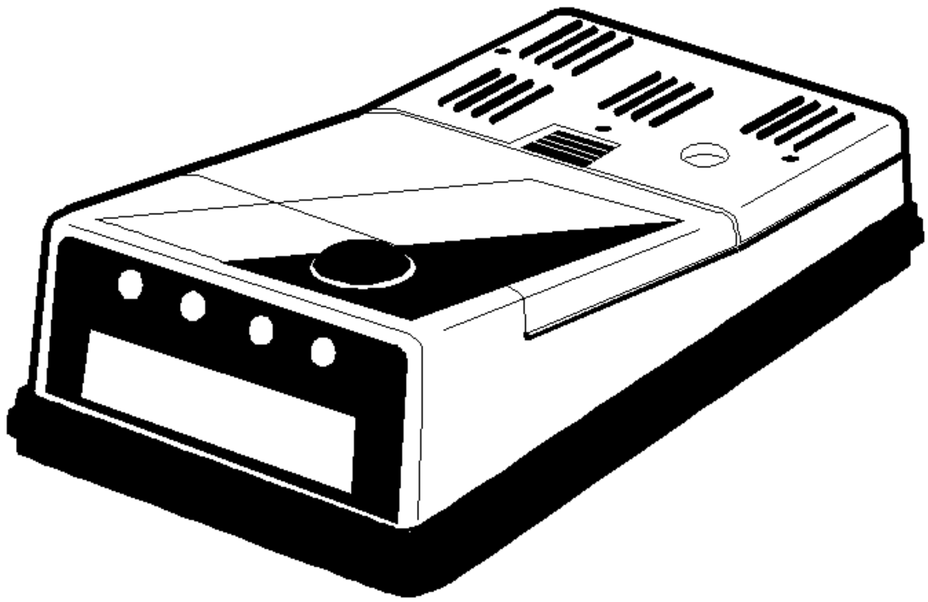
Reference Manual
PhD Ultra
Multi Gas Detector



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⚠WARNING

THE PhD ULTRA PERSONAL PORTABLE GAS DETECTOR HAS BEEN DESIGNED FOR THE DETECTION OF OXYGEN DEFICIENCIES, FLAMMABLE GAS, AND TOXIC VAPOR ACCUMULATIONS.

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

AVERTISSEMENT: LIRE ATTENTIVEMENT LES INSTRUCTIONS AVANT DE METTRE EN MARCHE.

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Introduction

The PhD Ultra is a personal, portable, microprocessor controlled gas detector that can monitor up to four atmospheric hazards simultaneously. The PhD Ultra measures oxygen, combustible gas, and up to two additional toxic gases. The PhD Ultra uses a top-mounted, back-lit, "Supertwist" LCD (liquid crystal display) to simultaneously show readings of the gases being measured. A loud audible alarm and individual alarm lights for each gas being monitored warn users of hazards.

The PhD Ultra offers a choice of three modes of operation, providing the right amount of information for users with different needs. The PhD Ultra microprocessor software allows true one-button operation. All procedures necessary for day-to-day operation, including automatic calibration adjustment, are controlled through the single on / off “mode” button. Biosystems EEPROM equipped “Smart Sensors” automatically let the instrument know which sensors are currently installed, assign the appropriate alarm settings, and let the instrument know if any changes have been made to the sensors since the last time the instrument was turned on. Two types of interchangeable battery packs (NiCad and disposable alkaline) provide up to 12 hours of continuous use.

The PhD Ultra is Classified by Underwriters Laboratories, Inc. and the Canadian Standards Association as to Intrinsic Safety for use in Hazardous Locations Class I, Division 1, Groups A, B, C, and D.

Classification for intrinsic safety is based on tests conducted in explosive gas / air (21 % oxygen) mixtures only. The PhD Ultra should not be used for combustible gas monitoring in atmospheres where oxygen concentrations exceed 21.0% oxygen.

ONLY THE COMBUSTIBLE GAS DETECTION PORTION OF THIS INSTRUMENT HAS BEEN ASSESSED FOR PERFORMANCE BY CSA.

UNIQUEMENT, LA PORTION POUR DÉTECTER LES GAZ COMBUSTIBLES DE CET INSTRUMENT A ÉTÉ ÉVALUÉE PAR UNDERWRITERS LABORATORIES.

⚠WARNING SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.

AVERTISSEMENT: LA SUBSTITUTION DE COMPOSANTS PEUT COMPROMETTRE LA SÉCURITÉ INTRINSÈQUE.

FOR SAFETY REASONS THIS EQUIPMENT MUST BE OPERATED AND SERVICED BY QUALIFIED PERSONNEL ONLY. READ AND UNDERSTAND THE INSTRUCTION MANUAL COMPLETELY BEFORE OPERATING OR SERVICING.

ATTENTION: POUR DES RAISONS DE SÉCURITÉ, CET ÉQUIPMENT DOIT ETRE UTILISÉ, ENTRETENU ET RÉPARÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ. ÉTUDIER LE MANUEL D'INSTRUCTIONS EN ENTIER AVANT D'UTILISER, 'ENTRETENIR OU DE RÉPARER L'ÉQUIPMENT.

⚠WARNING ANY RAPID UP-SCALE READING FOLLOWED BY A DECLINING OR ERRATIC READING MAY INDICATE A GAS CONCENTRATION BEYOND UPPER SCALE LIMIT WHICH MAY BE HAZARDOUS.

Avertissement: Toute lecture rapide et positive, suivie d'une baisse subite au erratique de la valeur, peut indiquer une concentration de gaz hors gamme de détection qui peut être dangereuse.

Signal Words

The following signal words, as defined by ANSI Z535.4-1998, are used in the PhD Ultra 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 PhD Ultra 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.

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 may result in serious injury or death.

3. ⚠WARNING Use only Duracell MN1500 or Ultra MX1500, Eveready Energizer E91-LR6, or Eveready EN91 size AA 1.5V Alkaline batteries in the PhD Ultra Alkaline Battery Pack. Substitution of batteries may impair intrinsic safety.

4. ⚠WARNING The accuracy of the PhD Ultra 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 PhD Ultra 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 PhD Ultra.

   Customers are strongly urged to use only Biosystems calibration materials when calibrating the PhD Ultra. 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 PhD Ultra 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 PhD Ultra calibration. Customers are strongly urged to use only Biosystems calibration materials when calibrating the PhD Ultra.

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 PhD Ultra.

11. ⚠WARNING A rapid up-scale reading followed by a declining or erratic reading may indicate a hazardous combustible gas concentration that exceeds the PhD Ultra's zero to 100 percent LEL detection range.

Chapter 1 PhD Ultra Description

1.1 PhD Ultra capabilities

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

1.2 Methods of sampling

The PhD Ultra may be used in either diffusion or sample-draw mode. In either mode, the gas sample must reach the sensors for the instrument to register a gas reading. The sensors are located inside of the instrument under the sensor grill cover.

In diffusion mode, the atmosphere being measured reaches the sensors by diffusing through vents in the sensor compartment cover. Normal air movements are enough to carry the sample to the sensors. The sensors react quickly to changes in the concentrations of the gases being measured. Diffusion-style operation monitors only the atmosphere that immediately surrounds the detector.

The PhD Ultra can also be used to sample remote locations with either the hand-aspirated sample-draw kit that is included with every PhD Ultra, or with a motorized continuous sample draw pump that is available separately. During remote sampling, the gas sample is drawn into the sensor compartment through the probe assembly and a length of tubing.

Use of the sample draw kits is covered in Chapter 2.

1.3 Multi-sensor capability

The PhD Ultra can be configured to simultaneously monitor oxygen, combustible gases and vapors and up to two toxic gases. Sensors can be added, removed and replaced in the field. The PhD Ultra microprocessor and "Smart Sensor" circuitry eliminates the need for manual switch setting and other laborious set-up procedures.

It is necessary to verify the accuracy of the PhD Ultra by calibration with known concentration test gas whenever a change is made to the sensors installed in the instrument.

The PhD Ultra design uses highly specific, 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. A wide variety of toxic sensors is available for use in the PhD Ultra.

In addition to sensors designed to measure specific toxic hazards, Biosystems also offers a dual purpose electrochemical sensor designed to detect both carbon monoxide and hydrogen sulfide. The "CO Plus" sensor is ideal for situations requiring use of a single sensor to monitor for both toxic hazards.

