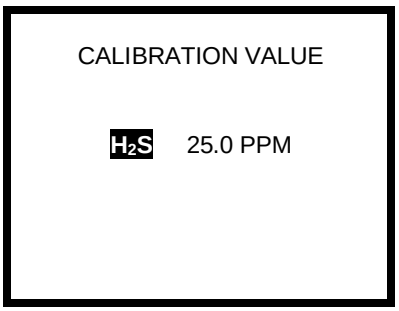
3. Use the up and down navigation arrows to select CO or H_2S and press the MODE button to confirm the selection.





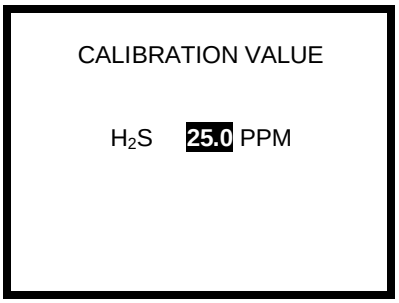
4. The right and left navigation arrows are used to move back and forth between the type and the amount of the calibration gas. To change the type of calibration gas, move the cursor to highlight CO or H_2S.



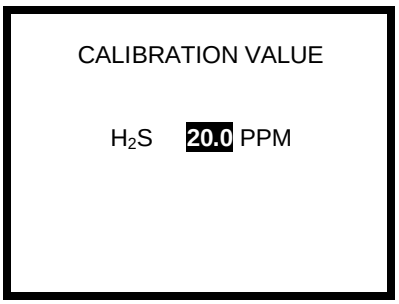


5. The up and down navigation arrows may then be used to toggle between CO and H_2S. Once the desired gas setting is shown, press the MODE button to save the setting or move on to step 6 to adjust the concentration of the calibration gas.

6. To change the concentration of CO or H_2S used in calibration, use the right navigation arrow to highlight the concentration in parts-per-million.

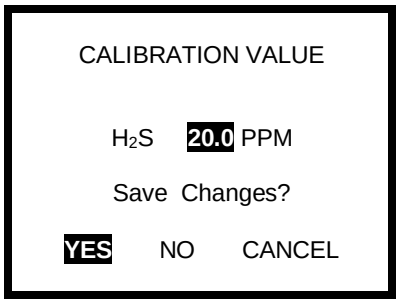


7. With the concentration highlighted, adjustments to the gas concentration are made using the up and down navigation arrows.

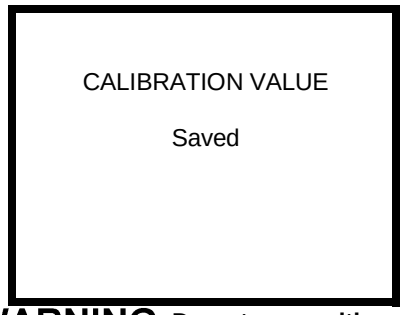


⚠WARNING Calibration values shown in the calibration value table must match those appearing on the calibration gas cylinder(s) that will be used to calibrate the Cannonball3. Non-matching calibration gas and calibration gas value settings will lead to inaccurate and potentially dangerous readings.

8. Press the MODE button when the appropriate gas selection and concentration have been reached.



9. Press the MODE button with YES highlighted to save the new settings.



⚠WARNING Do not use multi-component calibration gas mixtures containing both carbon monoxide and hydrogen sulfide when calibrating the CO Plus sensor In the Cannonball3. Calibration of the CO Plus sensor with multi-component calibration gas mixtures containing both CO and H_2S may lead to dangerously inaccurate readings.

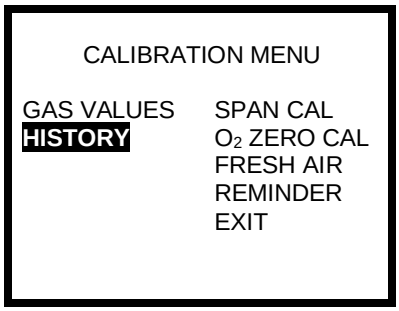
Sperian Instrumentation's multi-component calibration gas mixtures containing both carbon monoxide and hydrogen sulfide are labeled as "Not for use with CO Plus sensors".

Caution: With the CO Plus sensor, the calibration gas setting determines whether the instrument is configured for the direct reading of CO, or for the direct reading of H_2S. Calibration gas corresponding to the calibration gas setting must be used in the calibration of the instrument. If carbon monoxide is chosen in the calibration gas setting, the display will show CO+ and carbon monoxide must be used to verify accuracy. Similarly, if hydrogen sulfide is chosen in the calibration gas setting, the instrument will display H_2S+ and hydrogen sulfide must be used to verify accuracy. Use of the incorrect calibration gas may lead to inaccurate readings and potentially dangerous readings.

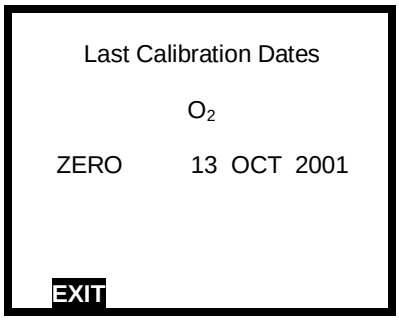
4.7.3 Calibration history

The Cannonball3 automatically remembers the latest successful calibration dates for all sensors currently recognized in the unit. To view the calibration history, do the following:

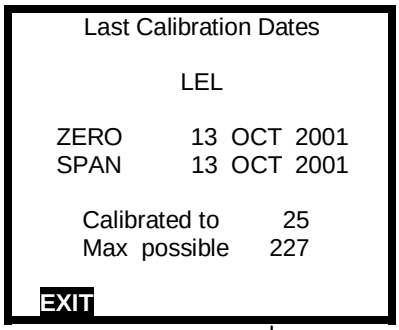
1. Enter the Calibration Menu as described in above in section 4.7.1.

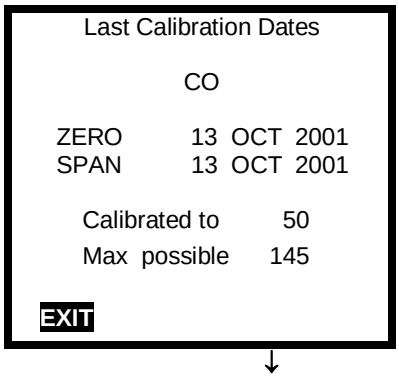


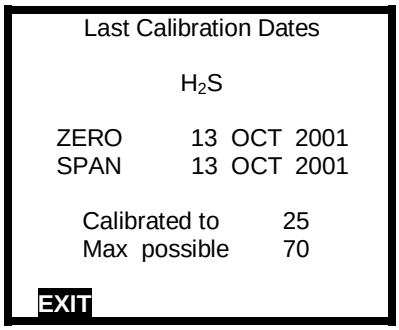
2. Use the navigation arrows to highlight HISTORY and press the MODE button.



3. Use the right and left navigation arrows to scroll through the information for the individual sensors.







4. Press the MODE button at any time to return to the main menu.

4.7.4 Calibration reminder

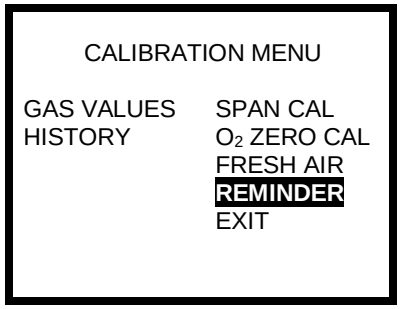
The calibration reminder feature allows the user to program the Cannonball3 to remind the user that calibration is due. The calibration reminder can be set by the user to any interval between 1 and 180 days and is automatically reset by a successful calibration. The calibration reminder may also be disabled if the user chooses to do so.

The repeat reminder option allows the user to decide whether the reminder will be repeated only once, or if it will be repeated every 15 minutes during instrument operation whenever calibration is due.

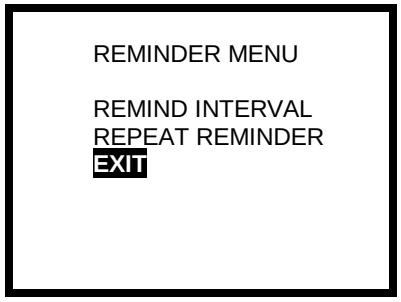
The Cannonball3 assesses its own calibration status once every 15 minutes while the instrument is turned on. In the event that the PhD5 comes due for calibration while it is running, the calibration reminder will be displayed within 15 minutes of the actual time when the instrument comes due for calibration.

To enter the Reminder Menu:

1. Enter the Calibration Menu as described above in section 4.7.1.



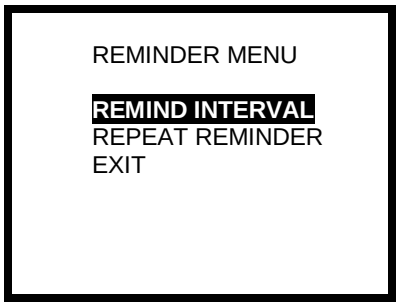
2. Use the navigation arrows to highlight REMINDER and press the MODE button to confirm the selection.



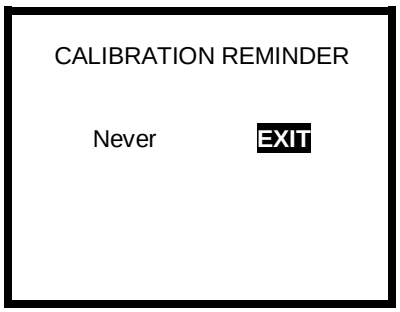
4.7.4.1 Remind Interval

The Calibration Reminder interval setting controls how many days can elapse following a successful calibration before the Cannonball3 will remind the user that it is due for calibration. The interval can be set to disabled by setting the remind interval to “never”, or it can be set to any interval between 1 day and 180 days.

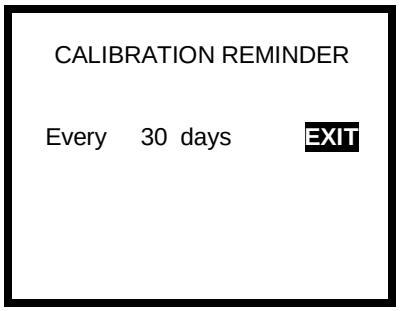
1. To change the reminder interval setting, enter the reminder menu as described above in section 4.7.4.



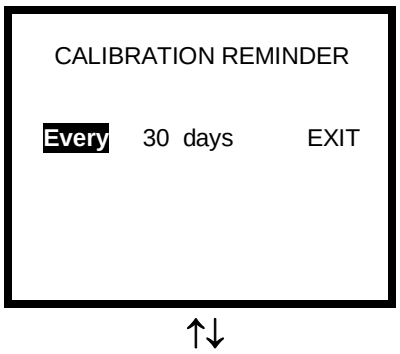
2. Use the navigation arrows to highlight “REMIND INTERVAL” and press the MODE button. The reminder interval will be shown as either “Every” with the number of days shown, or as “Never”.



