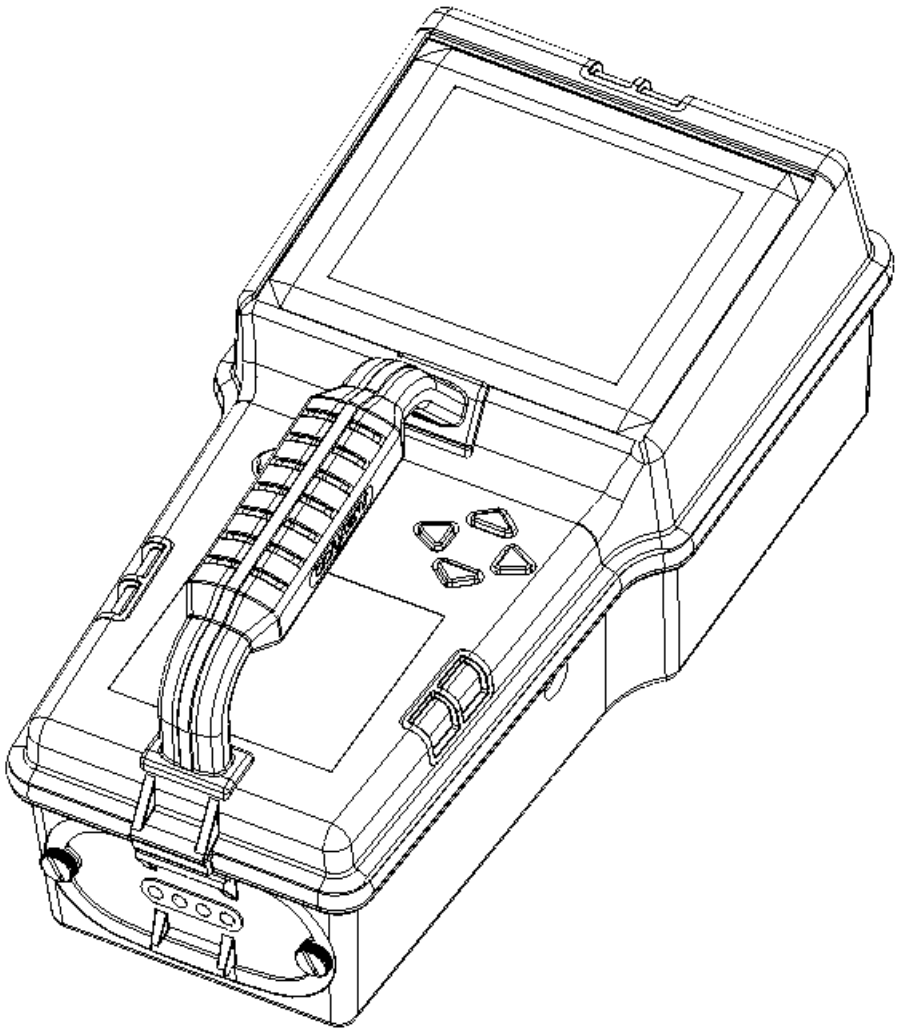
HC/LEL Sensor Addendum to Reference Manual

Cannonball 3

Multi Gas Detector



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⚠WARNING

THE Cannonball 3 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 AND THE CANNONBALL3 REFERENCE MANUAL BE READ, FULLY UNDERSTOOD, AND FOLLOWED.

THIS MANUAL IS NOT INTENDED TO REPLACE THE CANNONBALL3 REFERENCE MANUAL. IT IS ONLY AN ADDENDUM AND SHOULD BE USED IN CONJUNCTION WITH THE CANNONBALL3 REFERENCE MANUAL AT ALL TIMES.

HC/LEL Sensor Addendum to the Cannonball 3 Reference Manual

Part Number 13-236

Version 1.00

Biosystems

Middletown, Connecticut 06457

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Signal Words

The following signal words, as defined by ANSI Z535.4-1998, are used in the HC/LEL Sensor Addendum to the Cannonball 3 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 Cannonball 3 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 Cannonball 3. Substitution of batteries may impair intrinsic safety.**
4. **⚠WARNING The accuracy of the Cannonball 3 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 Cannonball 3 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 Biosystems for use in calibrating the Cannonball 3. Use of inappropriate calibration gas may lead to in accurate and potentially dangerous readings.**

   Customers are strongly urged to use only Biosystems calibration materials when calibrating the Cannonball 3. Use of non-standard calibration gas and/or calibration kit components can lead to dangerously inaccurate readings and may void the standard Biosystems warranty.

8. **⚠WARNING Use of non-standard calibration gas and/or calibration kit components when calibrating the Cannonball 3 can lead to inaccurate and potentially dangerous readings and may void the standard Biosystems warranty.**

   Biosystems offers calibration kits and long-lasting cylinders of test gas specifically developed for easy Cannonball 3 calibration. Customers are strongly urged to use only Biosystems calibration materials when calibrating the Cannonball 3.

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 Cannonball 3.**

11. **⚠WARNING A rapid up-scale reading followed by a declining or erratic reading may indicate a hazardous combustible gas concentration that exceeds the Cannonball 3'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.**

Section 1 Overview

This manual is intended as an addendum to the Cannonball3 Reference Manual and should be used in conjunction with the Cannonball3 Reference Manual at all times.

HC-PPM stands for HydroCarbon Parts Per Million and allows the Cannonball3 to be used to detect both explosive (% LEL) and trace (PPM) levels of hydrocarbons and other combustible gases in the presence of air. A secondary display located between the LEL and O2 readings shows the level of hydrocarbons detected from 0 to 10,000 PPM in 10 PPM increments. Once the levels of hydrocarbon exceeds 10,000 PPM, the HC display will shift to percent by volume since 10,000 PPM = 1.00% by volume.

Note: The HC/LEL sensor is not designed to work with a Cannonball3 in Dilution Mode. Dilution Mode will be automatically disabled once the HC/LEL sensor is installed.

1.1 LEL/PPM theory

Combustible gases and vapors will form fully explosive mixes in air at a level based on a certain volume percent in air. The lowest level at which a gas or vapor becomes explosive in air is known as the Lower Explosive Limit and is referred to as 100% LEL. The exact volume concentration yielding 100% LEL in air for a specific material can be found in materials property tables on the combustibility of gases and vapors in air. For convenience, a table of values is included in Appendix A for some of the more common materials.

For any gas/vapor, one volume percent (1% vol.) is always equal to 10,000 PPM. This follows mathematically from the fact that 100% by volume is equal to one million parts per million (PPM).

1% volume of any gas/vapor = 10,000 PPM

In the case of most hydrocarbons, the lower explosive limit is equal to somewhere between 0.5 and 5.5% by volume depending on the specific hydrocarbon(s) involved.