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

Sensor	Range	Resolution
LEL	0 – 100% LEL	1% LEL
O_2	0 – 30 %/Vol.	0.1%
CO	0 – 1000 PPM	1 PPM
H_2S	0 – 200 PPM	1 PPM
SO_2	0 – 150 PPM	0.1 PPM
NH_3 (-04 version)	0 – 50 PPM	1 PPM
CO Plus	CO: 0 – 1000 PPM H_2S: 0 – 200 PPM	1 PPM
Cl_2	0 – 50 PPM	0.1 PPM
ClO_2	0 – 15 PPM	0.1 PPM
NO	0 – 350 PPM	1 PPM
NO_2	0 – 50 PPM	0.1 PPM
HCN	0 – 100 PPM	0.2 PPM
PH_3	0 – 20 PPM	0.1 PPM
NH_3 (-21 version)	0 – 100 PPM	1 PPM

Table 1.3. PhD Ultra Ranges and Resolutions by Sensor Type

Sensor configuration procedures are discussed in greater detail in section 2.5.

1.4 Calibration

The PhD Ultra detector has been designed for easy calibration.

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

Accuracy may be verified at any time while the instrument is in normal operation. Press the mode button three times within two seconds to place the instrument in "Auto-Calibration Mode".

Calibration is a two step procedure. In the first step the PhD Ultra is taken to an area where the atmosphere is fresh and a "zero" adjustment is made automatically by pressing the on / off mode button.

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

Calibration procedures are discussed in detail in Chapter 3.

Use of these procedures is reserved for authorized personnel.

1.5 Instrument identifiers

The PhD Ultra includes two built-in instrument identifiers: the Instrument ID and Serial Numbers.

The instrument serial number is assigned at the factory and is shown on the label on the back of the instrument case. It is also permanently stored in the instrument memory and is displayed in the startup screens. The instrument serial number may not be modified by the user.

The instrument ID number is an identifier that is assigned by the user. For instructions on changing the instrument ID number see section 4.3.3.

1.6 Alarm logic

PhD Ultra gas alarms are user adjustable and may be set anywhere within the range of the sensor channel. When an alarm set point is exceeded a loud audible alarm sounds and a bright red LED alarm light flashes for each sensor that is in alarm.

PhD Ultra gas alarms are normally self-resetting. When readings drop back below the pre-set alarm levels, the instrument returns to normal operation, and the visual and audible alarms cease.

It is possible to set PhD Ultra gas alarms so that they "latch". In the latched condition, once an alarm occurs both visual and audible alarms continue to sound even after the atmospheric hazard has cleared. The instrument must then be manually reset before the alarms are silenced.

1.6.1 Atmospheric hazard alarms

⚠WARNING **The PhD Ultra portable gas detector has been designed for the detection of deficiencies of oxygen, accumulations of flammable gases and vapors, and accumulations of toxic vapors. 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. Failure to immediately leave the area may result in serious injury or death.**

⚠WARNING **A rapid up-scale reading followed by a declining or erratic reading may indicate a hazardous combustible gas concentration that exceeds the PhD Ultra's zero to 100 percent LEL detection range. Failure to immediately leave the area may result in serious injury or death.**

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

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

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

Appendices A and B discuss alarm levels and factory default alarm settings. The procedure for adjusting alarm set points is discussed in Chapter 4.

1.6.2 Sensor overrange alarms

If a sensor is exposed to a concentration of gas that exceeds its established range, the PhD Ultra will go into alarm. If the PEAK alarm is enabled, the overrange alarm appears exactly the same as a PEAK alarm, that is, the LED over the gas name and the audible alarm are activated. If the PEAK alarm is disabled, the overrange alarm is indicated by flashing the numerical reading on and off while the LED over the gas name and the audible alarm are also activated. This applies to all toxic sensors. If the LEL sensor goes into overrange alarm the display will alternate between an "X" for the LEL reading and an "LEL SENSOR OVER LIMIT" message.

⚠WARNING **In the event of an LEL overrange alarm the PhD Ultra 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 PhD Ultra features automatic warning against LEL sensor response failure due to lack of oxygen. When oxygen levels fall below 10% of gross volume, the PhD Ultra will intermittently display a message indicating that O_2 is too low for LEL to operate.

1.6.3 Low battery alarms

The PhD Ultra may be equipped with either a rechargeable NiCad or an alkaline battery pack. Alarms will be activated whenever battery voltage is too low to allow the safe operation of the instrument. The PhD Ultra is designed to automatically determine which type of battery pack has been installed, and use the appropriate low battery alarm settings.

1.6.3.1 Low battery alarm settings for NiCad battery packs

The PhD Ultra 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 in NiCad-equipped instruments is reduced to approximately 3.3 volts, an audible alarm will sound and the display will indicate that a low battery condition exists. At this stage, the low battery alarms may be silenced for a fifteen-minute period 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 3.25 volts. 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 immediately leave the hazardous area in which the instrument is being used.

When the voltage drops below 3.25 volts, the PhD Ultra will display a "Dead Battery" message to warn the user of imminent shut down. The instrument will then automatically turn itself off.

Following any low battery alarm the batteries should be replaced if the PhD Ultra is equipped with alkaline batteries or the battery should be recharged if the PhD Ultra is equipped with a NiCad rechargeable battery.

1.6.3.2 Low battery alarm settings for alkaline battery packs

If the PhD Ultra has been equipped with a disposable alkaline battery pack, the initial low battery alarm will be activated when voltage is reduced to 3.2 Volts. Protective shutdown occurs at 3.1 Volts.

⚠WARNING Use only Duracell MN1500 or Ultra MX1500, Eveready Energizer E91-LR6, or Eveready EN91 size AA 1.5V Alkaline batteries. Substitution of batteries may impair intrinsic safety.

1.6.4 Other alarms and special microprocessor features

PhD Ultra software includes a number of additional alarms designed to safeguard proper use of the instrument. When the PhD Ultra detects that an electronic fault or failure condition has occurred the proper audible and visual alarms will be activated and an explanatory message will be displayed.

⚠WARNING The PhD Ultra 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.

1.6.4.1 Combustible sensor “over-limit” alarm latch

Protective software “latches” the combustible alarm when the sensor is exposed to 100 % LEL combustible gas. Under these conditions the combustible gas reading will show an “X” to indicate an over-limit condition. The current gas reading display will alternate with a screen showing the message “LEL sensor over limit”. The audible and visual alarms will sound continuously until the instrument is manually reset by turning it off, and then turning the instrument back on in an area where the air is known to be fresh.

The “over-limit” alarm condition is discussed in detail in Chapter 3.

1.6.4.2 Missing sensor

The PhD Ultra continually monitors sensor status. When the instrument recognizes that a sensor is missing, the display will show “X” instead of the normal gas reading, the audible alarm will sound and the LED indicator for the affected sensor will be activated. Alarms will be silenced when the sensor is replaced.

1.6.4.3 “Needs Cal”

Whenever the instrument is turned on, the PhD Ultra automatically determines and displays readings for the sensors that are recognized by the instrument. If changes have been made to the type or number of sensors installed since the last time the instrument was turned on, the audible alarm will be activated and a “Needs Calibration” message will be displayed. A message screen will indicate which sensors must be calibrated before further use.

⚠WARNING A sensor that cannot be calibrated or is found to be out of tolerance must 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.

1.6.4.4 “Can’t ID sensor”

If the PhD Ultra is unable to read the EEPROM of a smart sensor currently installed, or if a smart sensor is removed while the instrument is turned off without being replaced with another sensor, a “Can’t ID Sensor” message will be displayed for the affected sensor channel (e.g. toxic 1”). Press the mode button to acknowledge the condition and the instrument will proceed to operate with those sensors that can be successfully read.

1.6.4.5 Down-scale or negative reading alarms

Significantly negative or “down-scale” readings cause the activation of PhD Ultra audible and visual alarms. Downscale alarm settings are assigned at the factory on a sensor-specific basis. For most toxic sensors the downscale alarm is set to negative one-half of the TWA alarm currently installed. (As an example, if the TWA alarm is set at 15 PPM, readings of negative 7.5 PPM would activate this alarm.)

1.6.4.6 Temperature out of range

The PhD Ultra design includes a temperature sensor located inside the instrument case in the area where the gas sensors are located. The microprocessor automatically adjusts the sensor output to compensate for temperature changes in the area in which the instrument is being operated. If the temperature falls outside the range for which the instrument can fully compensate, the current gas reading screen will show a “T” in place of the reading for the affected sensor.

1.6.4.7 Other electronic safeguards

Several automatic programs prevent tampering and misuse of the PhD Ultra by unauthorized persons. Each time the detector is turned on, an electronic self-test is performed that assures the user of proper performance. The sensors, LED alarm lights, and audible alarm are automatically tested whenever the PhD Ultra is turned on. The battery is monitored continuously for proper voltage. Detected electronic faults cause the activation of the appropriate alarms and the display of the appropriate explanatory message.

1.6.4.8 Security beep

The PhD Ultra may also be set-up to periodically “beep” to indicate that the instrument is turned on. Adding a security beep as well as making use of other optional set-up choices is done by using the four buttons on the instrument keypad located under the belt clip on the back of the instrument housing.