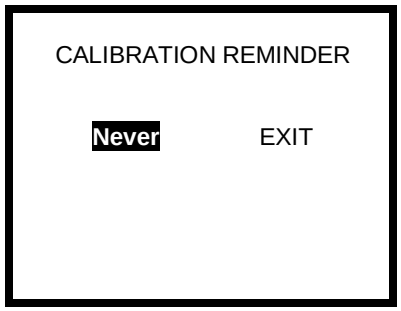
or



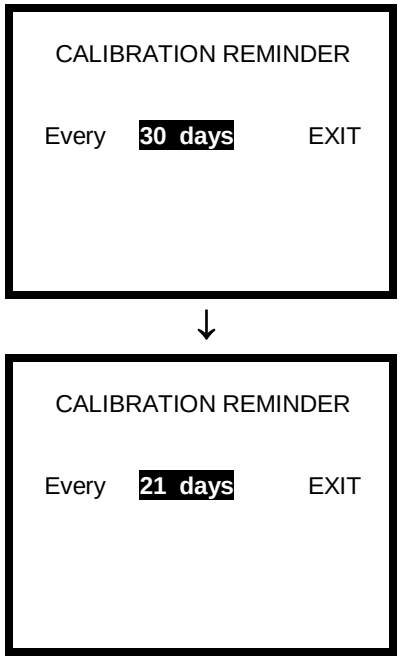
4. To enable or disable the Calibration Reminder, use the navigation arrows to highlight “Every” or “Never” and press the up navigation arrow to change it.



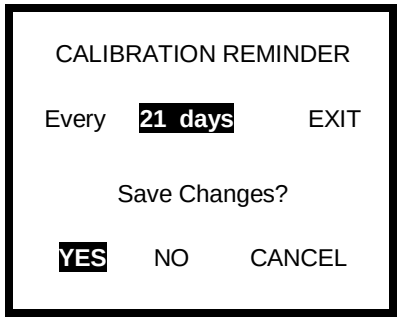
↑↓



4. The number of days between required calibrations will be shown when “Every” is displayed. To change the number of days, use the right and left navigation arrows to highlight the setting in days. Then use the up or down navigation arrows to adjust the interval.



5. Once the desired setting has been reached, press the MODE button.



7. Press the MODE button with YES highlighted to save the changes.

Once the reminder has been set, the instrument will display the number of days until the next required calibration during every subsequent instrument start up.

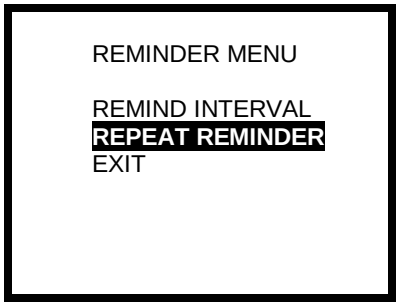
4.7.4.2 Repeat Reminder

The Cannonball3’s repeat reminder controls the frequency of reminders for the calibration due warning. The reminder may be set to “Once Only” or to “Every 15 minutes”.

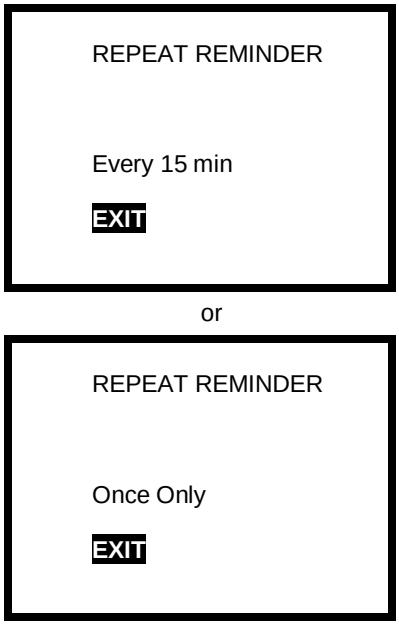
When set to “Once Only” the Cannonball3 will only show the calibration due warning once. If calibration comes due while the instrument is turned off, the warning is shown at start up. If the calibration comes due while the instrument is turned on, the warning will be displayed within 15 minutes of the actual time when the instrument comes due for calibration.

When set to “Every 15 minutes” the instrument will show the calibration due warning once every 15 minutes during operation.

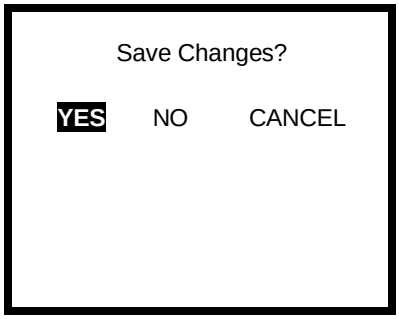
1. To change the repeat reminder setting, enter the reminder menu as described above in section 4.7.4.



2. Use the navigation arrows to highlight “REPEAT REMINDER” and press the MODE button.



3. Use the up and down navigation arrows to change the setting. When the setting is correctly displayed press the MODE button to enter the new setting.



4. Press the MODE button with YES highlighted to save the new settings.

Chapter 5. Record Keeping

Note: The material in this chapter is designed to acquaint the user with "manual" Cannonball3 record keeping functions. Consult the BioTrak Reference Manual for complete instructions in the use of BioTrak software.

5.1 Overview of record keeping options

Every Cannonball3 is equipped with either a "black box" data recorder or a datalogger. Both the black box data recorder and the datalogger store similar information such as gas readings, turn-on times, turn-off times and battery conditions. For instruments with the datalogger option, Biotrak software can be used to download the data from the Cannonball3 to an IBM-compatible PC at any time. Instruments with the black box data recorder must be returned to Sperian Instrumentation for data retrieval. The datalogger also offers numerous user-configurable options that are not available with the black box data recorder.

5.2 Black box data recorder

Cannonball3 instruments that are ordered without the datalogging option are equipped with a "black box" data recorder at no charge. The "black box" is continually in operation whether the user is aware of it or not. The black box stores important information such as gas readings, turn-on / turn-off times, temperatures, battery conditions, the 8 most recent calibration dates and settings, types of sensors currently installed, sensor serial numbers, warranty expiration and service due dates, temperature compensation curves, and current alarm settings.

There is a finite amount of memory storage available in the black box data recorder. Once the memory is full, the Cannonball3 will begin to write the new data over the oldest data. With a typical four-gas configuration, the black box data recorder will store approximately 137 hours of data before the memory is filled. At this point the Cannonball3 will begin to write new data over the oldest data In this way, the newest data is maintained.

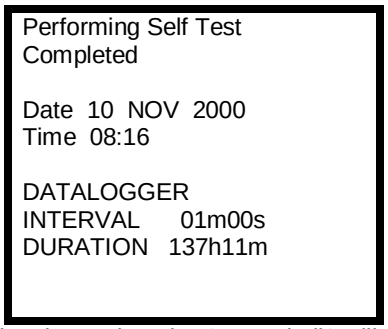
If the data in a black box data recorder is required for any reason, the entire Cannonball3 instrument must be returned to Sperian Instrumentation, where the data will be extracted, a report will be generated and then the unit will be returned to the user. Simply call Sperian Instrumentation at (800) 711 6776 to obtain a return authorization number. There is no charge for the downloading service, but the user is responsible for any freight charges incurred.

5.3 Datalogger upgrade

The "full" datalogger option is available on the Cannonball3 for users who need immediate access to the data stored in the instrument, or who require the ability to customize their record-keeping process.

Datalogging is a "transparent" function that is continually in operation. As long as the datalogger has not been disabled, it is not necessary to do anything special to begin logging data. Simply turning on the instrument causes it to begin recording data. The information stored by the datalogger may be downloaded to a computer to create a permanent record, or directly displayed on the Cannonball3 LCD.

Upon turn on, Cannonball3 instruments with an enabled datalogger will display the datalogging interval in the self-test screen as shown below.



With the datalogging option, the Cannonball3 will automatically log gas readings, turn-on / turn-off times, temperatures, battery conditions, the 8 most recent calibration dates and settings, types of sensors currently installed, sensor serial numbers, warranty expiration and service due dates, temperature compensation curves, and current alarm settings.

The Cannonball3 automatically updates all of this information whenever the instrument is turned on, whenever a change is made during operation, and again as the instrument is turned off.

The datalogger in the Cannonball3 can store the exposure values for up to 8214 datalogging intervals when using a typical four channel configuration such as O2, LEL, CO, and H2S. This provides for storage of approximately 137 hours of four-gas monitoring when a one-minute datalogging interval is specified. Using a longer datalogging interval increases the length of monitoring time for which data may be stored before the oldest data is overwritten by new data. For instance, if a datalogging interval of two minutes is selected, about 274 hours of monitoring data will be stored before the oldest data is overwritten. Different sensor configurations and/or datalogging interval settings allow for more or less datalogging time.

5.3.1 BioTrak Database Software

BioTrak database software provides two-way communication between datalogger-equipped Cannonball3 instruments and a Microsoft Windows-compatible personal computer. BioTrak database software allows information to be retrieved from the Cannonball3 and also allows the Cannonball3 to be programmed directly through an IBM-compatible PC.

It is important to note that it is not necessary to use the BioTrak software to program your instrument. Configuration and setup options may be programmed directly by using the navigation arrows on the instrument keypad.

Manual programming procedures are covered in detail below in section 5.3.2.

BioTrak software has been designed to make programming, downloading, and data analysis easy. The software allows optional instrument setups to be created by "filling out" forms right on the computer screen.

Note: The Cannonball3 is designed to download data from the instrument to a PC using an IrDA compliant infrared data transceiver. It may be necessary to purchase an IrDA transceiver if your computer is not equipped with this feature. Most new laptop style PCs are equipped with an IrDA port, but many desktop and older laptop style PC's are not. Consult your computer's owners' manual for details. If you must purchase an IrDA transceiver, Sperian Instrumentation recommends the JetEye PC IrDA Serial Adapter by Extended Systems (model number ESI-09680-7401), which can be purchased directly through Extended Systems or through Sperian Instrumentation (P/N 54-26-

0605). The Cannonball3 can not be downloaded without an IrDA port.

Biotrak software is designed to facilitate both the downloading of stored data and the uploading of new instrument configurations. Once information has been downloaded to the computer, it may be used for a variety of purposes. Data may be displayed and reviewed in detail on the computer monitor, or used to generate and print reports, tables and graphs of time history exposure data. It is also possible to export records to other software applications in the form of ASCII text or in a spreadsheet format. Another option is to simply retain downloaded records for future use as needed.

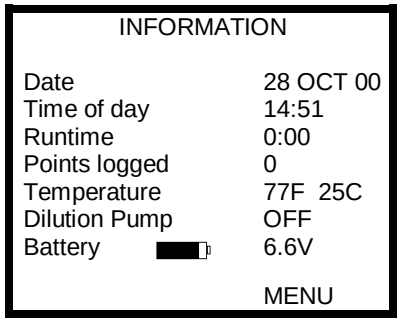
Note: The remaining material in this chapter is designed to acquaint our customers with "manual" Cannonball3 setup and download procedures. Consult the BioTrak Reference Manual for complete instructions in the use of BioTrak software.