100% LEL gas/vapor ~ 0.5-5.5% by volume hydrocarbon

It follows then that each 1% LEL of any given hydrocarbon is equal to somewhere between 50 and 550 PPM (depending on the specific hydrocarbon(s) involved).

Each 1% LEL gas/vapor ~ 50-550 PPM

A standard LEL-style combustible gas sensor typically has a lower detectable limit of 1-3% LEL, which corresponds to a minimum detection range of 50-1,650 PPM, depending on the specific material involved. Due to this limited resolution, a standard combustible gas sensor is of very limited or no use when it comes to work requiring PPM or trace level combustible gas/vapor detection.

Operations frequently requiring trace level of detection may include:

1. Pinpointing small gas/vapor leaks.

2. Determining levels of toxicity associated with proper selection of PPE.
3. Field screening of samples for residual solvent or fuel contamination.

1.2 Scale

The HC/LEL sensor factory default calibration is on a propane equivalent scale. The lower explosive limit (LEL) for propane is known to be 2.2% vol., so in the default set up each 1% LEL corresponds to 220 PPM propane.

The output of the HC-PPM sensor is very linear throughout the range from PPM levels up to volume percent and the corresponding percent LEL. In most applications a single point (typically 50% LEL) calibration can be used to set the sensitivity for both scales. If a more direct confirmation of accuracy is desired in the PPM range, the PPM and the LEL scale may be de-coupled. An independent calibration at the PPM level will then establish a second response scale for PPM, which will be related to the LEL scale by a ratio.

1.3 LEL-PPM Ratio options

The key to understanding the workings of the HC/LEL sensor is realizing that both the HC and the LEL readings are generated from a single sensor. The Cannonball3 software interprets the sensor output and converts it into two separate readings. Since these readings are generated from a single output, they can always be related by a ratio.

There are three possible ways to define the ratio between the %LEL and PPM scales. The SELECT LEL GAS and CUSTOM RATIO options require a single source of calibration gas for the HC/LEL sensor. The Cannonball3 then computes the PPM display based on the preset ratio, whether it is chosen from a list or defined by the user.

For increased accuracy to a specific material in the PPM range, a dual-source calibration option is available, which establishes independent response values for the PPM and LEL displays. This increases accuracy because the software is able to compute the exact response ratio based on two specific and controlled calibration sources.

1.3.1 Define ratio through SELECT LEL GAS

The SELECT LEL GAS option allows the user to choose a preset ratio that will be used to automatically compute the PPM readings based on the output of the LEL sensor. This approach has the advantage of using a single cylinder of calibration gas to calibrate the LEL and PPM sensor.

In the example given above in section 1.2, the user would select propane as the LEL gas and the HC response scale would be set to propane. Since 1% LEL propane is equal to 220 PPM propane, each 220 PPM registered on the HC display would be shown with a reading of 1% on the LEL display.

See section 4.5.2 for the SELECT LEL GAS option.

1.3.2 Define CUSTOM RATIO

The CUSTOM RATIO option is used for materials that do not appear on the SELECT LEL GAS list. The user enters a custom ratio that is used to compute the PPM readings based on the output of the LEL sensor. This approach also has the advantage of using a single cylinder of calibration gas cylinder to calibrate the LEL and PPM sensor.

In this case, the software determines the PPM readings based on the output of the LEL sensor and factors in the custom ratio to determine the PPM reading. The PPM reading will then equal the custom ratio value times 100 PPM per 1% LEL that is registered.

See section 4.5.3 for the CUSTOM RATIO option.

1.3.3 Define ratio through dual source calibration

To increase accuracy in the PPM range to a specific material, or to set the trace PPM scale consistently different from the LEL scale, the user can set independent response scales for the %LEL and PPM displays by calibrating the PPM scale independently of the LEL scale. The dual calibration option is typically done to address concerns associated with toxicity in the PPM range. An example of this would be a case where the Cannonball3 is used to monitor for natural gas in the LEL range and a secondary gas, such as toluene in the PPM range (at different times). This is done by disabling the CAL. PPM WITH LEL option in the Calibration Menu and then calibrating the HC and LEL scales independently with the appropriate gases.

See section 4.6 for the dual source calibration option.

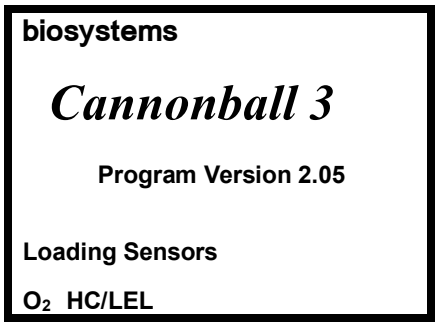
1.4 Instrument Firmware Requirements

To use the HC-PPM LEL sensor, the Cannonball3 must have an instrument firmware version of 2.00 or higher. Earlier versions of Cannonball3 firmware will not recognize the HC-PPM LEL sensor.

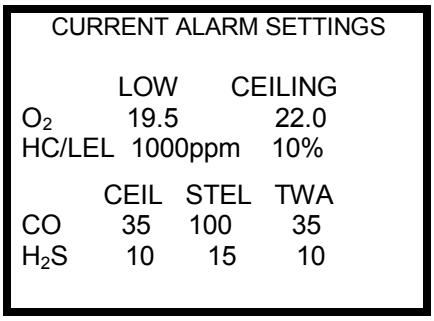
Software upgrade instructions are given on Biosystems website at www.biosystems.com.

Section 2Using the HC/LEL sensor

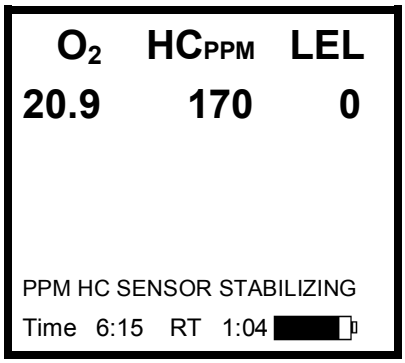
Upon instrument turn on, instruments equipped with the HC-PPM sensor will indicate the HC/LEL on the bottom line of the display.



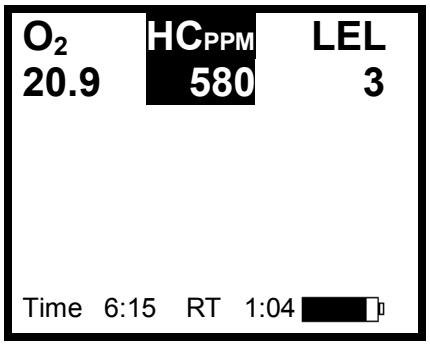
There are very few differences in the initial start up screens with the HC/LEL sensor installed versus the standard LEL sensor. One notable difference is the alarm display, which will show the distinct HC and LEL alarm setpoints.