Chapter 4 describes PhD Ultra advanced technical features in greater detail.

1.7 Instrument Firmware Requirement for Compatibility with the IQ System

Biosystems IQ System is an automated calibration station coupled with a data management system. To be compatible with the IQ System, the PhD Ultra must have instrument firmware version 3.40 or higher.

Instrument firmware version is given immediately after the PhD Ultra is turned on.

1.8 Classification for intrinsic safety

The PhD Ultra is Classified by Underwriters Laboratories, Inc. and the Canadian Standards Association as to Intrinsic Safety for use in Hazardous Locations Class I, Division 1, Groups A, B, C, & D. This means that the PhD Ultra has been successfully tested for safety in combustible gas / air (21 % oxygen) mixtures.

1.9 Options

1.9.1 Sensors

The PhD Ultra can be configured to detect oxygen, combustible gas, and up to two toxic gases. The sensor configuration may be changed in the field, or specified at the time of purchase. Calibration is required after any sensor change.

1.9.2 Batteries

PhD Ultra batteries are housed in removable snap-in battery packs. Two types of battery packs (rechargeable NiCad and alkaline) are available for use. Battery packs are clearly labeled as containing either NiCad or disposable alkaline batteries.

Battery packs are interchangeable. Battery packs can be replaced while the instrument is in the field. It is not necessary to open the instrument case to replace the battery pack that is currently installed.

The PhD Ultra should be turned off before changing or replacing battery packs. A spring-loaded catch holds the battery pack firmly in place in the instrument chassis. To remove the battery pack first pull back on the spring loaded catch, then pull the battery pack upward and backwards (towards the rear of the instrument).

To replace the battery pack, seat the notch in the front of the battery pack housing to the matching lip in the PhD Ultra instrument case. When the battery pack is properly positioned, press down gently on the rear of the battery pack to engage the spring loaded catch.

Do not store or leave your PhD Ultra with the battery pack removed.

Toxic sensors must be allowed to “warm-up” or stabilize when first installed in an instrument. When there is a power interruption (as when the battery pack is removed) the toxic sensors begin to destabilize. The longer a toxic sensor is without power the longer it will take for re-stabilization.

See the sensor stabilization chart in section 5.1 for more details.

Note: The PhD Ultra is designed to turn itself on whenever a battery pack is removed and replaced. This is to ensure that in the event of an interruption in power the instrument is not accidentally turned off. Any time the battery

pack is momentarily removed or replaced with another it will be necessary to manually turn the PhD Ultra off if the instrument is not going to be put to immediate use.

1.9.2.1 NiCad battery pack

The rechargeable NiCad battery pack is designed to provide up to 12 hours of continuous use. The NiCad battery pack is a sealed assembly and may not be disassembled in the field.

The NiCad battery may be recharged while the pack is installed in the instrument, or the battery pack may be removed from the instrument for separate recharging in the PhD Ultra Fast Charger.

Fully assembled NiCad battery packs may be removed or replaced while the instrument is being used in a hazardous location.

⚠WARNING **To maintain intrinsic safety, the PhD Ultra may not be located in a hazardous location while being recharged. If the NiCad battery pack is being recharged separately from the instrument, then the PhD Ultra Fast Charger must not be located in a hazardous area.**

1.9.2.2 Disposable alkaline battery pack

The PhD Ultra may also be equipped with a battery pack designed to hold 3 AA disposable alkaline batteries. A set of alkaline batteries will provide up to 12 hours of continuous use. The alkaline battery pack is removed in the same manner as the NiCad pack. The alkaline pack must be removed from the instrument in order to replace expended batteries. The alkaline pack is opened by removing the Phillips screw on the bottom of the battery pack, then squeezing the ends of the pack and gently removing the cover.

⚠WARNING **Only fully assembled alkaline battery packs may be removed or replaced while the instrument is being used in a hazardous location. Alkaline battery packs may not be opened and alkaline batteries may not be replaced while the battery pack is located in a hazardous area.**

Battery replacement and charging procedures are covered in greater detail in chapter 2.

1.9.3 Continuous sample draw pump

An optional slip-on, motorized sample-draw pump is available for situations requiring continuous "hands free" remote monitoring. The PhD Ultra's Intrinsic Safety Classification by UL and CSA includes the use of the PhD Ultra pump.

The pump contains a pressure sensor that detects when water or other fluids are being drawn into the unit, and immediately acts to shut off the pump in order to protect the sensors, pump, and other PhD Ultra components from damage.

Pump status is continuously monitored by the microprocessor. A flashing "P" in the upper left corner of the instrument display indicates when the pump is attached and operating properly. Low flow or other pump fault conditions activate an audible alarm and cause the display of the appropriate explanatory message.

The sample pump is powered directly by the PhD Ultra battery. Both alkaline and NiCad battery packs are designed to provide at least 8 hours of continuous pump operation even when the instrument is operated in low light conditions and the backlight is continuously lit.

1.10 PhD Ultra design components

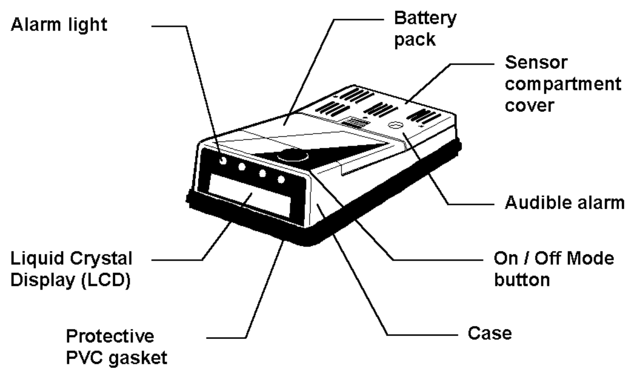


Figure 1.10.1. Major PhD Ultra Features (Top and Front Surfaces)

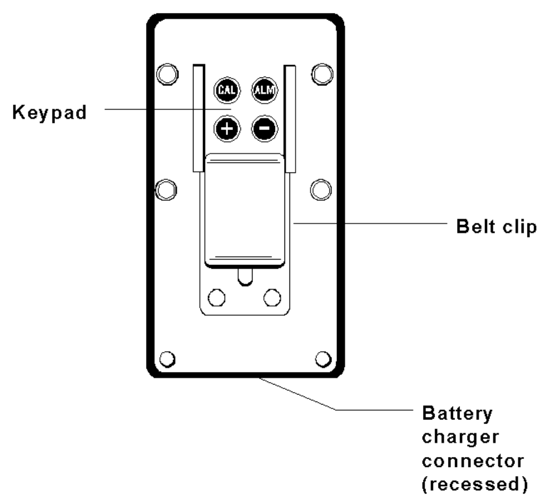


Figure 1.10.2. Major PhD Ultra Features (Bottom)

(1) Case: The instrument is enclosed in a solid, stainless steel-impregnated polycarbonate case. A water-resistant PVC gasket between the upper and lower sections of the case protects against leakage or exposure to liquids.

(2) Front face: The front face of the instrument houses the meter display and alarm lights.

(3) **LCD display:** A "Supertwist" liquid crystal display (LCD) meter allows display of readings, messages, and other information.

(4) **Alarm lights:** Four LED (light emitting diode) alarm lights provide a visual indication of alarm state. Each light is dedicated to a single channel of detection, and will emit a bright red light when a sensor alarm level is exceeded. One of the alarm light assemblies also includes a photo-sensor used to monitor the level of background illumination. An automatically-activated backlight brightens the meter display whenever the instrument is taken into a dark area.

(5) **On / Off "mode" button:** The large black push-button is called the "mode" button. It is used to turn the PhD Ultra on and off and to control most other operations, including the automatic calibration adjustment.

(6) **Sensor compartment cover:** The sensors are protected by a vented sensor compartment cover. Its own protective filter cap individually protects each sensor. A water-resistant PVC gasket and inner-liner protect the instrument against leakage or exposure to liquids.

(7) **Audible alarm orifice:** A cylindrical orifice extending through the sensor compartment cover houses the audible alarm. The waterproof audible alarm seats directly to the PVC inner-liner to protect the instrument against leakage or exposure to liquids.

(8) **Battery pack:** Two types of interchangeable battery packs (rechargeable NiCad and disposable alkaline) are available for use in the PhD Ultra. NiCad battery packs may be recharged while the pack is installed in the instrument, or the battery pack may be removed from the instrument and recharged separately.

Chapter 2 of the PhD Ultra owner's manual covers battery replacement and charging procedures.

(9) **Battery charger connector:** A water-resistant connector at the rear of the case is used to connect the PhD Ultra to the “drop in” style PhD Ultra fast charger.