5.3.2 The Datalogger Menu

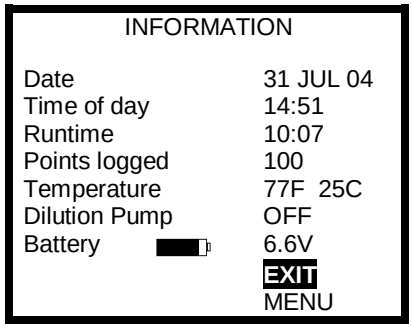
It is possible to adjust or customize the way the Cannonball3 records data in a number of different ways. Options include extended recording time, tagging the exposure data with time and date information, or assigning location and ID information.

Cannonball3 instruments equipped with datalogging capability will have a datalogger option in the Main Menu, which provides access to the Datalogger Menu. The Datalogger Menu provides access to all user-configurable datalogging options. To enter the Datalogger Menu:

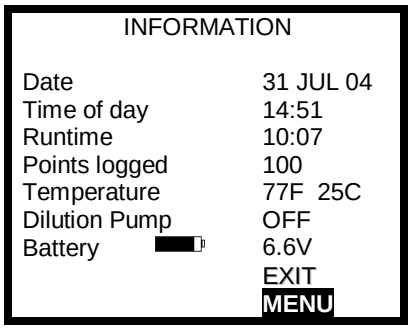
1. Turn the instrument on and wait until the gas readings screen appears.
2. Press the MODE button until you reach the Information screen (shown below).



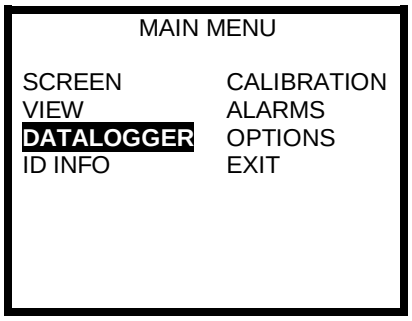
3. At the INFORMATION screen hold down the left navigation arrow for 3 seconds or until EXIT appears and is highlighted.



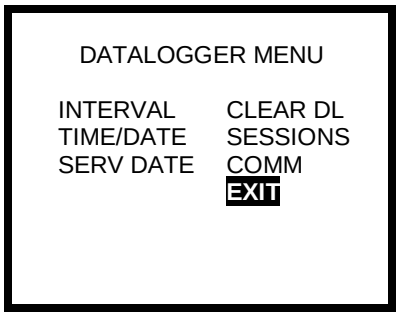
4. Press the down navigation arrow once to highlight MENU.



5. Press the MODE button once with MENU highlighted to enter the Main Menu.



6. Use the navigation arrows to highlight DATALOGGER and press the MODE button.



5.3.2.1 Setting the datalogging interval

The datalogger samples continuously, so the data stream must be broken into intervals to be recorded. The datalogging interval controls the frequency of the samples recorded by the instrument and may be set anywhere between one second and one hour by using the navigation arrows as detailed below.

There is a finite amount of memory storage available in the Cannonball3. Once the memory is full, the Cannonball3 will begin to write the new data over the oldest data. In this way, the newest data is maintained. A longer sampling interval will allow the retention of more hours of data before old data is overwritten making the Cannonball3 ideal for long-term sampling projects.

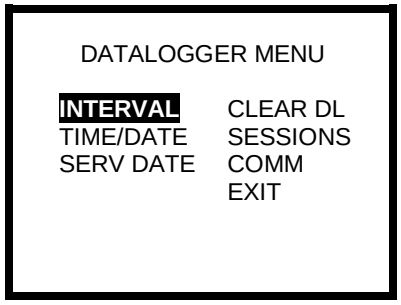
The datalogger in the Cannonball3 can store the exposure values for up to 8214 datalogging intervals when using a typical four channel configuration such as O2, LEL, CO, and H2S. This provides for storage of approximately 137 hours of four-gas monitoring when a one-minute datalogging interval is specified. Using a longer datalogging interval increases the length of monitoring time for which data may be stored before the oldest data is overwritten by new data. For instance, if a datalogging interval of two minutes is selected, about 274 hours of monitoring data will be stored for a typical four-gas instrument before the oldest data is overwritten. Different sensor configurations and/or datalogging interval settings allow

for more or less datalogging time before the oldest data is overwritten.

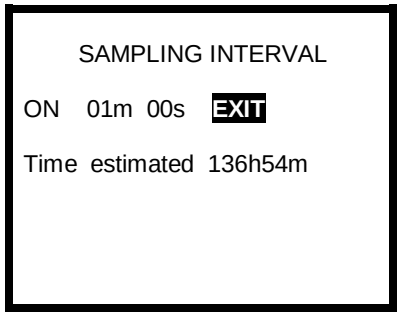
Note: Calculations that are made on a running basis (i.e. TWA, STEL, Ceilings, and Peak exposure values) are updated at regular intervals by the Cannonball3 microprocessor. Adjustments to the sampling interval has no affect on the way in which TWA, STEL, Ceiling, and Peak exposure values are calculated.

To adjust the sampling interval:

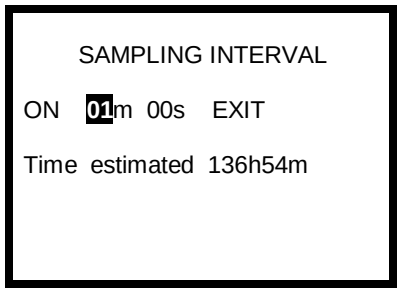
1. Enter the Datalogger Menu as described above in section 5.3.2.



2. Use the navigation arrows to highlight INTERVAL and press the MODE button.

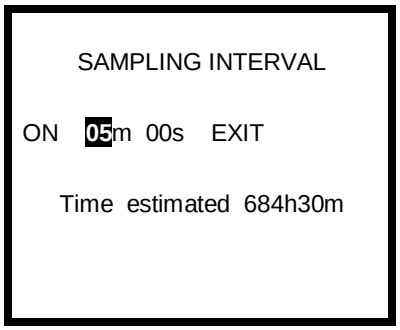


3. Use the navigation arrows to highlight the time interval (usually in minutes).

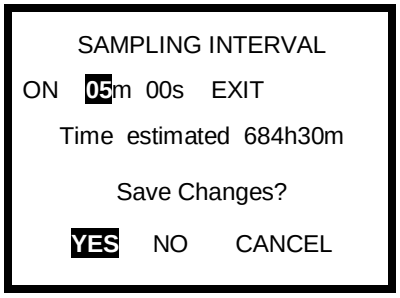


As discussed above, there is a finite amount of memory storage in the Cannonball3. As the interval is either lengthened or shortened, so is the time-estimated figure, which represents the amount of time before the oldest data will be overwritten.

4. With the interval highlighted, use the up and down navigation arrows to adjust the calibration interval



5. Once the sampling interval is adjusted, press the MODE button to enter the new interval.

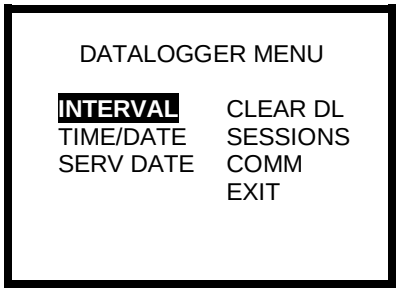


6. Press the MODE button with YES highlighted to save the changes.

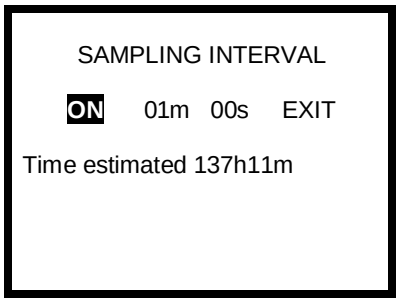
5.3.2.1.1 Disabling the datalogger

To disable the datalogger, turn the sampling interval to OFF.

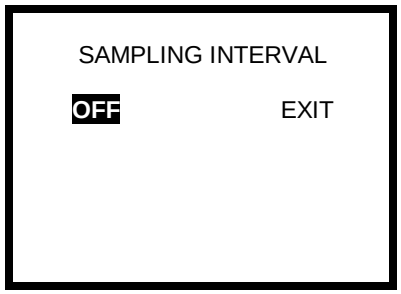
1. Enter the Datalogger Menu as described above in section 5.3.2.



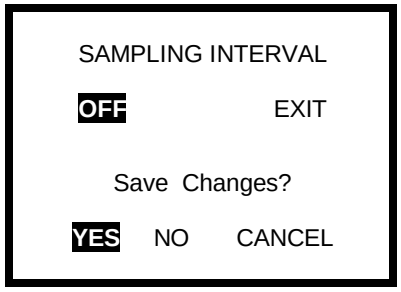
2. Use the navigation arrows to highlight INTERVAL and press the MODE button.



3. Use the right and left navigational arrows to move the cursor to highlight ON.



4. The up and down navigational arrows are used to toggle between ON and OFF. Press the MODE button with OFF highlighted.



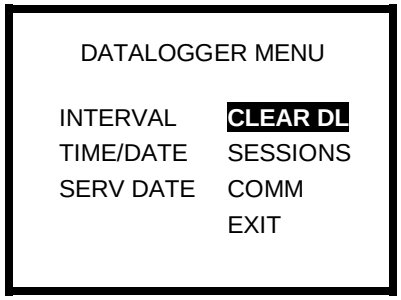
5. Press MODE with YES highlighted to save the new sampling interval setting.

5.3.2.2 Clearing the Datalogger

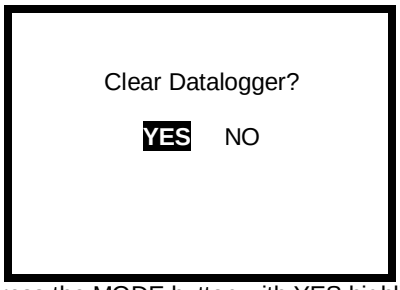
The datalogger can be cleared of all information through the CLEAR DL option.

To clear the datalogger, do the following:

1. Enter the Datalogger Menu as described above in section 5.3.2.1.



2. Use the navigation arrows to highlight CLEAR DL and press the MODE button.



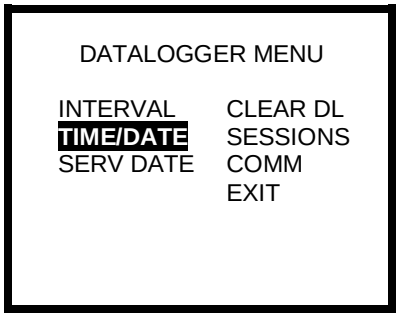
3. Press the MODE button with YES highlighted to clear the datalogger memory.