Once the start up sequence is complete, the current gas readings screen will be shown. Due to the sensitivity of the HC/LEL sensor, a stabilization period is necessary. The automatic calibration functions will be locked out for the first 90 seconds of use to allow the HC/LEL sensor to stabilize. The current gas readings screen will indicate that the PPM-HC sensor is stabilizing for 90 seconds.



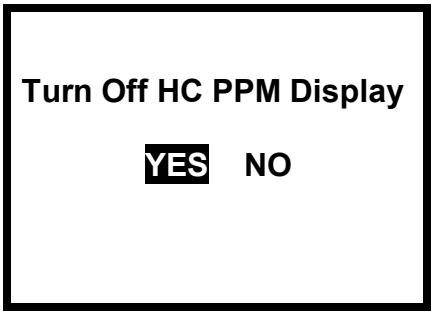
If the HC PPM sensor exceeds the default HC warning alarm the HCPPM level will be shown in reverse flashing text.



Other sensor readings may also be shown depending on the configuration of your Cannonball3.

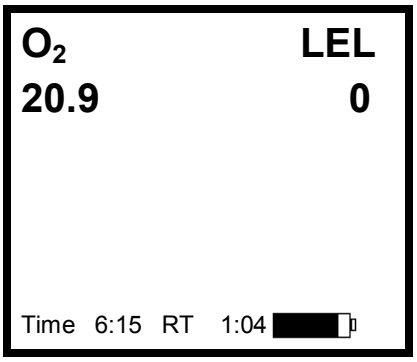
2.1 Enable/Disable HCPPM reading

To enable or disable the HCPPM readout during normal operation, simultaneously press the up and down navigation arrows at the current gas readings screen. The Cannonball3 will then prompt you as to whether you'd like to turn off or turn on the HC PPM display.

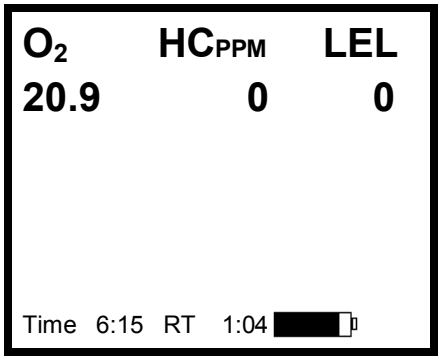


2.2 HC/LEL Display

In order to eliminate any possible confusion between the displayed readings, a Cannonball3 with the HC/LEL sensor enabled will always indicate the %LEL scale on the display in the upper right corner of the display.



The user may elect to show the "HCPPM" scale along side of the %LEL scale, which will appear in the upper center of the display.



In the HCPPM mode, readings are displayed in 10-PPM increments from 0 – 10,000 PPM. At 10,000 PPM, the reading automatically switches to percent by volume (vol%) with 0.01 % resolution (100 PPM). The following table summarizes the display resolution across all ranges.

HC-PPM Range	Resolution
0-10,000 PPM	10 PPM
1.00+ vol %	0.01% or 100 PPM

The upper range of vol % reading is determined by the % vol. gas yielding 100% LEL and the calibration setting(s) of the detector. The Cannonball3 will automatically disable the LEL sensor when readings reach 100% LEL.

Section 3Alarms related to HC/LEL

Cannonball 3 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.

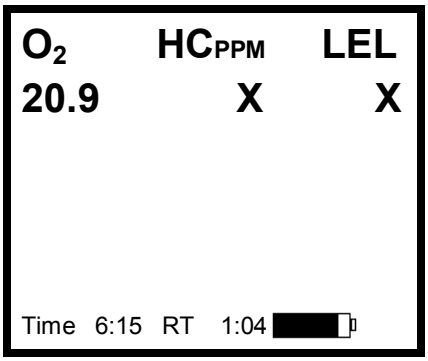
⚠WARNING In the event of an alarm condition it is important to follow established procedures. The safest course of action is to immediately leave the affected area, and to return only after further testing determines that the area is once again safe for entry. Failure to immediately leave the area during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

Cannonball 3 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 the instrument by pressing the MODE button.

3.1 LEL overrange alarm

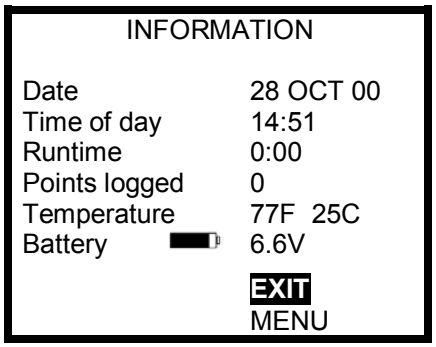
An LEL overrange alarm occurs when the instrument registers a reading in excess of 100% LEL, which indicates a combustible atmosphere. During an LEL overrange alarm, the HC/LEL sensor will be automatically shut down by

the instrument and both the LEL and the HC-PPM scales will display an "X".

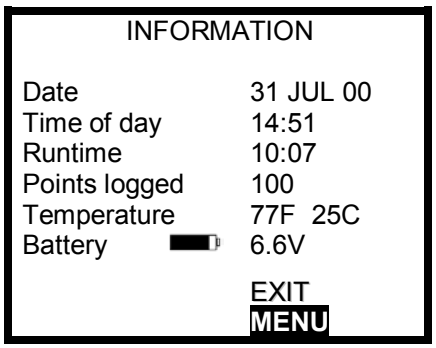


3.2 Entering the Alarms Menu

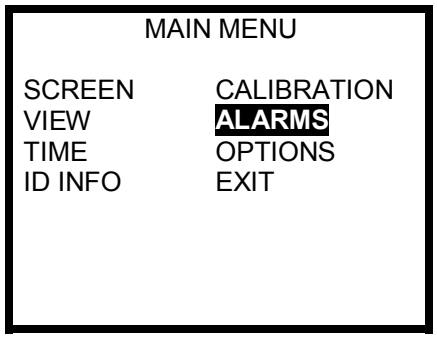
1. Turn the instrument on and wait until the gas readings screen appears.
2. Press the MODE button until the information screen is displayed.



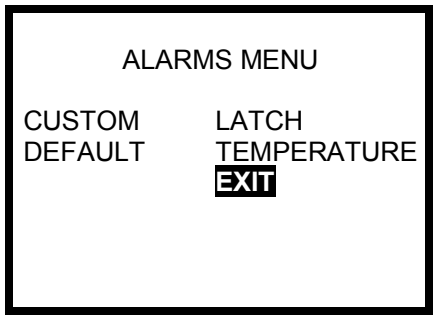
3. Hold down the left navigation arrow for 3 seconds or until EXIT appears and is highlighted.