(10) **Bottom surface:** A sturdy clip allows the user to wear the PhD Ultra on a belt or other article of clothing. Snaps are provided to hold the PhD Ultra securely in the padded leather weather cover.

(11) **Key pad:** The key pad is located on the back of the PhD Ultra under the belt clip. Slide the belt clip towards the rear of the instrument to access the four small push-buttons. The key pad consists of, four buttons labeled “+”, “-”, “CAL”, and "ALM”. These buttons are normally only used during set-up and other programming procedures.

Use of these push buttons is reserved for authorized personnel.

1.11 PhD Ultra accessories

Each PhD Ultra is delivered in a foam lined box containing the PhD Ultra detector, padded leather weather cover, carrying strap, sample draw / calibration adopter, hand-aspirated sample-draw kit (with 10 feet of sample draw tubing), 2 feet of additional tubing for use during calibration, reference manual, quick reference card, and comprehensive training video.

The sample draw kit comprises a slip-on sample draw / calibration adapter, squeeze bulb, sample probe, replacement sample probe filters, and ten feet of tubing.

1.11.1 “Alkaline” PhD Ultra detectors

If the PhD Ultra has been purchased as an “alkaline” instrument the standard accessories also include an alkaline battery pack and a set of 3 disposable AA alkaline batteries.

1.11.2 “NiCad” PhD Ultra detectors

If the PhD Ultra has been purchased as a “NiCad” instrument the standard accessories additionally include a NiCad battery pack, slip in PhD Ultra fast charger, as well as a spare alkaline battery pack and set of disposable batteries.

1.11 PhD Ultra kits

PhD Ultra detectors may also be purchased as part of complete kits.

1.11.1 PhD Ultra Confined Space Kits

Besides the standard accessories included with every PhD Ultra, Confined Space Kits also include calibration fittings, regulator, one cylinder of each of the appropriate calibration gases and foam lined waterproof carrying case for the instrument, calibration materials and other accessories.

Cylinders used in Confined Space Kits contain either 58 or 103 liters depending on the specific mixture of gas.

1.11.2 PhD Ultra Value Packs

It is also possible to order the PhD Ultra configured as a “Value Pack”. The Value Pack comprises an alkaline PhD Ultra, all standard accessories, 34 liter cylinder of all-in-one calibration gas, fixed flow rate regulator, and foam lined carrying case.

Chapter 2 Basic operation

2.1 Operation overview

2.1.1 Turning the PhD Ultra on

The large black push-button on the top of the PhD Ultra case is called the "MODE" button. It is used to turn the PhD Ultra on and off, and to control most other operations of the instrument. Push the mode button once to turn the PhD Ultra on.

2.1.2 Start-up sequence

After the detector 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 PhD Ultra will also determine which “Smart Sensors” are currently installed, and whether there have been any changes since the last time the instrument was used.

The first screen shown during the start-up sequence gives the instrument’s software version number.

```
   biosystems
PhD Ultra V3.40
```

The instrument will proceed to load instrument and sensor data.

```
    Loading
Instrument Data
```

A screen will be shown for each sensor that is recognized in the instrument.

```
  Loading O2
  Sensor Data
```

```
  Loading LEL
  Sensor Data
```

↓

etc.

The instrument serial number will be shown followed by the datalogger interval screen.

```
 Serial Number
 20409
```

```
** Datalogger **
 1:00       60hr
```

The figure at the left represents the sampling interval in minutes. The figure at the right represents the operating time before the oldest data will be overwritten by new data.

For more information on the datalogger sampling interval settings, see section 4.5.3.

The instrument’s current date and time settings will then be shown.

```
DATE 19 MAY 2004
TIME  2:30 PM
```

Note: If the date and time are incorrect, see section 4.5.3.3 for instructions.

The PhD Ultra automatically evaluates itself to determine its electronic fitness for use by performing an electronic self-test.

```
Performing
Self Test
```

During the self-test the audible alarm will sound and each LED alarm light will be briefly activated. The system’s onboard memory (RAM) will then be tested.

```
  Testing RAM
  Please Wait
```

The next screen shows the type of battery pack installed, the current battery pack voltage, and temperature in both Centigrade and Fahrenheit.

```
NiCad Bat. 3.6V
Temp. 25 C 77 F
```

The temperature displayed is not necessarily the temperature of the ambient air that surrounds the instrument. The temperature shown is actually a reading taken on the inside of the instrument case in the area where the sensors are located. This information is used by the PhD Ultra microprocessor to properly adjust the sensor output when the instrument is used in changing temperatures.

The current alarm settings will be shown before the instrument is ready for use.

```
CURRENT ALARM
SETTINGS
```

```
O2 19.5%-23.5%
LEL    10%
```

```
CO (Ceiling)
  35 ppm
```

```
CO (STEL) 100ppm
   (TWA)   35ppm
```

Note: PhD Ultra gas reading alarms are user adjustable and may be set anywhere within the range of the sensor channel. In many cases it is possible to comply with OSHA guidelines while using higher alarm points than the “default” factory alarm settings. Factory default settings may be easily restored at any time. The procedure for changing or restoring the default alarm settings is discussed in Chapter 4.

```
  Starting New
    Session
```

The final screen in the self-test and start-up sequence is the current gas level screen. This screen shows the kind of sensors currently installed and the current readings. When the instrument is operated in either the “Basic” or “Technician” mode, numerical readings are shown.

```
 O2  LEL  CO H2S
20.9   0   0   0
```

If the instrument is operated in the "Text Only" mode an "OK" message will be displayed as long as an alarm set point has not been exceeded. If the readings exceed a pre-set alarm level, the message changes from "OK" to a numerical reading, the LED alarm light flashes, and the audible alarm sounds.

```
O2  LEL  CO  H2S
OK  OK   OK   OK
```

2.1.3 Other start-up screens

Several additional screens may be shown under some circumstances. Usually the screen message is self-explanatory.

2.1.3.1 "Self-adjusting" or "Correcting"

In some cases the PhD Ultra may detect an electronic fault or need for adjustment when first turned on. A screen will indicate the nature of the fault. If the instrument is capable of correctly adjusting itself a screen will indicate "Self Adjusting" or "Correcting". When the correction has been successfully completed the instrument will continue the self-test and start-up sequence.

2.1.3.2 "Non-standard alarms"

If the instrument determines that dangerously non-standard or custom oxygen or LEL combustible gas alarms have been selected, the LCD will display the message "Non-Standard Alarms" at start-up. The LCD will display the alarm settings for the affected sensors.

```
WARNING: Alarms
 Non-Standard
```

```
 O2 Low =   0.0
MODE=Acknowledge
```

Press the mode button to proceed with the non-standard settings.

Note: Factory default settings may be easily restored at any time. The procedure for restoring factory default alarm settings is discussed in Chapter 4.

2.1.3.3 "Needs Cal"

Biosystems EEPROM equipped "smart" sensors automatically identify themselves to the PhD Ultra in which they are installed. The PhD Ultra is aware any time sensors are added, deleted, changed or replaced. Any time a change is made to the sensors, the PhD Ultra will display the message "Needs Cal" followed by a list of the affected sensors. This is an indication that the accuracy of the affected sensors should be verified by exposure to known concentration test gas before further use.

⚠WARNING Following a "Needs Cal" warning, the PhD Ultra 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.

2.1.4 Turning the PhD Ultra off

Hold the mode button down for three seconds to turn the instrument off. In order to prevent accidental shut downs, the mode button must be depressed for a full three seconds in order to turn the instrument off. After three seconds (marked by three beeps of the audible alarm) the LCD display will display the message "Release button".

```
Release Button
```

If the button is released prior to the display of the "Release button" message, the instrument will not turn off.

After the button is released the LCD display will save intrument data and then shut down

```
     Saving
Instrument Data
```

```
Begin SHUT DOWN
  Please Wait
```

The shutdown sequence is complete when the meter display blanks out in about ten seconds.

2.2 Operating modes

The PhD Ultra offers a choice of three modes of operation, "Text Only", "Basic", and "Technician". Mode selection is a function of how much information is required, the skill level of the user, and the nature of the job.

Regardless of operating mode selection, anytime the PhD Ultra is on it is remembering the peak readings of all gases measured, and is calculating both Time Weighted Averages and Short Term Exposure Levels for any toxic gas sensors installed. Regardless of operating mode, the PhD Ultra will go into alarm whenever an alarm set point is exceeded.

An alarm condition occurs when one of the sensor readings exceeds a pre-set alarm level. When an alarm condition occurs, the current gas readings screen will change to reflect the new gas value, the LED alarm lights will flash, and the audible alarm will sound.