5.3.2.3 Setting the time and date

Since the Cannonball3 records instrument data that may be used at a later date, it is important that the time and date be accurate.

To change the time and date:

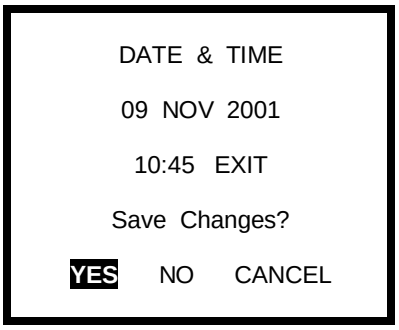
1. Enter the Datalogger Menu as described above in section 5.3.2.



2. Use the navigation arrows to highlight TIME/DATE and press the MODE button.

3. The right and left navigation arrows are used to move back and forth between the day, month, year, and time settings and the exit key. Once the time setting that needs to be adjusted is highlighted, the up and down navigation arrows are used to adjust the setting.

4. The MODE button may be pressed at any time to confirm the new time settings.

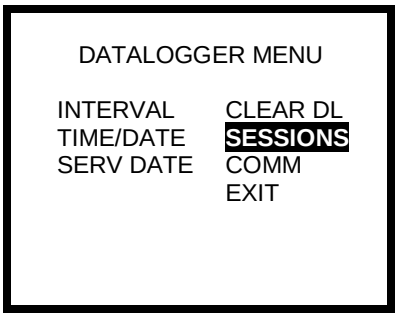


5. Press the MODE button with YES highlighted to confirm the new time and date settings.

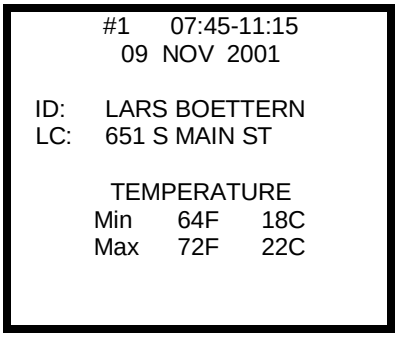
5.3.2.4 Sessions

Data recorded at individual sessions can be accessed through the SESSIONS subdirectory of the Datalogging Menu. To view the session memory:

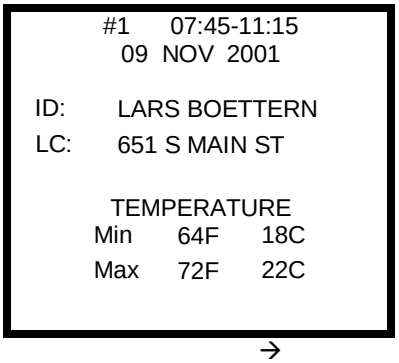
1. Enter the Datalogging Menu as described above in section 5.3.2.

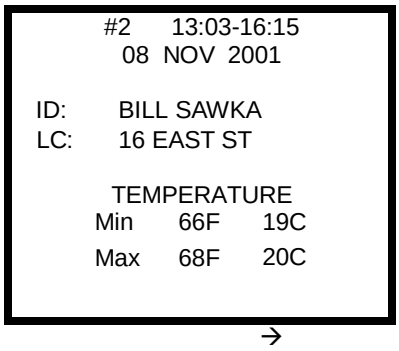


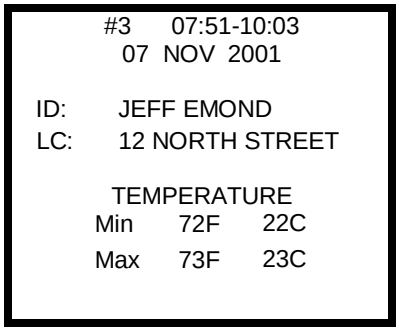
2. Use the navigation arrows to highlight SESSIONS and press the MODE button. The information gathered from the most recent operating session will be displayed.



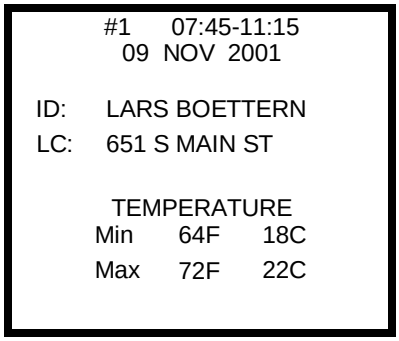
3. The right and left navigation arrows are used to scroll through the data from individual session memories.



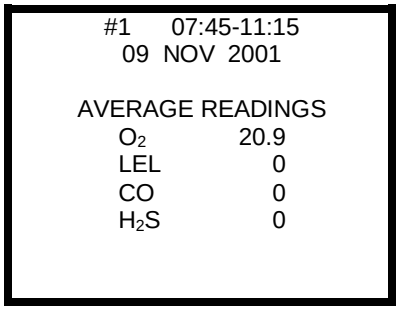




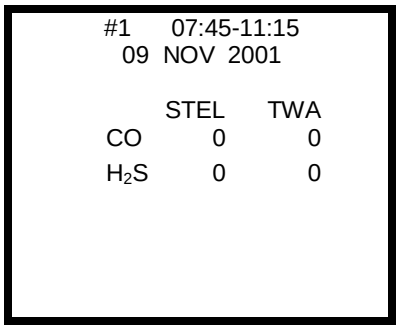
4. The up and down navigation arrows are used to access specific data from the individual monitoring sessions.



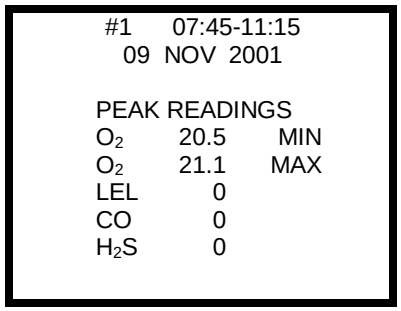
↑↓



↑↓



↑↓

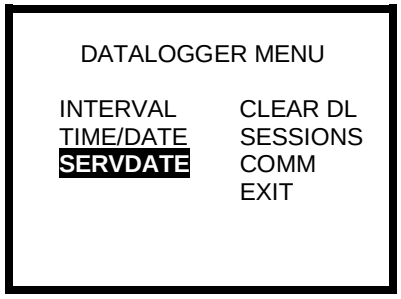


5. Press the MODE button at any time to return to the Main Menu.

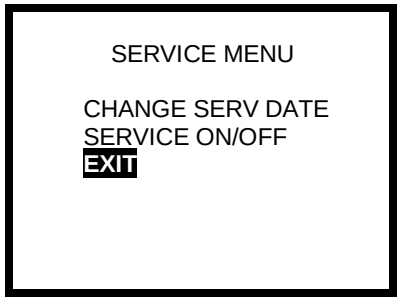
5.3.2.5 Service Date

The Cannonball3 can be programmed to automatically remind the user to service the sensors in the unit. To reach the service due date settings for the individual sensors do the following:

1. Enter the Datalogger Menu as described above in section 5.3.2.

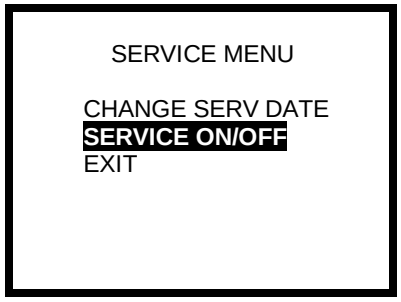


2. Use the navigational arrows to highlight SERV DATE and press the MODE button.

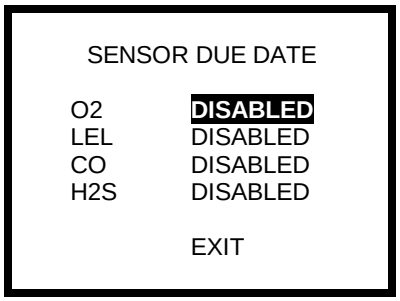


5.3.2.5.1 Enable/disable sensor service due date settings

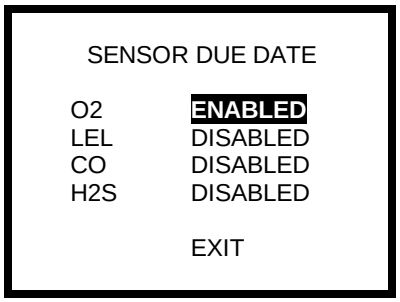
1. Enter the Service Menu screen as described above.



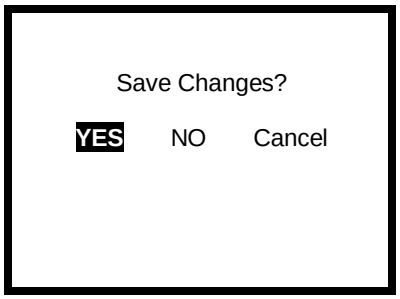
2. Use the up navigation arrows to highlight SERVICE ON/OFF and press the MODE button.



3. To enable (or disable) the service due setting for an individual sensor, use the up and down navigation arrows to highlight the setting adjacent to the sensor, and then press the right or left navigation arrow once.



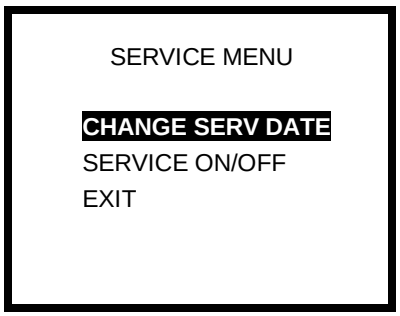
4. Once the sensor due date settings are enabled or disabled as required, press the MODE button to enter the settings.



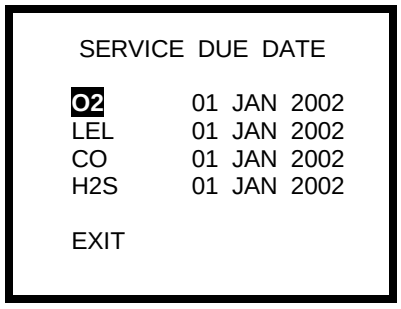
5. Press the MODE button with YES highlighted to confirm the new settings.

5.3.2.5.2 Change sensor service dates

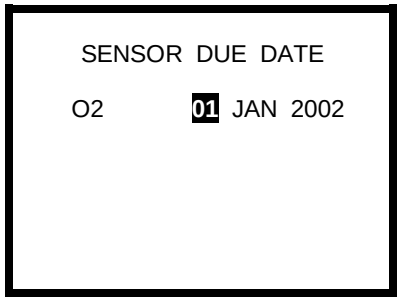
1. Enter the Service Menu as described above.



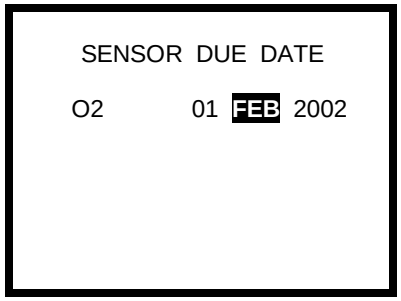
2. Use the up navigation arrows to highlight CHANGE SERV DATE and press the MODE button.