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



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

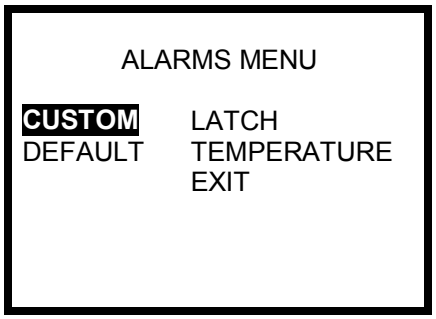


3.3 Custom HC/LEL alarm settings

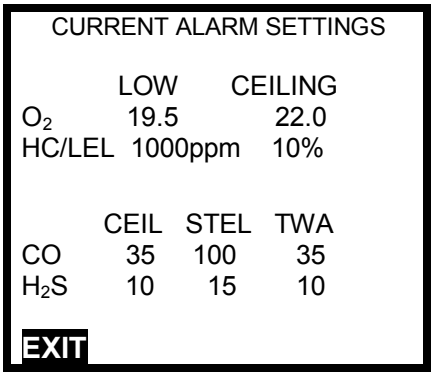
Cannonball 3 gas alarms are user-adjustable and may set anywhere within the range of the sensor channel. The HC/LEL sensor responds predictably from 0 PPM to 100% LEL. The range for the HC/LEL sensor is from 0% LEL (or 0 PPM hydrocarbon) to 100% LEL.

To customize alarm settings:

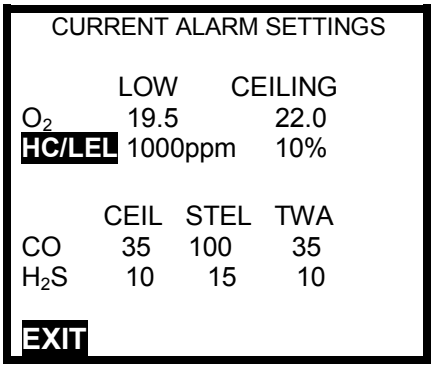
1. Enter the Alarm Menu as described above in section 3.2.



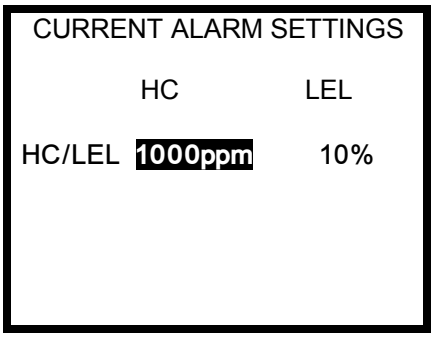
2. Use the navigation arrows to highlight CUSTOM and press the MODE button. The current alarm settings screen will then be shown.



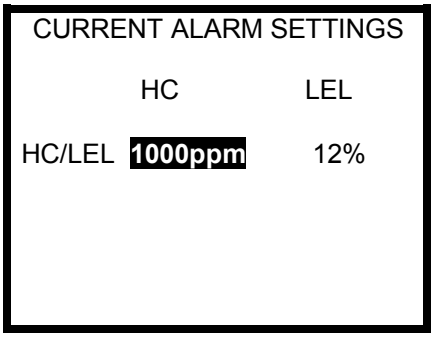
3. To modify the HC/LEL alarm settings, use the up and down navigation arrows to select the HC/LEL sensor.



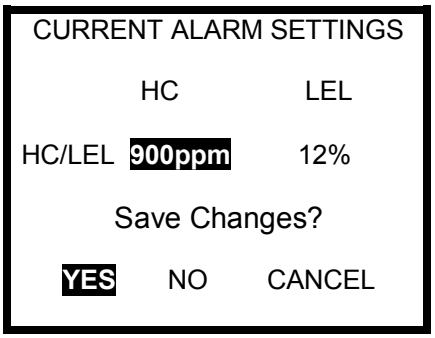
4. Press the MODE button to confirm the selection.



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 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.

Section 4Calibration

The Cannonball 3 multi-gas detector has been designed for easy calibration. A single control, the

on/off MODE button, is 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.

The operating software used to monitor the HC/LEL sensor allows for two simultaneous scales of detection. To increase accuracy in the PPM range for a specific material, the Cannonball3 offers independent calibrations for PPM and LEL gas levels. The HC/LEL sensor responds predictably from 0 PPM to 100% LEL. Independent calibration for both PPM and LEL gas levels establishes a specific output ratio that will be used to calculate the HC reading.

Note: As discussed above, this manual is intended to be used in conjunction with the Cannonball3 Reference Manual. The calibration instructions contained here cover specific procedures involving the HC/LEL sensor only. For more detailed calibration instructions and a complete list of warnings and cautions, see the Cannonball3 Reference Manual.

4.1 Verification of accuracy

⚠WARNING Accuracy of the Cannonball 3 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 Cannonball 3 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 a test gas of known concentration and noting the sensor response. LEL sensor readings are considered accurate when they are within ±10% of the expected concentration as given on the calibration gas cylinder. If readings are accurate, there is no need to adjust your gas detector. If the readings are inaccurate, the instrument must be span calibrated before further use.

If independent calibrations have been selected for the HC and LEL scales, the instrument should be exposed to both LEL-range calibration gas and PPM-range calibration gas.

Biosystems offers calibration kits and long lasting cylinders of test gas specifically developed for easy Cannonball 3 calibration.

⚠WARNING Use of non-standard calibration gas and/or calibration kit components when calibrating the Cannonball 3 can lead to inaccurate and potentially dangerous readings, and may void the standard Biosystems warranty.

Customers are strongly urged to use only Biosystems calibration

materials when calibrating the Cannonball 3.

4.2 Effect of contaminants on the HC/LEL sensor

The atmosphere in which the Cannonball 3 is used can have lasting effects on the sensors. LEL sensors may suffer losses in sensitivity leading to degraded performance if exposed to certain substances.

⚠WARNING Accuracy of the Cannonball 3 should be checked periodically with known concentration calibration gas. Failure to check accuracy can lead to inaccurate and potentially dangerous readings.

4.2.1 HC/LEL sensor desensitization

Hot-bead combustible sensors, including the HC/LEL sensor, 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.

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 Cannonball 3 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 while showing a dangerously reduced response to methane.

Biosystems' "Propane Equivalent" calibration gas mixtures have been developed to eliminate this potentially dangerous source of calibration error. Biosystems' "Propane Equivalent" mixtures are based on methane, so any loss of sensitivity to methane is detected (and can be corrected) immediately.

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

4.2.2 Effects of high concentrations of combustible gas on the HC/LEL 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 HC/LEL sensitivity, the Cannonball 3's alarm will "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 an enabled 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 Cannonball 3 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 Cannonball 3 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 Cannonball 3 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 Cannonball 3 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.