2.2.1 Text Only mode

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

```
O2  LEL  CO  H2S
OK  OK   OK   OK
```

An alarm condition occurs when one of the sensor readings exceeds a pre-set alarm level. The indication will change from "OK" to the numerical gas value that is registered by the instrument. The

LED alarm lights will flash and the audible alarm will sound during an alarm condition.

```
 O2  LEL  CO H2S
19.1  OK  OK  OK
```

PhD Ultra alarms are normally self-resetting. When readings drop back below the pre-set alarm levels, the screen returns to the "OK" indication, and visual and audible alarms cease.

In Text Only mode, press the mode button to toggle between the two available screens. The first screen is the current gas readings screen, which in Text Only mode will show OK unless an alarm set point has been exceeded. Press the mode button to access the runtime screen, which shows the time, battery voltage, running time for the instrument since last turned on (in hours and minutes), and temperature (in both Fahrenheit and Centigrade).

```
 11:43 0027 3.9V
00:27:55 75F 24C
```

Note: It is <u>not</u> possible to make calibration adjustments while the PhD Ultra is operated in the Text Only mode. The PhD Ultra must be operated in either Basic or Technician mode in order to initiate the "Auto-Calibration" sequence.

2.2.2 Basic mode

The "Basic" mode of operation provides the user with numerical readings at all times, but keeps operation of the gas detector simple.

In Basic mode the user has access to two "screens" of information. Press the mode button to toggle between the two available screens. The first screen is the current gas readings screen, which will always provide numerical readings in Basic mode.

```
 O2  LEL  CO H2S
20.9   0   0   0
```

Press the mode button to access the runtime screen, which shows battery voltage, running time for the instrument since last turned on (in hours and minutes), and temperature (in both Fahrenheit and Centigrade).

```
 11:43 0027 3.9V
00:27:55 75F 24C
```

In Basic mode it is possible to enter the "Auto-Calibration" mode in order to make zero and span calibration adjustments. This feature is not enabled when the instrument is operated in the Text Only mode.

Calibration procedures are discussed in detail in Chapter 3.

An alarm condition occurs when one of the sensor readings exceeds a pre-set alarm level. The numerical reading changes to reflect the new value, the LED alarm light flashes, and the audible alarm sounds.

```
 O2  LEL  CO H2S
19.1   0   0   0
```

PhD Ultra alarms are normally self-resetting. When readings drop below the pre-set alarm levels, visual and audible alarms cease, and the instrument resumes normal operation.

2.2.3 Technician mode

The "Technician Mode" provides access to all advanced functions and displays, including the automatic calibration subroutines.

Calibration procedures are discussed in detail in Chapter 3.

In Technician mode, following completion of the start-up and self-test sequence, the current gas readings screen will be shown with numeric displays for all sensors. An alarm condition occurs when one of the sensor readings exceeds a pre-set alarm level. In an alarm condition, the numerical readings change to reflect the new value, the LED alarm light flashes, and the audible alarm sounds.

PhD Ultra alarms are normally self-resetting. When readings drop back below the pre-set alarm levels, visual and audible alarms cease, and normal operation of the instrument resumes.

Press the mode button to scroll through the numerous screens of information available in Technician mode.

2.2.3.1 Peak readings

From the current gas readings screen in Technician mode, press the mode button once to display the "Peak" readings for the gases being measured. These readings represent the highest (or in the case of oxygen highest and lowest) values registered by the instrument during any period of operation. Peak readings are updated on a second by second basis.

The PhD Ultra will automatically cycle between two peak reading screens, one for oxygen, and one for the other gases being measured. The oxygen peak reading screen shows both the high (HI) and low (LO) readings.

```
PEAK   LO    HI
 O2   20.6  20.9
```

```
PEAK   LEL CO H2S
         0  0   0
```

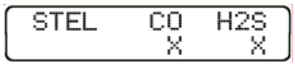
2.2.3.2 STEL readings

Press the mode button again to display the "STEL" readings for the toxic sensors currently installed.

```
 STEL    CO  H2S
          0    0
```

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

Note: For the first 15 minutes after the PhD Ultra is initially turned on the STEL reading is a projected value. The PhD Ultra 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.

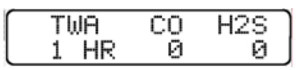


The STEL reading is constantly updated. Audible and visual gas alarms will be activated whenever the most recent 15-minute average exceeds the STEL alarm set point.

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

2.2.3.3 TWA readings

Press the mode button again to display the TWA (Time Weighted Average) exposure levels. TWA values are calculated by projecting exposures over an eight-hour period.

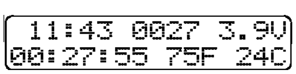


It is not possible to compute a toxic gas TWA until the PhD Ultra has been monitoring for at least 15 minutes. Until the minimum monitoring time has elapsed, the TWA screen will show an "X" where the reading should be.

Note: After 30 minutes the screen will also begin to indicate how long the instrument has been on. This “run time” indication will be given in hours and completed 15-minute intervals.

2.2.3.4 Runtime screen

Press the mode button again to display the runtime screen, which shows battery voltage, running time for the instrument since last turned on (in hours and minutes), and temperature (in both Fahrenheit and Centigrade).



Press the mode button again to return to the current gas readings screen.

2.2.4 Changing operating modes

To change operating modes, simply slide the belt clip located on the back of the PhD Ultra case downward to expose the four push buttons on the instrument keypad. Push the "+" and "-" buttons at the same time to change operating modes. Each time the operating mode is changed the display screen will briefly indicate the operating mode that has been selected. The instrument will not incur any loss of data due to a change in operating mode.

Note: Shifting modes or otherwise reprogramming the instrument should only be done by employees who are authorized to do so.

2.3 Batteries

PhD Ultra batteries are housed in removable battery packs. Two types of battery packs (rechargeable NiCad and alkaline) are available for use. Battery packs are fully interchangeable and can be replaced while the instrument is in the field. It is not necessary to open the instrument case to replace or change the battery pack.

Battery packs are clearly labeled as containing either NiCad or disposable alkaline batteries. The gasketed battery packs are held firmly in place by a spring-loaded catch on the instrument. The PhD Ultra should be turned off before changing or replacing battery packs.

Note: The PhD Ultra is designed to turn itself on whenever a battery pack is removed and then replaced. This is to ensure that in the event of a power interruption the instrument is not accidentally turned off. Any time the battery pack is momentarily removed or replaced with another it will be necessary to manually turn the PhD Ultra off if the instrument is not going to be put to immediate use.

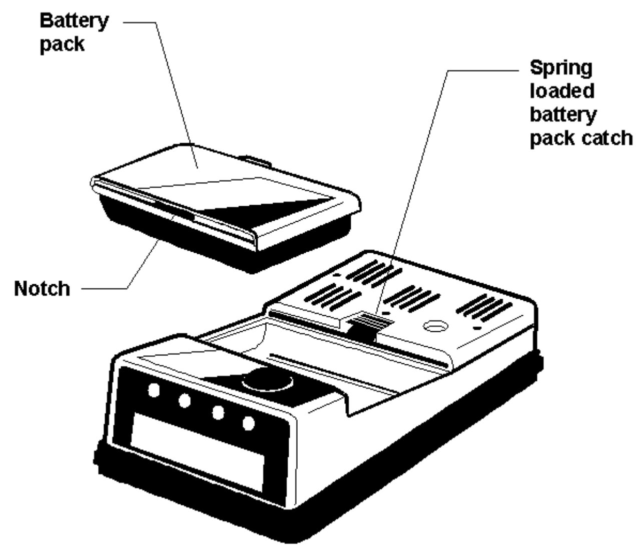


Figure 2.3. PhD Ultra with Battery Pack Removed

To remove the battery pack pull back on the spring-loaded catch, and pull the battery pack upward and backwards (towards the rear of the instrument). To replace the battery pack, seat the notch at the front of the battery pack housing to the matching lip in the PhD Ultra instrument case. When the battery pack is properly positioned, press down gently on the rear of the battery pack to engage the spring loaded catch.

2.3.1 NiCad battery pack

When the PhD Ultra is operated in the diffusion mode, the rechargeable NiCad battery pack will provide up to 12 hours of continuous use. The NiCad pack is a sealed assembly that may not be disassembled in the field. The NiCad battery may be recharged while the pack is installed in the instrument, or the battery pack may be removed from the instrument and recharged separately in the PhD Ultra Fast Charger.

Fully assembled NiCad battery packs may be removed or replaced while the instrument is being used in a hazardous location.

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

The PhD Ultra is Classified by Underwriters Laboratories, Inc. and the Canadian Standards Association as to Intrinsic Safety for use in Class I, Division 1, Groups A, B, C, & D Hazardous Locations. This classification is void while the PhD Ultra is operated while connected to the battery charger in hazardous areas.