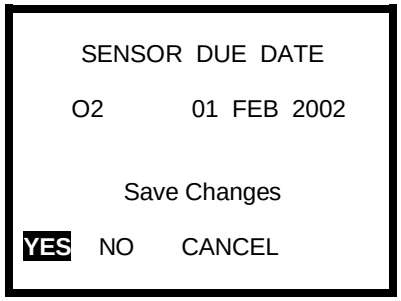
3. Use the up and down navigation arrows to highlight the sensor that requires due date adjustment and press the MODE button.



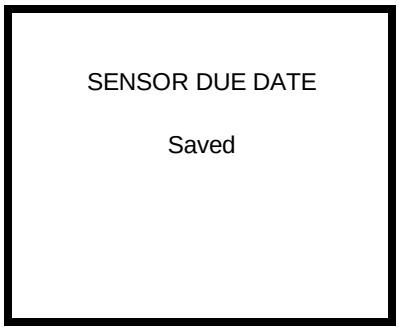
4. Use the right and left navigation arrows to highlight the day, month or year. Then use the up and down navigation arrows to adjust the setting.



5. Once the date has been set, press the MODE button to enter the new date.



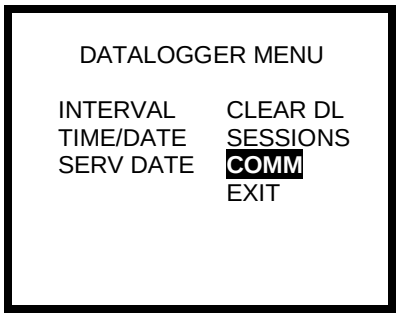
6. Press the MODE button with YES highlighted to confirm the new service due date settings.



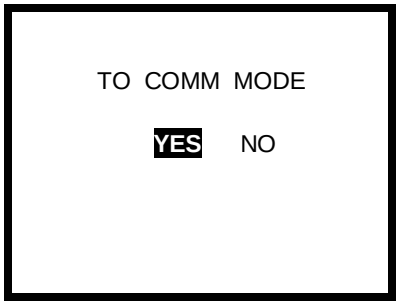
5.3.2.6 Communications mode

Communications mode enables the Cannonball3's IrDA port for downloading to or uploading from a personal computer. To enter communications mode, do the following:

1. Enter the Datalogger Menu as described above in section 5.3.2.



2. Use the navigation arrows to highlight COMM and press the MODE button.



3. Press the MODE button with YES highlighted to enter communication mode and enable the IrDA port.

Chapter 6. Basic maintenance

CAUTION: Maintenance in the Cannonball3 should only be performed by appropriately trained personnel.

6.1 Sensors

The Cannonball3 is designed to recognize the "Smart Sensors" that are currently installed and automatically set the appropriate alarm settings and display readings. The Cannonball3 also automatically recognizes when changes have been made to the sensors installed since the instrument was last turned on.

Note: Any changes made to the sensors installed, even changing one sensor for another of the exact same type will trigger a "Needs Cal" message the next time the instrument is turned on. The Cannonball3 must be re-calibrated before being returned to service any time changes are made to the sensors installed.

Caution: The Cannonball3 must be turned off prior to removing or replacing sensors.

6.1.1 Sensor replacement

To remove or replace sensors in the Cannonball3, do the following:

1. Make sure the Cannonball3 is turned off.
2. Remove the battery pack.
3. Remove the six Philip's head screws from the bottom of the instrument and separate the upper and lower case assemblies. Take special care not to disconnect any of the hoses connecting the sensor compartment, pump and inlet fittings. In the event of a hose disconnection, see figure 6.2.3 below.
4. Remove the two screws from the top of the sensor compartment.
5. Lift up the sensor compartment cover to expose the sensors.
6. Identify the sensor that you wish to replace and gently pull the sensor out of its socket.
7. Press the replacement sensor into place. If a sensor cap has been provided with the replacement sensor, discard the sensor cap.
8. Replace the sensor compartment cover and secure with two screws removed in step 4.
9. Rejoin the upper and lower case assemblies and secure with the six screws removed in step 3.
10. The new sensor must be allowed to stabilize prior to use. The following chart gives a breakdown by sensor type with the required stabilization period for current Cannonball3 sensors.

Sensor	Stabilization Period
Oxygen (54-25-90)	1 hour
LEL (54-25-80(all versions))	5 minutes
All Toxic sensors except those shown below	15 minutes
54-25-04 NH_3 Sensor	24 hours

The instrument does not need to be turned on while new sensors are stabilizing, but functioning batteries must be installed in the instrument. If the instrument is a NiMH unit, a powered charger should be attached to the instrument for the duration of the stabilization period.

11. The Cannonball3 will automatically recognize the changes that have been made upon turn on and display the "Warning Needs Cal" message.
12. Recalibrate the Cannonball3 with calibration gas appropriate for the new sensor before the instrument is put back into service.

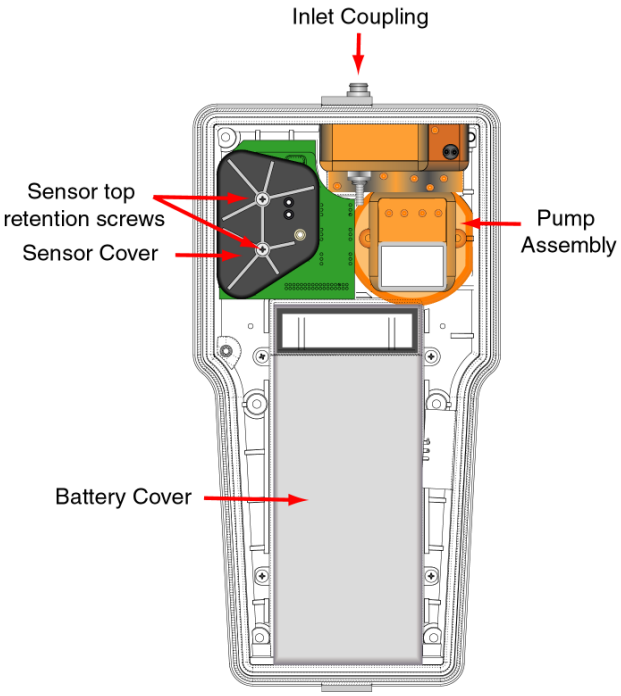


Figure 6.1.1 Internal assembly diagram

Cannonball3 programming includes safeguards to recognize maladjusted sensors. If the settings on the new sensor are significantly different from those of the old sensor, a message will be displayed indicating that that the sensor reading is "Too Low" or "Too High" for One-Button-Auto-Calibration adjustment.

Once the new sensor has been fresh air adjusted using the "manual" calibration procedure, it will then be possible to do subsequent fresh air and span calibrations by pressing the MODE button to initiate the One-Button-Auto-Calibration procedures.

Note: The first fresh air adjustment after installation of a new sensor should be done using the manual calibration procedure as discussed in section 4.6.1 of this manual.

6.1.2 New sensor releases

From time to time Sperian Instrumentation may release a new type of sensor, or make changes to existing sensors in order to improve performance. In some cases it may be necessary to make changes to the Cannonball3's internal instrument software before making use of the new sensor. If a sensor that is incompatible with the current configuration of the instrument's internal software is installed, a message stating that the sensor is "Not Supported" will be displayed at the time the instrument is turned on. Please contact the Sperian Instrument Service Center at (860) 344-1079 for an explanation of the required modifications.

6.1.3. Troubleshooting sensor problems

6.1.3.1 Can't make a "One Button" automatic fresh air adjustment

Possible causes:

1. The atmosphere in which the instrument is located is contaminated (or was contaminated at the time the instrument was last zeroed).
2. A new sensor has just been installed
3. Instrument has been dropped or banged since last turned on.

Solution:

Take the instrument to fresh air and allow readings to stabilize. Do a manual fresh air zero adjustment using buttons on the instrument keypad as discussed in section 4.6.1.

6.1.4 Sensor caps

Part Number	Description
54-26-0990	Oxygen Sensor Cap
54-26-0981	LEL Sensor Cap
54-26-0914	'Duo–Tox' Sensor Cap
54-26-0901	CO / CO+ Sensor Cap
54-26-0902	H_2S Sensor Cap
54-26-0903	SO_2 Sensor Cap

6.2 Internal motorized pump

Every Cannonball3 includes a built-in continuous sample draw pump. Since the Cannonball3's sensor compartment is contained within the instrument, the gas sample must be drawn into the instrument by the pump through a probe assembly that is attached to the inlet coupling on the front of the unit.

The sample draw pump includes a pressure sensor designed to protect the Cannonball3 from exposure to water or other liquids. If there is a change in pressure in the sample draw assembly due to fluid intake, the pump immediately shuts down. After a few seconds audible and visual alarms indicating a low flow condition will also be activated.

CAUTION: The sample probe and hose assembly must be attached to the sample draw inlet coupling for the Cannonball3 to operate properly. Failure to attach the sample probe assembly may result in damage to the instrument.

Procedures for proper use of the motorized sample pump are contained in Chapter 2.

The pressure sensor in the sample draw pump is designed to detect changes while the sample-draw probe is being held in a vertical position. If the probe is held horizontally or at a low angle when inserted into a fluid, a pressure drop sufficient to cause the pump to shut down may not be generated, and water could be drawn into the instrument. To avoid potential damage, care must be taken to keep the probe vertical any time fluids might be present.

As an additional safeguard, the pump also contains an internally housed particulate filter. If the pump is operated in a particularly dirty atmosphere, the internal filter can become clogged and will require periodic replacement.

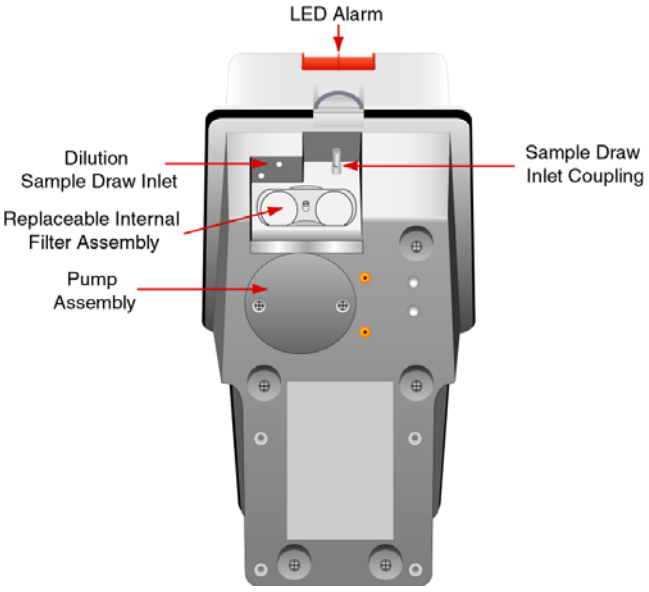


Figure 6.2 Bottom side of lower case assembly

6.2.1 Pump replacement

To replace the pump module, simply loosen the two pump module retention screws on the bottom of the lower case assembly and remove the pump module from the instrument. Install the new pump module, tighten the retention screws and restart the instrument.