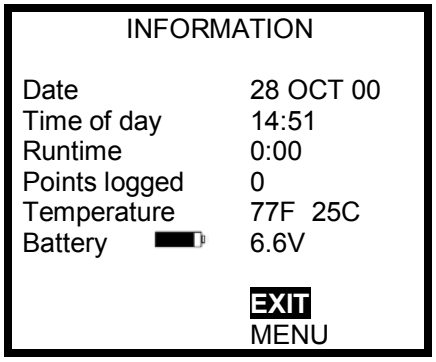
⚠WARNING A rapid up-scale reading followed by a declining or erratic reading may indicate a hazardous combustible gas concentration that exceeds the Cannonball 3's zero to 100 percent LEL detection range for units without a dilution pump, or zero to approximately 200 percent detection range for units 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.

4.3 Calibration Menu

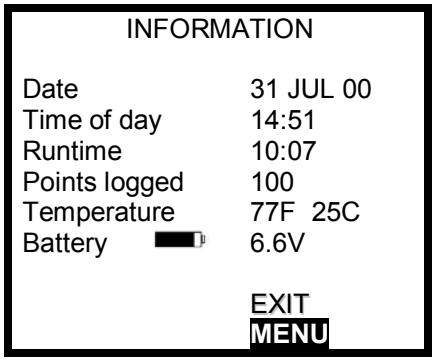
To enter the Calibration Menu:

1. Turn the instrument on and wait at least 90 seconds for the HC/LEL sensor to stabilize.

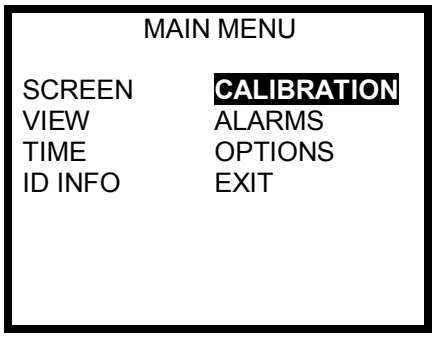
2. Press the MODE button until the information screen is displayed.



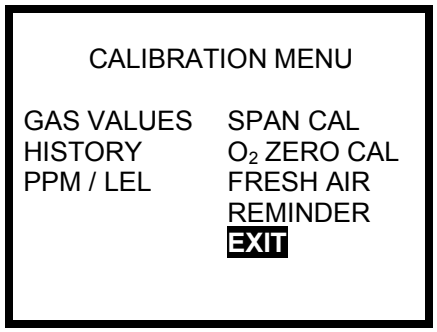
3. Hold down the left navigation arrow for 3 seconds or until EXIT appears and is highlighted.



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



5. Use the navigation arrows to highlight CALIBRATION and press the MODE button. The Calibration Menu will then be shown. Note the addition of the PPM / LEL option.

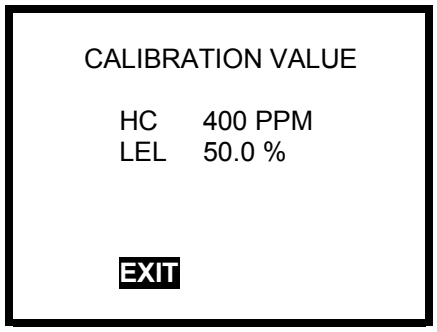


4.4 Calibration Gas Settings

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

4.4.1 Changing HC Calibration Gas Values

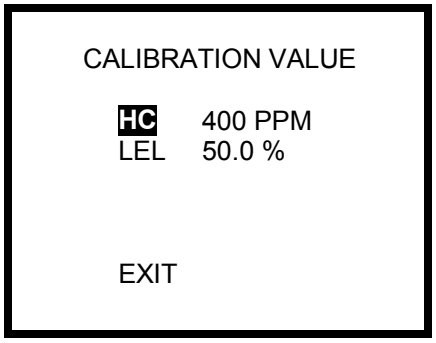
1. Enter the Calibration menu as described above in section 4.3.
2. Use the navigation arrows to highlight GAS VALUES and press the MODE button.



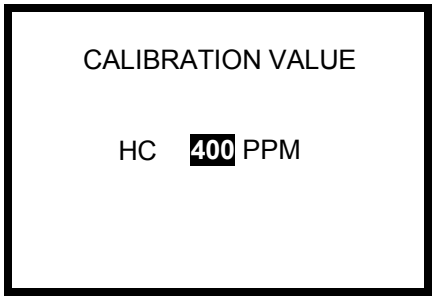
⚠WARNING Calibration values shown in the calibration value table must match those appearing on the calibration gas cylinder(s) that will be used to calibrate the Cannonball 3. Non-matching calibration gas and calibration gas value settings will lead to inaccurate and potentially dangerous readings.

3. Use the up and down navigation arrows to highlight the gas

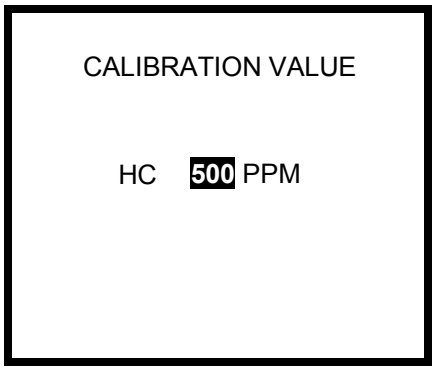
concentration value that requires adjustment.



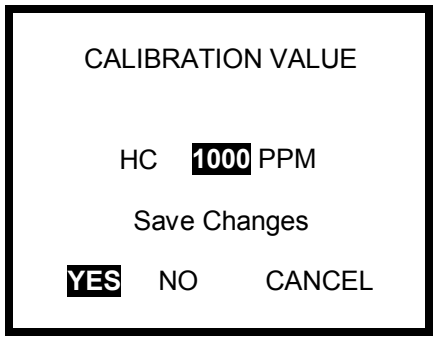
4. Press the MODE button once the appropriate concentration is highlighted. The concentration will then be highlighted.



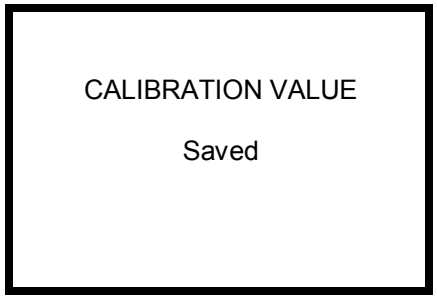
5. Use the up and down navigation arrows to adjust the calibration value.



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.



Note: The HC calibration gas settings will only be utilized when the CAL PPM WITH LEL option is disabled. See section 4.6 below for details.