2.3.2 Disposable alkaline battery pack

The PhD Ultra may also be equipped with a battery pack designed to hold a set of 3 AA disposable alkaline batteries. When the PhD Ultra is operated in diffusion mode, the alkaline battery pack will provide up to 12 hours of continuous use. The alkaline pack must be removed from the instrument in order to replace the batteries. The alkaline battery pack is removed in the same manner as the NiCad pack. To maintain intrinsic safety the alkaline battery pack cover is held in place by a captive screw that is located in the center of the underside of the battery pack. To open the alkaline pack, use a screwdriver to loosen the screw and gently remove the cover.

Make sure that replacement batteries are properly aligned in the battery pack housing before returning the instrument to service.

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

2.3.3 Low battery alarms

The PhD Ultra is designed to automatically determine which type of battery pack has been installed, and use the appropriate low battery alarms. Alarms will be activated whenever battery voltage is too low to allow the safe operation of the instrument.

Battery pack voltage may be checked at any time while the instrument is in normal operation by pressing the mode button to access the runtime screen. Allow the PhD Ultra to operate two to three minutes before checking battery voltage. A reading of 3.8 Volts or higher indicates that either type of battery pack has sufficient power to provide eight hours of continuous operation.

2.3.3.1 Low battery alarm settings for NiCad battery packs

When NiCad battery pack voltage is reduced to 3.3 Volts, 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 a fifteen-minute period by pressing the mode button. The alarm will continue to sound every fifteen minutes until the voltage reaches 3.25 Volts.

The initial low battery screen alternates with a second screen that indicates that the alarm may be silenced by pressing the mode button.

```
** WARNING **
BATTERY = 3.3V
```

```
** WARNING **
  Press Mode
```

When battery pack voltage has dropped to 3.25 Volts it is no longer safe to continue to use the instrument until the battery has been recharged. At this point the alarm will begin to sound continuously, and may no longer be silenced by pushing the mode button. If voltage drops below 3.25 Volts the PhD Ultra will display a "Dead Battery" message to warn the user of imminent shut down. The instrument will then automatically turn itself off.

```
 ** DANGER **
 DEAD BATTERY
```

```
Will Shut Down
  Press Mode
```

The PhD Ultra NiCad battery pack should be recharged as soon as possible after any low battery alarm. It is important to recharge or replace the battery pack before further use.

2.3.3.2 Low battery alarm settings for alkaline battery packs

If the PhD Ultra has been equipped with a disposable alkaline battery pack, the initial low battery alarm will be activated when voltage is reduced to 3.2 Volts. Protective shutdown occurs at 3.1 Volts.

2.3.4 Recharging NiCad battery packs

Standard accessories included with every “NiCad” instrument include a slip-in PhD Ultra “Fast Charger”. Each standard Fast Charger assembly consists of two components a slip-in cradle and a 110 VAC "wall cube" type power source. European and Australian chargers may use a different wall cube.

NiCad battery packs may be recharged while they are installed in the PhD Ultra detector, or they may be removed from the instrument for separate recharging. The Fast Charger is designed to completely recharge NiCad battery packs in 2 hours. When "fast" charging is complete the charger automatically converts to a "trickle" charge to avoid damage to the battery pack due to overcharging.

CAUTION: PhD Ultra NiCad battery packs may only be charged with Biosystems battery chargers. Use of any other charger may result in damage to the instrument and voids the standard Biosystems warranty.

NiCad battery pack equipped PhD Ultra detectors should be kept continuously on the charger at all times when not in use.

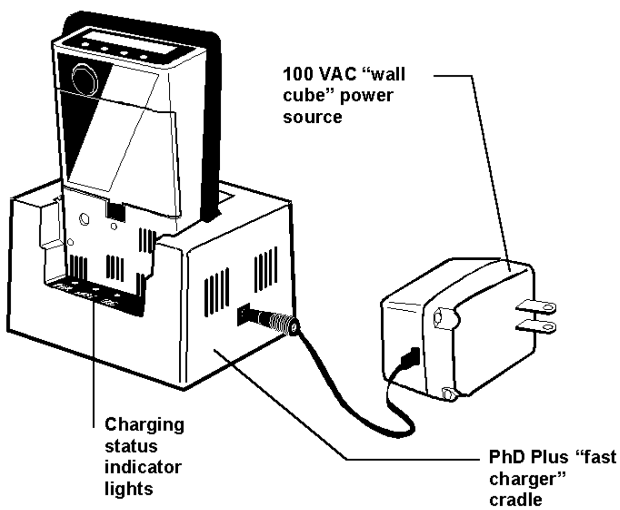


Figure 2.3.4. PhD Ultra Fast Charger (standard version)

2.3.4.1 Charging procedure with NiCad battery pack installed

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

(1) Check that the instrument is turned off. (If it is not, press the mode button until the message "Release button" appears on the screen.)

(2) Connect the charger cradle to the 110 VAC "wall cube" power source.

(3) Plug the "wall cube" in and check to see that the "PWR" (power-on) indicator LED on the charger cradle is lit.

(4) Slip the PhD Ultra into the charger cradle and check to see that the "FAST" (fast charger) indicator LED on the charger cradle is lit.

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

(5) When charging is complete the "FAST" indicator will turn off. Charging is complete any time after the "TRIC" (trickle charge) indicator is lit.

2.3.4.2 Charging the NiCad battery pack separately from the instrument

(1) Check that the instrument is turned off. (If it is not, press the mode button until the message "Release button" appears on the screen.

(2) Connect the charger cradle to the 110 VAC "wall cube" power source.

(3) Plug the "wall cube" in and check to see that the "PWR" (power-on) indicator LED on the charger cradle is lit.

(4) Remove the NiCad battery pack from the PhD Ultra

(5) Slip the NiCad battery pack into the charger as shown in Figure 2.3.4.2. Check to see that the "FAST" (fast charge) indicator LED is lit.

(6) Charging is complete any time after the "TRIC" (trickle charge) indicator is lit.

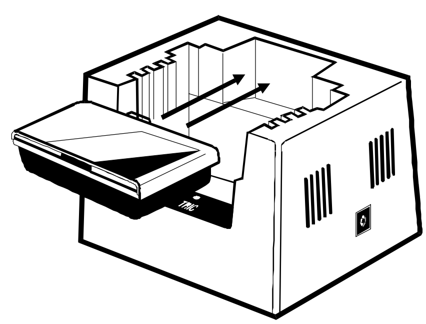


Figure 2.3.4.2. Placement of NiCad Battery Pack in Fast Charger

2.3.4.3 "Cycling" NiCad battery packs

If the NiCad battery duration is not being received, try exercising or "cycling" the battery. To cycle the NiCad battery pack:

(1) Install the battery pack in the PhD Ultra and turn the instrument on.

(2) Allow the instrument to run until the low battery voltage alarms have been activated.

(3) Recharge the NiCad battery pack.

(4) Repeat procedure as necessary.

Over a period of three or four days of cycling it is frequently possible to restore a significant portion of lost performance. If cycling fails to improve performance, the battery pack will probably need to be replaced.

2.4 Methods of sampling

The PhD Ultra may be used as either a "Diffusion" or "Sample-Draw"-type monitoring device.

In normal operation, the PhD Ultra detector is worn on the belt, used with its shoulder strap, or held in the hand. Once turned on, the PhD Ultra monitors continuously. The atmosphere being measured reaches the sensors by diffusing through vents in the sensor compartment cover. Normal air movements are enough to carry the sample to the sensors. The sensors react quickly to changes in the concentrations of the gases being measured. This type of "diffusion" operation monitors only the atmosphere that immediately surrounds the detector.

It is possible to use the PhD Ultra to sample remote locations by using a sample-draw kit. Two sample-draw kits are available. In each case the gas sample is drawn in through a probe assembly, and travels through a length of hose back to the instrument. One type of kit uses a hand-operated squeeze-bulb to draw the sample through the hose while the other uses a motorized continuous mechanical pump that draws its power directly from the PhD Ultra battery pack. A hand-aspirated sample-draw kit is included as an accessory with every PhD Ultra.

2.4.1 Using the hand aspirated sample draw kit

(1) Connect the slip-on sample draw / calibration adapter with the squeeze bulb and hose assembly.

(2) Connect the end of the hose closest to the bulb to the sample draw adapter.

(3) Connect the other end of the hose to the sample probe as shown in **Figure 2.4.1.1.**

(4) Attach the sample draw adapter to the PhD Ultra as shown in **Figure 2.4.1.2**.

(5) Cover the end of the sample draw probe assembly with a finger, and squeeze the aspirator bulb. If there are no leaks in the sample draw kit components, the bulb should stay deflated for a few seconds.

⚠WARNING Failure to test the sample draw kit prior to each use may result in inaccurate readings.

(6) Insert the end of the sample probe into the location to be sampled.