CAUTION: Be sure to properly seat the o-ring on the base of the new pump module before installation. Failure to seat the o-ring will compromise the Cannonball3's resistance to water and dust and may result in instrument damage.

6.2.2 Internal filter replacement

The internal filter assembly is located at the front of the Cannonball3 and is retained by a single screw. To replace the filters, simply remove the retention screw, replace the filters and reinstall the retention screw.

6.2.3 Pump failure at start up

Pump seals are automatically tested by the Cannonball3 during the start-up sequence.

Sample Pump Test

Block End of Sample Probe

Pump Test Failed

Remove Blockage and Retest

Pump Failure!

Following a pump test failure, the instrument will shut itself off.

In the event of a pump failure, perform the following steps:

1. Remove the probe assembly from the instrument and turn the Cannonball3 back on. If the pump test passes, proceed to step 2a below. If the pump test fails, proceed to step 2b below.

2a If the pump test passes, then the leak is in the probe assembly. Inspect the probe assembly and look for leaks. Replace filters or probe part as necessary.

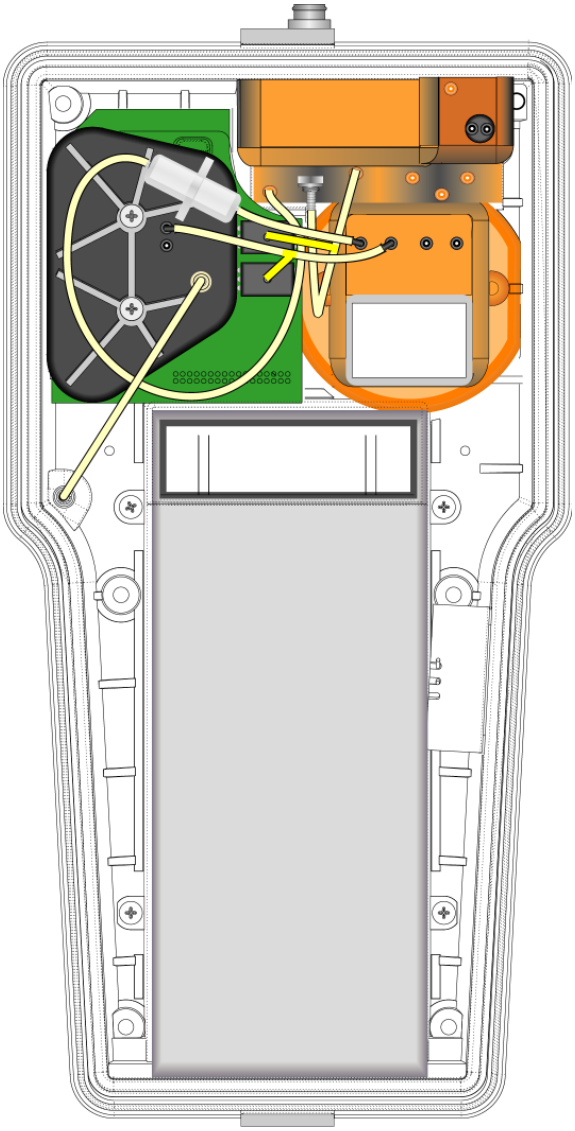


Figure 6.2.3 Pump/tubing assembly diagram

2b If the pump test fails, then the leak is inside the instrument. If the leak is inside proceed to step 3.

3. Verify that the pump itself is correctly installed with the gasket seated correctly around the base of the pump. Retest. If the test fails proceed to step 4.

4. Remove the retention screw on the replaceable internal filter assembly and check the filters. Replace them as needed and reinstall the assembly. Retest. If the test fails proceed to step 5.

5. Open up the instrument and check that all hoses are correctly attached (see the hose diagram below) Retest. If the pump test fails again, either replace the pump entirely, or return the instrument to Sperian Instrumentation.

6.2.4. Can't resume normal operation after a "Low Flow" shut down

Possible causes:

1. Sample probe or internal pump filters need replacement.
2. Sample hose is kinked.
3. Sample probe and probe assembly contains fluids.

Solution(s):

Turn off Cannonball3, remove pump, disconnect sample probe an hose assembly, allow any trapped fluids to drain; replace filters as necessary, examine hose to make sure there are no kinks blocking normal flow.

If these measures fail to resolve the problem, the pump itself may be the cause. In this case, the pump assembly should be removed from the Cannonball3 and returned to Sperian Instrumentation.

6.3 Sample probe assembly

The sample probe handle contains moisture barrier and particulate filters designed to remove contaminants that might otherwise harm the instrument.

CAUTION: Never operate the Cannonball3 without the sample probe and hose assembly. The sample probe handle contains replaceable filters designed to block moisture and remove particulate contaminants. If the pump is operated without the probe assembly in place particulate contaminants may cause damage to the pump, sensors and internal components of the Cannonball3.

Particulate contaminants are removed by means of a cellulose filter. The hydrophobic filter includes a 0.1 μm Teflon™ barrier which blocks the flow of moisture as well as any remaining particulate contaminants.

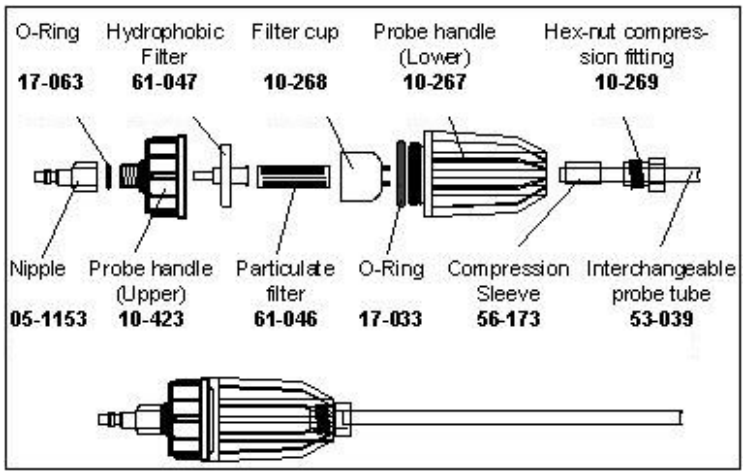


Figure 6.3 Cannonball3 sample draw probe.

Sample probe filters should be replaced whenever visibly discolored due to contamination. A spare filter replacement kit (Sperian Instrumentation part number 54-05-K0401) is included with every Cannonball3.

6.3.1 Changing sample probe filters

The threaded sample probe handle is unscrewed (as shown in Figure 2.4.2 above) to provide access to the filters. The particulate filter is held in place by a clear filter bowl. To replace the particulate filter, remove the old filter and bowl, insert a new filter into the bowl, and slide the bowl back into place in the probe handle. The hydrophobic barrier filter fits into a socket in the rear section of the probe handle. (The narrow end of the hydrophobic barrier filter is inserted towards the rear of the handle.)

6.3.2 Changing sample probe tubes

The standard 11.5" long butyrate probe tube is held in place by means of a hex-nut compression fitting and compression sleeve. The standard probe tube is designed to be easily interchangeable with other custom length sections of 1/4" OD tubing, or probe tubes made of other materials (such as stainless steel).

To exchange probe tubes, loosen the hex-nut compression fitting, remove the old tube, slide the compression sleeve into place around the new tube, insert the new tube into the probe handle, and replace and tighten the hex-nut.

Note: When connected to the Cannonball3, the sample probe and hose assembly will be automatically checked for leakage whenever the Cannonball3 is turned on.

6.4 O-Rings

The Cannonball3 uses o-ring seals on the battery pack, pump assembly and filter assembly to prevent water and other foreign material from entering the interior of the instrument. It is important to regularly clean and service the o-rings to ensure that the Cannonball3 will stay dry and operational.

6.4.1 Removal of o-rings

Upon removal of the battery pack, pump assembly or filter assembly, the o-rings will be easily located and should come off easily with a little pressure. In the event that the o-ring is difficult to remove, use a non-metal object such as a toothpick as an aid.

CAUTION: Never use a metal object to remove an o-ring. The use of a metal object to remove an o-ring may result in structural damage to the battery pack, pump assembly or filter assembly. Damage to these parts could compromise the water and particle resistance of the Cannonball3.

Note: In some early versions of the Cannonball3, the o-ring was glued to the battery pack. If the battery pack o-ring proves extremely difficult to remove, do not remove it. Call Sperian Instrumentation's Service Department at 800 711 6776 x-509 for further instructions.

6.4.2. Inspection and cleaning of o-rings

Remove the o-ring.

Gently clean the o-ring by running it between your fingers. Remove any debris with a lint-free cloth.

Inspect the o-ring for nicks, scratches, cuts, tears, scars or any other deformity. If any deformities are located, the o-ring must be replaced.

Inspect the groove in which the o-ring sits. Remove any debris that has accumulated in the groove with a cotton swab or a lint-free cloth.

6.4.3 Lubrication of o-rings

CAUTION: Use only Sperian Instrumentation-approved lubricant on the o-rings for the Cannonball3. The use of non-approved lubricants may result in degraded combustible sensor performance and/or compromised instrument integrity!

Clean and inspect the o-ring as described above in section 6.4.2.

Place a generous amount of Sperian Instrumentation lubricant between your thumb and forefinger and coat the entire o-ring. The entire surface of the o-ring must be covered with a thin, uniform coating of the lubricant.

Note: See section 6.4.4 below for recommended lubricants.

CAUTION: Do not apply excessive amounts of lubricant to the o-ring. The excess lubricant will attract debris, which could compromise the integrity of the o-ring and the Cannonball3.

Once the o-ring is properly lubricated, reseat it into the groove from which it was removed. The battery pack, pump assembly or filter assembly may then be reinstalled in the instrument.

6.4.4 Recommended lubricants

As discussed in section 4.2.2, combustible sensors will be adversely affected by exposure to substances containing volatile silicone. Since many lubricants contain silicone, care must be taken to use a lubricant that does not contain silicone.

Sperian Instrumentation has conducted extensive testing on various lubricants and recommends the use of "Plumbers Grease" which is manufactured by "Plumbshop" (Plumbshop part number PS2970). If you have difficulty locating "Plumbers Grease", Sperian Instrumentation keeps a supply of it on hand. Please reference part number 22-156 when ordering.

6.4.5 O-ring kits

Sperian Instrumentation offers two different o-ring maintenance kits for the Cannonball3

Part number 54-36-20 includes a 1 ounce tube of "Plumbers Grease" and 10 assorted o-rings to fit the battery pack, pump assembly and filter assembly.