4.5 Single LEL gas calibration for both scales

If a single calibration gas is used to calibrate the HC/LEL sensor, it is necessary to declare the PPM-level hydrocarbon that you expect to encounter in order to generate accurate HC readings. This is due to the fact that the LEL value for most hydrocarbons ranges between 0.5% and 5.5% volume. Declaring the hydrocarbon ensures an accurate conversion of the LEL reading to the PPM reading for the specific material involved.

If you are unsure of the particular hydrocarbon that you expect to encounter, or expect to encounter a wide range of hydrocarbons,

Biosystems recommends leaving the default setting in place. The default setting of propane sets the ratio at 1% LEL = 220 PPM.

The internal circuitry of the Cannonball3 allows the instrument to be configured for sensitivity based on the LEL of a specific hydrocarbon. The software provides a list of common hydrocarbons with their particular LEL value in the SELECT LEL GAS option. If the instrument is to be used to monitor for a hydrocarbon that does not appear on the list, the LEL value can be manually entered through the CUSTOM RATIO option.

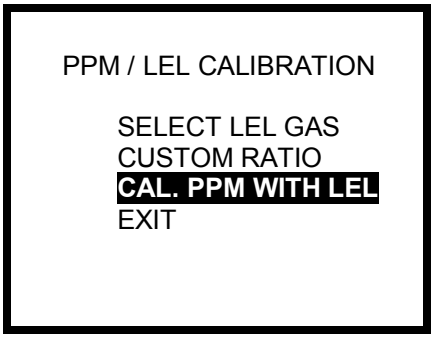
It's important to understand that the LEL sensor is calibrated through the Fresh Air calibration and the Span calibration. The response ratio that is selected by the user is used to convert the LEL reading into a valid HC reading for the declared material.

4.5.1 Enable CAL PPM WITH LEL

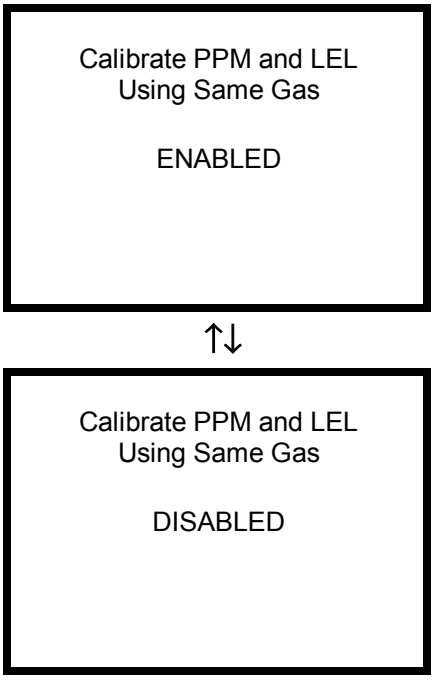
To use a single source of calibration gas for the calibration of both the LEL and the PPM sensitivity, enable the "CAL PPM WITH LEL" option. Calibrating the instrument will then establish a scale for both the HC reading and the LEL reading.

1. Enter the Calibration menu as described above in section 4.3.

2. Use the navigation arrows to highlight PPM / LEL and press the MODE button.



3. Use the up and down navigation arrows to highlight CAL PPM WITH LEL and press the MODE button. The following screen will be shown.



4. For single cylinder calibration of both the LEL and HC ranges, use the up and down navigation arrows to

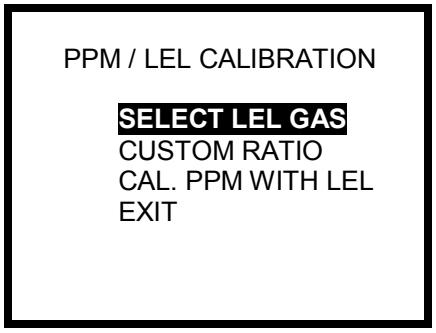
change the setting to ENABLED and press the MODE button

4.5.2 Select LEL GAS

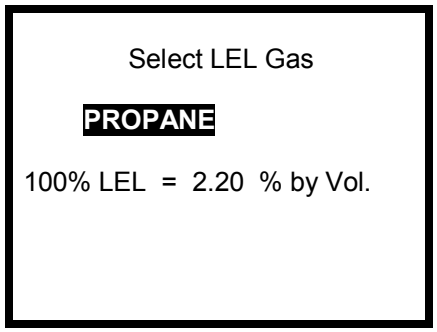
Once the “CAL PPM WITH LEL” option has been enabled, the LEL Gas should be selected based on the hydrocarbon that you expect to encounter in the PPM range in the field. If the hydrocarbon is not given in the list and you know its LEL value in terms of percent by volume, proceed to section 4.5.3 CUSTOM RATIO.

1. Enter the Calibration menu as described above in section 4.3.

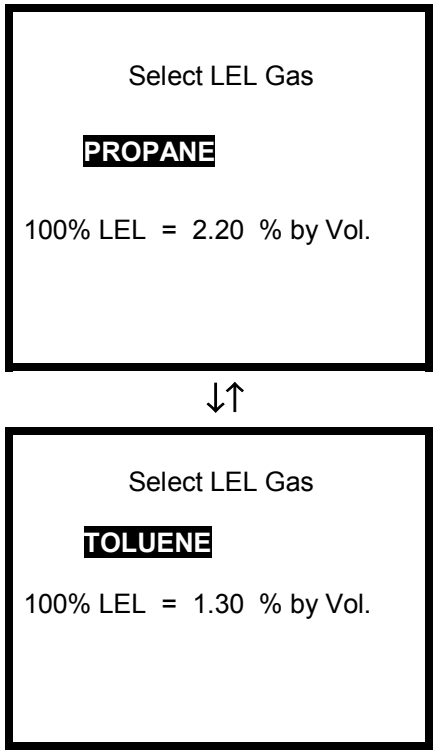
2. Use the navigation arrows to highlight PPM / LEL and press the MODE button.



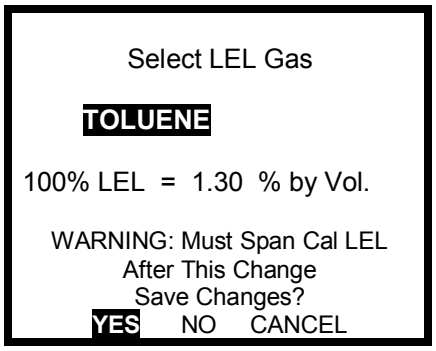
3. Use the navigation arrows to highlight SELECT LEL GAS and press the MODE button.



4. Use the up and down navigation arrows to scroll through the list of available gases until the specific gas that you expect to encounter in the PPM range is shown.