(7) Squeeze the aspirator bulb one time for each foot of sample hose for the sample to reach the sensor compartment. Then continue squeezing the bulb for an additional 45 seconds until readings stabilize.

⚠WARNING Failure to correctly follow the usage instructions for the sample draw kit may lead to inaccurate readings.

(8) Note the gas measurement readings.

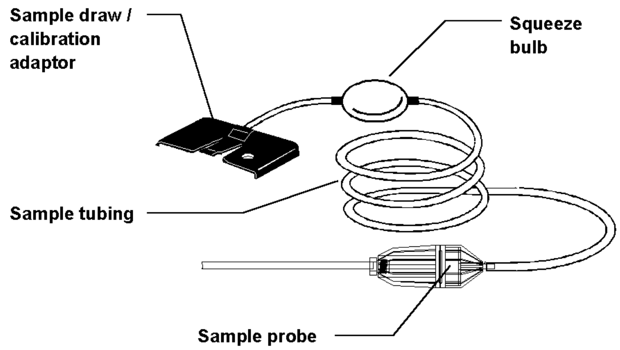


Figure 2.4.1.1. PhD Ultra hand aspirated sample draw kit

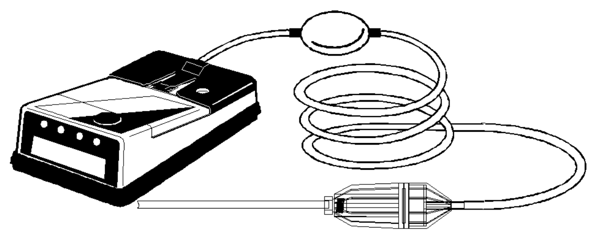


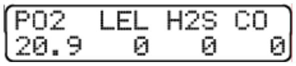
Figure 2.4.1.2. PhD Ultra with hand aspirated sample draw kit attached

CAUTION: Hand aspirated remote sampling only provides continuous gas readings for the area in which the probe is located when the bulb is being continuously squeezed.

Each time a reading is desired, it is necessary to squeeze the bulb a sufficient number of times to bring a fresh sample to the sensor compartment and to continue squeezing for another 45 seconds or until readings stabilize. If continuous remote sampling is required, a battery operated, continuous, mechanical sample-draw pump should be used.

2.4.2 Continuous (slip-on) sample draw pump

Use of the slip-on sample draw pump allows the PhD Ultra to continuously monitor remote locations. The pump is powered directly by the PhD Ultra battery. A flashing “P” indicator in the upper left corner of the LCD display indicates that the pump is attached and in normal operation.



CAUTION: **Never perform remote sampling with the PhD Ultra 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, contaminants may cause damage to the pump, sensors and internal components of the PhD Ultra.**

The sample draw pump includes a unique pressure sensor designed to protect the PhD Ultra 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: **Insertion of the sample draw tube into a fluid horizontally or at a low angle may lead to water ingress and may cause damage to the PhD Ultra.**

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 pump assembly.

In order to avoid potential damage, care must be taken to keep the probe vertical any time fluids might be present.

2.4.2.1 Using the continuous sample draw pump

(1) Turn the PhD Ultra on.

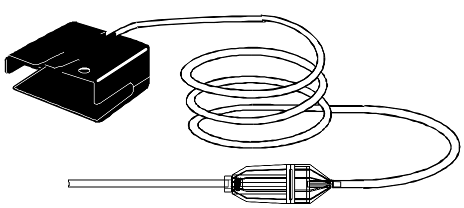


Figure 2.4.2.1.1. Sample draw pump and probe assembly

(2) Connect the slip-on battery operated pump with the hose and probe assembly as shown above in **Figure 2.4.2.1.1.**

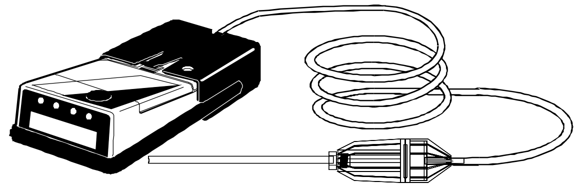


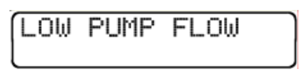
Figure 2.4.2.1.2. PhD Ultra with sample drawing pump attached

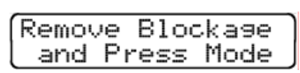
(3) Slip the pump onto the PhD Ultra as shown above in **Figure 2.4.2.1.2.**

(4) Make sure the pump is securely attached. (You should hear a solid “click” as the pump housing catch engages with the edge of the sensor grill cover.)

(5) The pump will turn on automatically when properly attached to the PhD Ultra.

(6) Cover the end of the sample draw probe assembly with a finger. If there are no leaks in the sample draw kit components, the pump should go into a low-flow alarm and shut down, and the audible and visual low flow alarms should be activated. A message screen will identify that there is a low pump flow condition. A second screen will advise you to remove the blockage and press “mode” to resume operation.





⚠WARNING Failure to test the pump and sample draw kit prior to each use may result in inaccurate readings.

(7) Insert the end of the sample probe into the location to be sampled.

(8) Wait long enough for the pump to have drawn the sample through the entire length of hose, and for the sensors to have stabilized. (Allow one additional second for each foot or three seconds for each meter of sample hose.)

⚠WARNING Failure to correctly follow the usage instructions for the pump sample draw kit may lead to inaccurate readings.

(9) Note gas measurement readings

2.4.2.2 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 PhD Ultra detector and disconnect the sample draw pump.

(2) Remove the sample draw assembly from the area being monitored. Be careful to keep the sample draw probe in a vertical position.

(3) Examine the sample draw probe and hose to make sure no fluids remain trapped.

(4) Allow any trapped fluids to completely drain. (It may be necessary to disconnect the hose or sample draw probe before drainage can occur.)

(5) Replace the sample draw probe filters if necessary.

(6) Re-attach the pump in fresh air and wait for readings to stabilize.

(7) Resume sampling.

2.4.2.3 Resuming diffusion monitoring

In order to stop using the pump and resume diffusion monitoring, simply disconnect the pump assembly from the PhD Ultra. The audible and visual alarms will be activated and the LCD will display the message "Pump Disconnect". Press the mode button to acknowledge and resume normal diffusion operation.

PUMP DISCONNECT
Press Mode

2.4.3 Sample probe assembly

The sample probe handle contains moisture barrier and particulate filters designed to remove contaminants that may cause harm to either the continuous pump or the instrument. **Never operate the sample draw pump unless the hose and probe assembly is attached!**

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

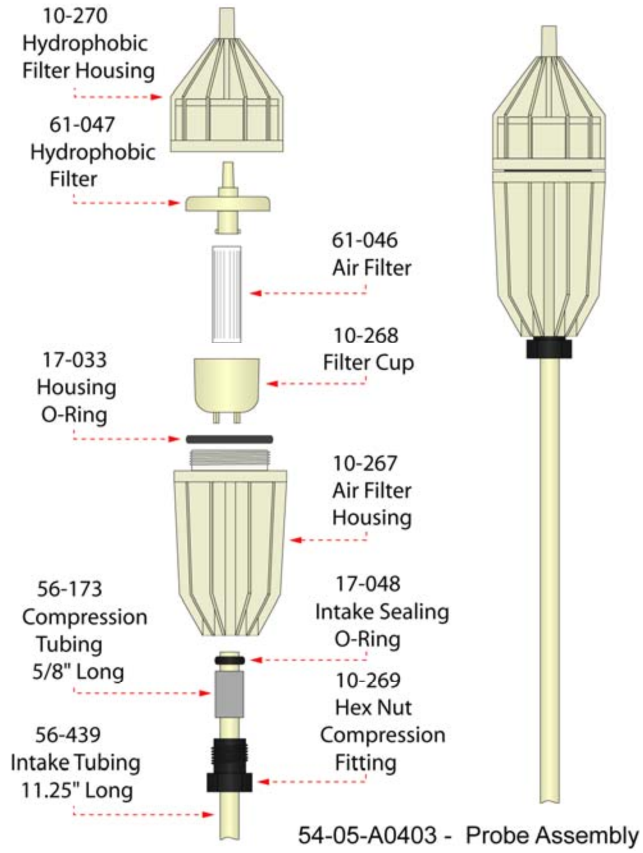


Figure 2.4.3. PhD Ultra sample probe assembly

Sample probe filters should be replaced whenever visibly discolored due to contamination, or when the continuous pump "low flow" alarm indicates blockage. A spare filter replacement kit (part number 54-05-K0401) is included with every PhD Ultra.

2.4.3.1 Changing sample probe filters

The threaded sample probe handle is unscrewed (as shown in Figure 2.4.3.) to access the filters. The particulate filter is held in place by means of 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.)

2.4.3.2 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).