54-36-21 includes 10-1 ounce tubes of “Plumbers Grease” and 100 assorted o-rings to fit the battery pack, pump assembly and filter assembly.

6.5 Returning your Cannonball3 to Sperian Instrumentation for service or repair

Please contact the Sperian Instrumentation Service Department at (860) 344-1079 to obtain a “Return Authorization” number prior to shipment. A Sperian Instrument Service Representative will record all relevant information or special instructions at that time.

To ensure safe transport, whenever possible please use the original Cannonball3 packing materials when returning instruments to Sperian Instrumentation for service. If the original packing materials are not available, please take additional care to pack the instrument in packing materials that will protect the instrument and accessories during shipment.

Note: The return authorization number must be clearly marked on the outside of the box.

Writing the return authorization number prominently on the outside of the box ensures that the return will be immediately identified and logged into our system at the time it is received. Proper tracking helps avoid unnecessary delays in completion of service procedures.

Note: When returning a Cannonball3 for service, always return the instrument together with all accessories including spare battery packs and chargers.

Please contact the Sperian Instrument Service Department at (860) 344-1079 if you require any additional information.

Thank you for choosing the Cannonball3, and thank you for choosing Sperian Instrumentation.

Appendices

Appendix A- Toxic gas measurement - Ceilings, TWAs and STELs

Many toxic substances are commonly encountered in industry. The presence of toxic substances may be due to materials being stored or used, the work being performed, or may be generated by natural processes. Exposure to toxic substances can produce disease, bodily injury, or death in unprotected workers.

It is important to determine the amounts of any toxic materials potentially present in the workplace. The amounts of toxic materials potentially present will affect the procedures and personal protective equipment which must be used. The safest course of action is to eliminate or permanently control hazards through engineering, workplace controls, ventilation, or other safety procedures. Unprotected workers may not be exposed to levels of toxic contaminants which exceed Permissible Exposure Limit (PEL) concentrations. Ongoing monitoring is necessary to insure that exposure levels have not changed in a way that requires the use of different or more rigorous procedures or equipment.

Airborne toxic substances are typically classified on the basis of their ability to produce physiological effects on exposed workers. Toxic substances tend to produce symptoms in two time frames.

Higher levels of exposure tend to produce immediate (acute) effects, while lower levels of long-term (chronic) exposure may not produce physiological symptoms for years.

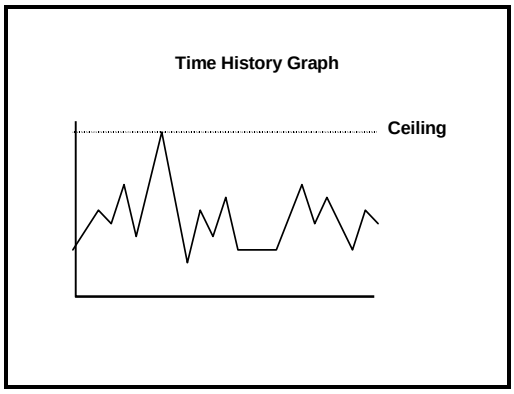
Hydrogen sulfide (H_2S) is a good example of an acutely toxic substance which is immediately lethal at relatively low concentrations. Exposure to a 1,000 PPM (parts per million) concentration of H_2S in air produces rapid paralysis of the respiratory system, cardiac arrest, and death within minutes.

Carbon monoxide (CO) is a good example of a chronically toxic gas. Carbon monoxide bonds to the hemoglobin molecules in red blood cells. Red blood cells contaminated with CO are unable to transport oxygen. Although very high concentrations of carbon monoxide may be acutely toxic, and lead to immediate respiratory arrest or death, it is the long term physiological effects due to chronic exposure at lower levels that take the greatest toll of affected workers. This is the situation with regards to smokers, parking garage attendants, or others chronically exposed to carbon monoxide in the workplace. Exposure levels are too low to produce immediate symptoms, but small repeated doses reduce the oxygen carrying capacity of the blood over time to dangerously low levels. This partial impairment of the blood supply may lead over time to serious physiological consequences.

Because prudent monitoring programs must take both time frames into account, there are three independent exposure measurements and alarm types built into the Cannonball3 design.

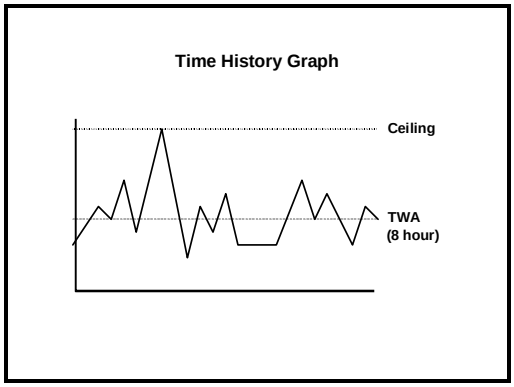
1. Ceiling level:

OSHA has assigned some, but not all, toxic substances with a ceiling level. This is the highest concentration of a toxic substance to which an unprotected worker should ever be exposed, even for a very short time. **Never enter an environment even momentarily when concentrations of toxic substances exceed the ceiling level**.



2. Time Weighted Average (TWA):

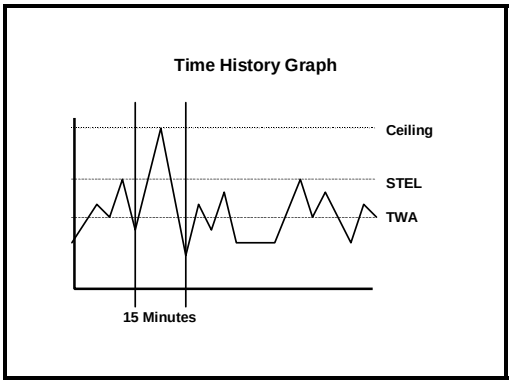
The maximum average concentration to which an unprotected worker may be exposed over an eight hour working day. During this time, STEL and ceiling concentration limits may not be exceeded.



3. Short Term Exposure Limits (STEL):

Toxic substances may have short term exposure limits which are higher than the eight hour TWA. The STEL is the maximum average concentration to which an unprotected worker may be exposed in any fifteen minute interval during the day. During this time, neither the eight hour TWA or the ceiling concentration may be exceeded.

Any fifteen minute periods in which the average STEL concentration exceeds the permissible eight hour TWA must be separated from each other by at least one hour. A maximum of four of these periods are allowed per eight hour shift.



Appendix B Electrochemical Sensor Cross Sensitivity Data

The table below provides the cross-sensitivity response of the Cannonball3 toxic gas sensors to common interference gases. The values are expressed as a percentage of the primary sensitivity, or the reading of the sensor when exposed to 100ppm of the interfering gas at 20ºC. These values are approximate. The actual values depend on the age and condition of the sensor. Sensors should always be calibrated to the primary gas type. Cross-sensitive gases should not be used as sensor calibration surrogates without the express written consent of Sperian Instrumentation.

SENSOR	CO	H_2S	SO_2	NO	NO_2	Cl_2	ClO_2	H_2	HCN	HCl	NH_3	C_2H_4	C_2H_2
Carbon Monoxide(CO)	100	10	5	10	-15	-5	-15	50	15	3	0	75	250
Carbon Monoxide (CO+)	100	350	50	30	-60	-60	-120	50	n/d	n/d	0	75	250
Carbon Monoxide (CO-H)	100	10	5	n/d	(-)	(-)	(-)	5	n/d	n/d	n/d	(+)	(+)
Hydrogen Sulfide (H_2S)	0.5	100	20	2	-20	-20	-60	0.2	0	0	0	n/d	n/d
Sulfur Dioxide (SO_2)	1	1	100	1	-100	-50	-150	0.2	n/d	n/d	0	(+)	(+)
Nitrogen Dioxide (NO_2)	-5	-8	-1	0	100	90	270	0	n/d	n/d	0	n/d	n/d
Chlorine (Cl_2) (nonspecific)	0	-3	-1	0	110	100	310	0	n/d	n/d	0	n/d	n/d
Chlorine (Cl_2) (specific)	0	-3	0	n/d	12	100	0	0	0	2	n/d	0	0
Chlorine Dioxide (ClO_2) (nonspecific)	0	-1	-0.3	0	40	33	100	0	n/d	n/d	0	n/d	n/d
Chlorine Dioxide (ClO_2) (specific)	0	0	0	n/d	n/d	0	100	0	0	0	n/d	0	0
Ammonia (NH_3) –21	0	<5	0	n/d	0	0	n/d	0	0	0	100	0	0
Ammonia (NH_3) -04	0	130	70	15	-5	-50	-150	0	5	0	100	0	n/d
Phosphine (PH_3)	0.5	25	20	n/d	(-)	(-)	(-)	0.1	n/d	n/d	n/d	1	0.5
Hydrogen Cyanide (HCN)*	0.5	350	160	-5	-100	-20	-60	0.1	100	65	-5	50	n/d

n/d = no data, (+) undetermined positive, (-) undetermined negative

O_2 Sensor/CO_2 Cross Sensitivity: The output of the O_2 sensor used in the Cannonball3 will be enhanced by approximately 0.3% of signal per 1% of CO_2.

*Reduced sulfur gases (H_2S and SO_2) are considered to be HCN sensor poisons. HCN sensors are not recommended for use in areas prone to sulfur gas presence.

Appendix C Cannonball3 sensors ranges

Part No.	Description		Range	Resolution
54-25-80	LEL	Combustible gas	0 – 100% LEL	1% LEL
54-25-90	O_2	Oxygen	0 – 30%/Vol.	0.1%
54-25-01	CO	Carbon monoxide	0 – 1000 PPM	1 PPM
54-25-05	CO+	CO Plus dual purpose CO / H_2S Provides a non-specific readout for CO and H_2S	CO: 0 – 1000 PPM H_2S: 0 – 200 PPM	1 PPM
54-25-19	CO-H	CO Minus, reduced sensitivity to H_2	0 – 800 PPM	1 PPM
54-25-02	H_2S	Hydrogen sulfide	0 – 200 PPM	1 PPM
54-25-14	Duo-Tox	Dual channel CO/H_2S Provides substance specific readouts for CO and H_2S	CO: 0 – 1000 PPM H_2S: 0 – 200 PPM	1 PPM 1 PPM
54-25-03	SO_2	Sulfur dioxide	0 – 25 PPM	0.1 PPM
54-25-15	SO_2-Ext	Sulfur dioxide extended range	0 – 100 PPM	0.1 PPM
54-25-04†	NH_3	Ammonia **(For software versions prior to 2.0)**	0 – 50 PPM	1 PPM
54-25-21†	NH_3	Ammonia	0 – 100 PPM	1 PPM
54-25-08†‡	Cl_2	Chlorine (non-specific)	0 – 50 PPM	0.1 PPM
54-25-18†‡	Cl_2	Chlorine (specific)	0 – 50 PPM	0.1 PPM
54-25-12†‡	ClO_2	Chlorine dioxide (non-specific)	0 – 15 PPM	0.1 PPM
54-25-20†‡	ClO_2	Chlorine dioxide (specific)	0 – 5 PPM	0.01 PPM
54-25-09†	NO_2	Nitrogen dioxide	0 – 50 PPM	0.1 PPM
54-25-10†	HCN	Hydrogen cyanide	0 – 100 PPM	0.2 PPM
54-25-13	PH_3	Phosphine	0 – 20 PPM	0.1 PPM

† Special reactive gas calibration adapter (54-26-0405) required for proper calibration.