5. Once the appropriate gas is shown, press the MODE button.



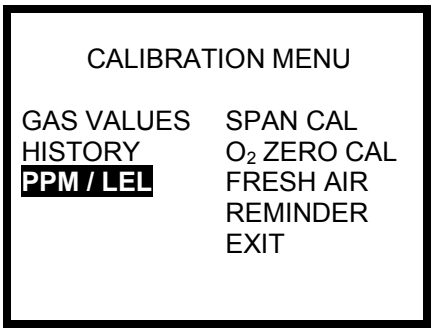
6. The instrument will issue a warning that the LEL sensor must be span calibrated after this change. Press the MODE button with YES highlighted to accept the change.
7. Perform the standard Fresh Air and Span calibrations as described in the Cannonball3 Reference Manual.

⚠WARNING The HC/LEL sensor must be calibrated with the appropriate calibration gas following any changes to the custom ratio settings. Failure to calibrate may result in inaccurate and potentially dangerous readings.

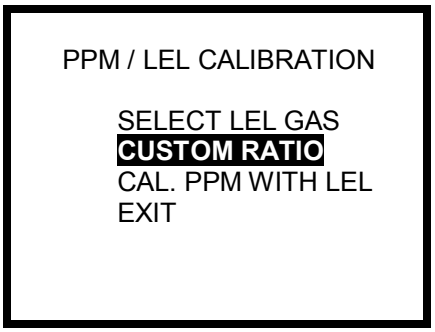
4.5.3 Custom Ratio

If the PPM-level hydrocarbon that you expect to encounter in the field is not shown in the select LEL Gas list, and you know the LEL for the hydrocarbon it terms of percent by volume, it can be entered through the CUSTOM RATIO option.

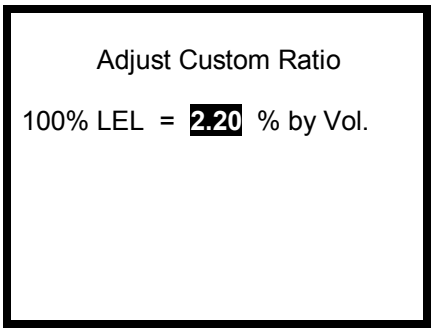
1. Enter the Calibration menu as described above in section 4.3.1.



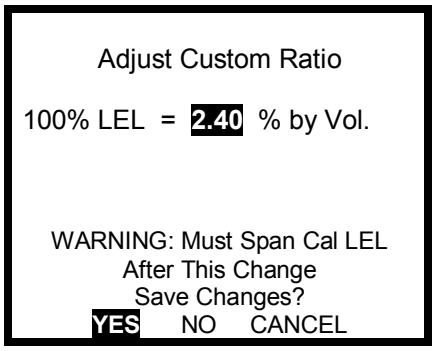
2. Use the navigation arrows to highlight PPM / LEL and press the MODE button.



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



4. Use the up and down navigation arrows to adjust the ratio. Press the MODE button once the ratio is adjusted to the appropriate level.



5. The instrument will issue a warning that the LEL sensor must be span calibrated after this change. Press the MODE button with YES highlighted to accept the change.
6. Perform the standard Fresh Air and Span calibrations as described in the Cannonball3 Reference Manual

⚠WARNING The HC/LEL sensor must be calibrated with the appropriate calibration gas following any changes to the custom ratio settings. Failure to calibrate may result in inaccurate and potentially dangerous readings.

4.6 Dual HC and LEL calibration options

To enhance the accuracy of the PPM reading for a specific material, the Cannonball3 can be calibrate directly in both the LEL range and the PPM range with two different gases. The instrument will then use the response values derived from both calibrations to generate accurate PPM and LEL readings in the field for the gases to which the instrument has been calibrated.

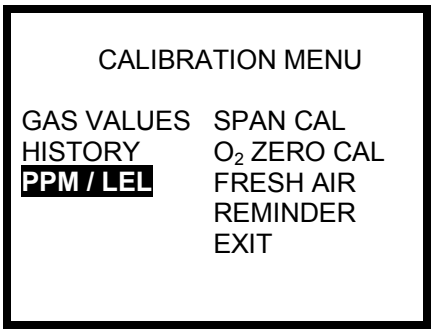
Note: Performing two separate calibrations with a single calibration gas will not increase accuracy in either sensor range.

To de-couple the scales for the LEL and PPM readings, disable the "CAL PPM WITH LEL" option as described below in section 4.6.1. Performing independent calibrations for both LEL and PPM will then establish independent response scales for readings in the PPM range versus readings in the LEL range.

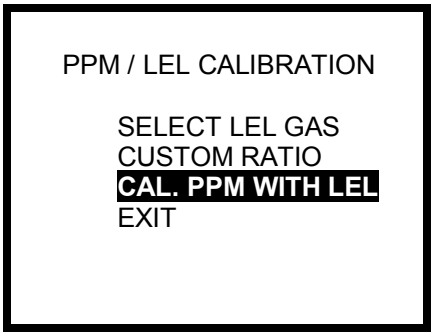
Note: The Cannonball3 must be calibrated with two distinct combustible calibration gases once the CAL PPM WITH LEL option is disabled.

4.6.1 Disable CAL PPM WITH LEL

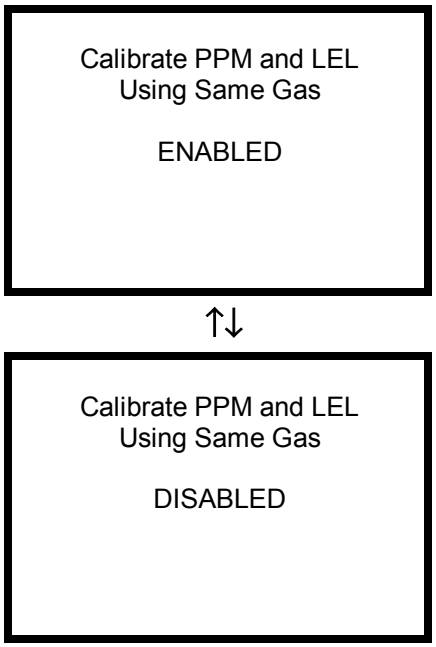
1. Enter the Calibration menu as described above in section 4.3.1.



2. Use the navigation arrows to highlight PPM/LEL and press the MODE button.



2. Use the up and down navigation arrows to highlight CAL PPM WITH LEL and press the MODE button. The following screen will be shown.

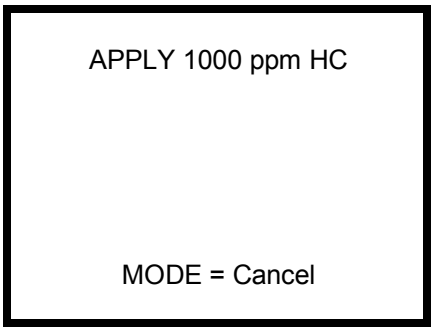


4. For independent calibration of the HC/LEL sensor in both the LEL and PPM ranges, use the up and down navigation arrows to change the setting to “DISABLED” and press the MODE button.
5. Perform the Fresh Air and Span calibrations as described in the Cannonball3 Reference Manual.