‡ The non-specific Cl_2 and ClO_2 sensors can be used for the detection of both gases. The specific Cl_2 and ClO_2 sensors are designed for the target gas only.

Appendix D LEL Correction Factors

The commonly accepted way to estimate the relative response of a sensor calibrated on one combustible gas to exposure to another gas is by taking the actual instrument reading, and multiplying it by a correction factor.

It is very important to understand that if an error is made in determining the specific kind of gas present, and the wrong correction factor is used, the accuracy of the calculation may be significantly affected.

In actual practice, the relative response varies somewhat from sensor to sensor. The response ratios may also shift over the life of a particular sensor, especially in the event the sensor loses sensitivity as a consequence of being "poisoned".

Using correction factors

As an illustration, consider a Cannonball3 calibrated on methane, which is then used to monitor ethanol. When calibrated to methane, the instrument is actually less responsive to ethanol than to methane, so the readings will be low. Multiplying the instrument reading by the correction factor for ethanol will produce the true % LEL.

Given that the correction factor for ethanol is 1.2, if the instrument reading is 40 percent LEL, then the true concentration is seen to be about 48% LEL.

(40 % LEL) X (1.2) = (48% LEL)
Instrument **Correction** **Actual**
Reading *Factor* *Concentration*

It is important to note that the correction factor for ethanol is different when the instrument is calibrated on propane. In the case of a propane calibrated instrument, instrument readings for ethanol will be high. Given that the correction factor for ethanol in this case is 0.76; when the instrument reads 40 percent LEL, the true concentration for ethanol is 30% LEL.

(40 % LEL) X (.76) = (30% LEL)
Instrument **Correction** **Actual**
Reading Factor Concentration

Combustible Gas / Vapor	Correction factor when instrument is calibrated on Propane	Correction factor when instrument is calibrated on Methane
Hydrogen	**0.54**	**0.83**
Methane	**0.65**	**1.0**
Propane	**1.0**	**1.5**
n-Butane	**1.0**	**1.5**
n-Pentane	**1.1**	**1.7**
n-Hexane	**1.2**	**1.8**
n-Heptane	**1.3**	**2.0**
n-Octane	**1.6**	**2.5**
Methanol	**0.65**	**1.0**
Ethanol	**0.76**	**1.2**
Isopropyl Alcohol	**1.0**	**1.5**
Acetone	**0.93**	**1.4**
Ammonia	**0.46**	**0.71**
Toluene	**1.6**	**2.5**
Methyl Ethyl Ketone	**1.2**	**1.8**
Ethyl Acetate	**1.2**	**1.8**
Gasoline (Unleaded)	**1.1**	**1.7**

Appendix E: Calibration Frequency Recommendation

One of the most common questions that we are asked at Sperian Instrumentation is: ***"How often should I calibrate my gas detector?"***

Sensor Reliability and Accuracy

Today's sensors are designed to provide years of reliable service. In fact, many sensors are designed so that with normal use they will only lose 5% of their sensitivity per year or 10% over a two-year period. Given this, it should be possible to use a sensor for up to two full years without significant loss of sensitivity.

Verification of Accuracy

With so many reasons why a sensor can lose sensitivity and given the fact that dependable sensors can be key to survival in a hazardous environment, frequent verification of sensor performance is paramount.

There is only one sure way to verify that a sensor can respond to the gas for which it is designed. That is to expose it to a known concentration of target gas and compare the reading with the concentration of the gas. This is referred to as a "bump" test. This test is very simple and takes only a few seconds to accomplish. **The safest course of action is to do a "bump" test prior to each day's use**. It is not necessary to make a calibration adjustment if the readings fall between 90%* and 120% of the expected value. As an example, if a CO sensor is checked using a gas concentration of 50 PPM it is not necessary to perform a calibration unless the readings are either below 45 PPM or above 60 PPM.

***The Canadian Standards Association (CSA) requires combustible gas sensors to undergo calibration when the displayed value during a bump test fails to fall between 100% and 120% of the expected value for the gas.**

Lengthening the Intervals between Verification of Accuracy

We are often asked whether there are any circumstances in which the period between accuracy checks may be lengthened.

Sperian Instrumentation is not the only manufacturer to be asked this question! One of the professional organizations to which Sperian Instrumentation belongs is the Industrial Safety Equipment Association (ISEA). The "Instrument Products" group of this organization has been very active in developing a protocol to clarify the minimum conditions under which the interval between accuracy checks may be lengthened.

A number of leading gas detection equipment manufacturers have participated in the development of the ISEA guidelines concerning calibration frequency. Sperian Instrumentation's procedures closely follow these guidelines.

If your operating procedures do not permit daily checking of the sensors, Sperian Instrumentation recommends the following procedure to establish a safe and prudent accuracy check schedule for your Sperian instruments:

1. During a period of initial use of at least 10 days in the intended atmosphere, check the sensor response daily to be sure there is nothing in the atmosphere that 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.
2. If these tests demonstrate that it is not necessary to make adjustments, the time between checks may be lengthened. The interval between accuracy checking should not exceed 30 days.
3. When the interval has been extended the toxic and combustible gas sensors should be replaced immediately upon warranty expiration. This will minimize the risk of failure during the interval between sensor checks.
4. The history of the instrument response between verifications should be kept. Any conditions, incidents, experiences, or exposure to contaminants that might have an adverse effect on the calibration state of the sensors should trigger immediate re-verification of accuracy before further use.
5. Any changes in the environment in which the instrument is being used, or changes in the work that is being performed, should trigger a resumption of daily checking.
6. If there is any doubt at any time as to the accuracy of the sensors, verify the accuracy of the sensors by exposing them to known concentration test gas before further use.

Gas detectors used for the detection of oxygen deficiencies, flammable gases and vapors, or toxic contaminants must be maintained and operated properly to do the job they were designed to do. Always follow the guidelines provided by the manufacturer for any gas detection equipment you use!

If there is any doubt regarding your gas detector's accuracy, do an accuracy check! All it takes is a few moments to verify whether or not your instruments are safe to use.

One Button Auto Calibration

While it is only necessary to do a "bump" test to ensure that the sensors are working properly, all current Sperian gas detectors offer a one-button auto calibration feature. This feature allows you to calibrate a Sperian gas detector in about the same time as it takes to complete a "bump" test. The use of automatic bump test and calibration stations can further simplify the tasks, while automatically maintaining records.

Don't take a chance with your life.
Verify accuracy frequently!

Please read also Sperian Instrumentation's application note: *AN20010808 "Use of 'equivalent' calibration gas mixtures"*. This application note provides procedures to ensure safe calibration of LEL sensors that are subject to silicone poisoning.

Sperian Instrumentation's website is located at

http://www.biosystems.com

Appendix F Sperian Instrumentation Warranty Gas Detection Products

General

Sperian Protection Instrumentation, LLC (hereafter Sperian) warrants gas detectors, sensors and accessories manufactured and sold by Sperian, to be free from defects in materials and workmanship for the periods listed in the tables below.

Damages to any Sperian products that result from abuse, alteration, power fluctuations including surges and lightning strikes, incorrect voltage settings, incorrect batteries, or repair procedures not made in accordance with the Instrument's Reference Manual are not covered by the Sperian warranty.

The obligation of Sperian under this warranty is limited to the repair or replacement of components deemed by the Sperian Instrument Service Department to have been defective under the scope of this standard warranty. To receive consideration for warranty repair or replacement procedures, products must be returned with transportation and shipping charges prepaid to Sperian at its manufacturing location in Middletown, Connecticut, or to a Sperian Authorized Warranty Service Center. It is necessary to obtain a return authorization number from Sperian prior to shipment.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ANY AND ALL OTHER WARRANTIES AND REPRESENTATIONS, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. SPERIAN WILL NOT BE LIABLE FOR LOSS OR DAMAGE OF ANY KIND CONNECTED TO THE USE OF ITS PRODUCTS OR FAILURE OF ITS PRODUCTS TO FUNCTION OR OPERATE PROPERLY.

Instrument & Accessory Warranty Periods

Product(s)	Warranty Period
Biosystems PHD6, PhD[5], PhD Lite, PhD Plus, PhD Ultra, Cannonball*3,* MultiVision, Toxi, Toxi/Oxy Plus, Toxi/Oxy Ultra, ToxiVision, Ex Chek	As long as the instrument is in service
ToxiPro®, MultiPro	2 years from date of purchase
ToxiLtd®	2 years after activation or 2 years after the "Must Be Activated By" date, whichever comes first
Toxi3Ltd®	3 years after activation or 3 years after the "Must Be Activated By" date, whichever comes first
Mighty-Tox 2 Prorated credit is given towards repair or purchase of a new unit of the same type.	0 – 6 months of use 100% credit 6 – 12 months of use 75% credit 12 – 18 months of use 50% credit 18 – 24 months of use 25% credit
IQ Systems, Series 3000, Airpanel, Travelpanel, ZoneGuard, Gas✓Chek1 and Gas✓Chek4	One year from the date of purchase
Battery packs and chargers, sampling pumps and other components, which by their design are consumed or depleted during normal operation, or which may require periodic replacement	One year from the date of purchase

Sensor Warranty Periods

Instrument(s)	Sensor Type(s)	Warranty Period
Biosystems PHD6, PhD Plus, PhD Ultra, PhD[5], PhD Lite, Cannonball*3*, MultiVision, MultiPro, ToxiVision, ToxiPro®, Ex Chek	O_2, LEL**, CO, CO+, H_2S & Duo-Tox	2 Years
	All Other Sensors	1 Year
Toxi, Toxi/Oxy Plus, Toxi/Oxy Ultra	CO, CO+, H_2S	2 Years
	All Other Sensors	1 Year
All Others	All Sensors	1 Year

**** Damage to combustible gas sensors by acute or chronic exposure to known sensor poisons such as volatile lead (aviation gasoline additive), hydride gases such as phosphine, and volatile silicone gases emitted from silicone caulks/sealants, silicone rubber molded products, laboratory glassware greases, spray lubricants, heat transfer fluids, waxes & polishing compounds (neat or spray aerosols), mold release agents for plastics injection molding operations, waterproofing formulations, vinyl & leather preservatives, and hand lotions which may contain ingredients listed as cyclomethicone, dimethicone and polymethicone (at the discretion of Sperian's Instrument Service department) void Sperian Instrumentation's Standard Warranty as it applies to the replacement of combustible gas sensors.**