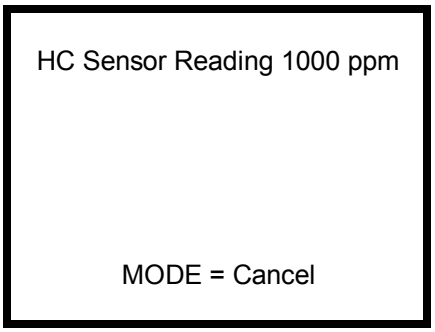
4.7 Automatic Span Calibration Guidelines

The automatic span calibration function for the Cannonball3 with HC/PPM sensor is identical to the automatic span calibration function for all Cannonball3 instruments with an LEL sensor. See chapter 4 of the Cannonball3 Reference Manual for explicit directions on the Automatic Span Calibration function.

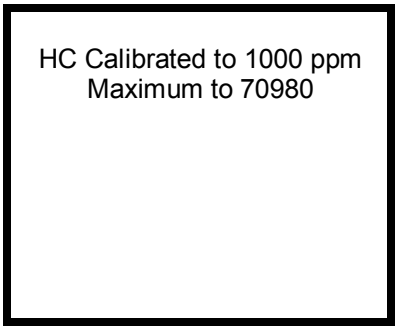
If the “CAL PPM WITH LEL option is disabled as described above in section 4.6.1, the Cannonball3 will prompt for the HC calibration after the standard Fresh Air Calibration and before the standard Span Calibration.



Apply calibration gas with the appropriate level of HC. The sensor will respond quickly.



Once the HC calibration is complete, the display will show the maximum span calibration value for the HC sensor.



The Cannonball3 will then proceed with the standard Span calibration as described in the Cannonball3 Reference Manual.

Appendix A: Data on Flammable Gases and Vapors

	LEL* (Volume %)	UEL** (Volume %)	Vapor Density (air = 1)
Alkane (Paraffin) Hydrocarbons			
Methane	5.0	15	0.55
Ethane	3.0	12.5	1.0
Propane	2.2	10	1.5
Butane	1.8	9.0	2.0
Pentane	1.5	7.8	2.48
Hexane	1.2	7.5	2.97
Heptane	1.1	6.7	3.5
Octane	0.8	6.5	3.9
Alkene (Olefin) Hydrocarbons			
Ethylene	3.02	34	0.98
Propylene	2.4	10.3	1.49
Alkyne Hydrocarbons			
Acetylene	2.5	100	0.91
Propyne (methyl acetylene)	1.7	N/A	1.4
Aromatic Hydrocarbons			
Benzene	1.40	7.1	2.77
Toluene	1.27	7.0	3.14
o-Xylene	1.0	7.6	3.7
Cumene	0.9	6.5	4.1
Styrene	1.1	6.1	3.6
Alcohols			
Methanol (wood alcohol)	5.5	44.0	1.1
Ethanol (grain alcohol)	3.3	19.0	1.59
Isopropyl Alcohol	2.02	11.8	2.1
Ketones, Esters & Ethers			
Acetone	2.6	12.8	2.00
Methyl Ethyl Ketone	1.8	9.5	2.5
Ethyl Acetate	2.2	11.4	3.04
Ethyl Ether	1.85	48.0	2.56
Oxides			
Carbon Monoxide	12.5	74	0.97
Ethylene Oxide	3.0	80	1.5
Propylene Oxide	2.0	22	2.0
Elementary & Inorganics			
Ammonia	15.0	28.0	0.58
Hydrogen	4.0	80	0.07
Hydrogen Sulfide	4.3	46	1.19
Fuels & Natural Products			
Gasoline	1.3	6.0	3-4
Turpentine	0.8	N/A	>1
Kerosine (JP-8 or Jet A Fuel)	0.86	N/A	>1

* LEL = Lower Explosive Limit ** UEL = Upper Explosive Limit

Appendix B: Biosystems Standard Warranty Gas Detection Products

General

Biosystems, A Bacou-Dalloz Company, (hereafter Biosystems) warrants gas detectors, sensors and accessories manufactured and sold by Biosystems, to be free from defects in materials and workmanship for the periods listed in the tables below.

Abuse, mechanical damage, alteration, or repair procedures not made in accordance with the instrument Reference Manual void the Biosystems standard warranty.

The obligation of Biosystems under this warranty is limited to the repair or replacement of components deemed by the Biosystems 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 to Biosystems at its manufacturing location in Middletown, Connecticut, with transportation and shipping charges prepaid. It is necessary to obtain a return authorization number from Biosystems 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. Biosystems 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
PhD[5], PhD *Lite*, PhD Plus, PhD Ultra, Cannonball 3, MultiVision, Toxi Vision and Toxi Series	As long as the instrument is in service
Mighty-Tox	90 days after activation or 90 days after the "Must Be Activated By" date, whichever comes first
Mighty-Tox 2 Mighty-Tox 2 prorated credit is given towards repair or purchase of a new unit.	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
Series 3000, Airpanel, Travelpanel, ZoneGuard, Gas✓Chek1 and Gas✓Chek4	One year from the date of purchase
Battery packs, 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
PhD[5], PhD *Lite,* Cannonball 3	O_2, LEL**, CO, CO+, H_2S & Duo-Tox	2 Years
	All Other Sensors	1 Year
PhD Plus / Ultra, Toxi Vision, MultiVision	O_2, LEL**, CO, CO+, H_2S	2 Years
	All Other Sensors	1 Year
Toxi Series	LEL**, CO, CO+, H_2S	2 Years
	All Other Sensors	1 Year
All Others	All Sensors	1 Year

****Damage to combustible gas sensors incurred by exposure to known sensor poisons such as silicone and siliconized caulks/sealants (a.k.a. RTV - Room Temperature Vulcanizing), silicone rubber molded products & coatings, greases for laboratory glassware (stopcock, ground glass joints, etc.), toner fusing agent in photocopiers, die lubricants in cutting, stamping or other material converting operations, heat transfer fluids in fine chemical & pharmaceutical manufacture, lubricants, waxes & polishing compounds (neat or spray aerosols), mold release agents for plastics injection molding operations, waterproofing formulations, vinyl & leather preservatives, or release papers used as the backings of pressure sensitive adhesive backed roll or sheet goods may (at the discretion of Biosystems Instrument Service Department) void Biosystems' Standard Warranty as it applies to the replacement of combustible gas sensors.**