Probe tubes are exchanged by loosening the hex-nut compression fitting, removing the old tube, sliding the compression sleeve into place around the new tube, inserting the new tube into the probe handle, and finally replacing and re-tightening the hex-nut.

Note: The sample probe must be checked for leakage (as discussed in Section 2.4.1.) whenever filters or probe tubes are exchanged or replaced before it is returned to service.

2.5 Biosystems EEPROM equipped "Smart Sensors"

Each sensor installed in a PhD Ultra 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 PhD Ultra. The fact that each sensor is capable of remembering and communicating important information about itself to the instrument allows for a number of important PhD Ultra operating benefits.

2.5.1 Identification of type of sensor by instrument

Any sensor installed in the PhD Ultra automatically identifies itself to the instrument microprocessor. The PhD Ultra automatically recognizes the sensors installed, displays the sensor on the liquid crystal display (LCD) and assigns the correct alarm settings.

2.5.2 Other information stored with the sensor EEPROM

Besides being identified by type of sensor, recorded sensor information also includes the sensor serial number, the most recent calibration settings, temperature compensation curves, and the most recent alarm settings. The PhD Ultra automatically updates all of this data for the sensors currently installed 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 PhD Ultra notes 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 PhD Ultra will still note the change in serial numbers of the sensors installed, and display the "Needs Cal" message.

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

2.5.3 Sensor replacement

Sensor replacement procedures are covered in detail in section 5.1.

2.5.4 Missing sensor

The PhD Ultra is able to determine if a sensor is removed or becomes disconnected while the instrument is in normal operation. Removal of a sensor while the instrument is turned on will trigger a "Missing Sensor" display message, and cause the audible and visual alarms for the affected sensor channel to be activated.

2.5.5 "Can't ID sensor"

If the PhD Ultra is unable to read the EEPROM of a smart sensor currently installed, or if a smart sensor is removed while the instrument is turned off without being replaced with another sensor, a "Can't ID Sensor" message will be displayed, and the affected sensor channel, (for instance, "Toxic 1") will be identified.

Press the mode button to acknowledge the condition, and allows the use of the instrument for those sensors that can be successfully read by the instrument.

Chapter 3 Calibration

The PhD Ultra multi-gas detector has been designed for easy calibration. A single control, the on/off mode button, is used to initiate the automatic calibration sequence and to automatically make calibration adjustments.

It is also possible to manually calibrate the instrument by using the four pushbuttons located on the instrument keypad.

"One-Button Auto-Calibration" procedures are discussed in Section 3.4. Manual calibration procedures are discussed in Section 3.5.

3.1 Verification of accuracy

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

⚠WARNING Always check the expiration date on calibration gas cylinder(s) prior to use. Expired calibration gas can lead to inaccurate and potentially dangerous readings.

Verification of accuracy is a two step procedure. In the first step the PhD Ultra is taken to an area where the atmosphere is fresh and the readings are checked. If the readings differ from those expected in fresh air, a "zero" 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. Oxygen readings are considered to be accurate when the display is within ±0.5% of the expected concentration as given on the calibration gas cylinder. LEL and toxic readings are considered accurate when they are between 90% and 120% of the expected value as given on the calibration gas cylinder. (CSA requires the reading to fall between 100% and 120% to be considered accurate). 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.

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

⚠WARNING Use of non-standard calibration gas and/or calibration kit components when calibrating the PhD Ultra 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 PhD Ultra.

3.1.1 Effect of contaminants on PhD Ultra sensors

The atmosphere in which the PhD Ultra monitor is being used can have an effect on the sensors. Sensors may be poisoned or suffer degraded performance if exposed to certain substances.

There are three basic types of sensors that may be installed in the PhD Ultra detector: oxygen, combustible gas (LEL), and electrochemical toxic. Each type of sensor uses a slightly different detection principle so the conditions that affect the accuracy of the sensors vary from one type of sensor to the next.

⚠WARNING The accuracy of the PhD Ultra sensors should be checked immediately following any known exposure to contaminants by testing with known concentration test gas before further use.

3.1.1.1 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 Biosystems instruments are not recommended for continuous use in atmospheres which contain more than 25% CO_2.

3.1.1.2 Effects of contaminants on combustible sensors

Combustible sensors may be affected by exposure to substances containing silicone (found in many lubricants and hydraulic fluids), the tetra-ethyl-lead in "leaded" gasoline, and halogenated hydrocarbons (Freons, or solvents such as trichloroethylene and methylene chloride). High concentrations of hydrogen sulfide may also damage the sensor.

Note: See the Biosystems Standard Warranty in Appendix G for a more extensive list of LEL sensor contaminants.

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

A partially poisoned sensor might 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.

3.1.1.2.1 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 PhD Ultra is designed to "alarm latch" whenever the concentration of combustible gas exceeds 100 percent LEL. Under these conditions the combustible gas reading will show an "X" to indicate an over-limit condition. The current gas reading display will alternate (toggle) with a screen showing the message "LEL sensor over limit". The audible and visual alarms will sound continuously until the instrument is manually reset by turning it off, then turning the instrument back on in an area where the air is known to be fresh.

⚠**WARNING** **A combustible sensor over-range 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 over-range alarm, the PhD Ultra 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 PhD Ultra 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 PhD Ultra 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 test gas before further use.**

Note: The combustible sensor used in the PhD Ultra requires a minimum of 10% oxygen by volume in order to generate accurate combustible gas readings. Combustible sensor accuracy may be diminished 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 PhD Ultra's zero to 100 percent LEL detection range. Failure to leave the area immediately may result in serious injury or death!**

Avertissement: Toute lecture rapide et positive, suivie d'une baisse subite au erratique de la valeur, peut indiquer une concentration de gaz hors gamme de détection qui peut être dangereuse.

3.1.1.3 Effects of contaminants on toxic gas sensors

Biosystems "substance-specific" electrochemical "smart sensors" used to measure toxic gases 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 be affected by exposure 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.

Cross sensitivity of PhD Ultra toxic sensors to common interfering gases is listed in Appendix E.

3.1.2 Biosystems "CO Plus" dual purpose carbon monoxide / hydrogen sulfide sensor

Carbon monoxide and hydrogen sulfide are the two most common toxic gases associated with confined space entry. In addition to "substance specific" sensors designed to measure these toxic hazards, Biosystems also offers a dual-purpose sensor designed to detect both carbon monoxide and hydrogen sulfide. The "CO Plus" sensor is ideal for situations requiring use of a single sensor to monitor simultaneously for both toxic hazards.

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 will simultaneously detect both carbon monoxide and hydrogen sulfide, it is only possible to directly monitor for one of these hazards.

Note: When a specific contaminant such as hydrogen sulfide is known to be potentially present, the best approach is usually to use a direct reading substance specific sensor. The OSHA standard for permit required confined

space entry (29 CFR 1910.146) explicitly requires the use of direct reading, substance specific sensors whenever a particular toxic hazard is known to be likely to be present. If hydrogen sulfide is known to be potentially present, one of the toxic sensors selected should be specifically for the detection of H_2S, and calibrated directly to this hazard.

The "CO Plus" sensor can be calibrated to either hydrogen sulfide or carbon monoxide. In order to change the type of gas used to calibrate the "CO Plus" sensor, it is necessary to enter the "Configuration Setup" menu as discussed in Chapter 4 and select the new calibration gas.

⚠WARNING **Do not use multi-component calibration gas mixtures containing both carbon monoxide and hydrogen sulfide when calibrating a PhD Ultra with a CO Plus sensor installed. Calibration of the CO Plus sensor with multi-component calibration gas mixtures containing both CO and H_2S may lead to inaccurate and potentially dangerous readings.**

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

Biosystems "CO Plus" sensors are designed for the simultaneous detection of both carbon monoxide **and** hydrogen sulfide. "CO Plus" sensors may be calibrated to either carbon monoxide or hydrogen sulfide. The calibration gas used to calibrate "CO Plus" sensors may contain only one or the other of these two gases. Calibrating a "CO Plus" sensor with a gas mixture containing both carbon monoxide and hydrogen sulfide may produce dangerously low readings.

Biosystems multi-component calibration gas mixtures that contain both carbon monoxide and hydrogen sulfide are labeled as "Not for use with CO Plus sensors".

⚠WARNING **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 direct reading requirement must be used in the calibration of the instrument. If carbon monoxide is chosen in the calibration gas setting option, 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 option, 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 and potentially dangerous readings.**

If the sensor is calibrated to carbon monoxide the current gas reading display will identify a "CO+" sensor as currently installed and the PhD Ultra will automatically use the alarm settings for carbon monoxide. If hydrogen sulfide is chosen as the calibration gas the display will identify the sensor installed as an "H_2S+" sensor and H_2S alarm settings will automatically be used.

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

A properly calibrated "CO Plus" sensor will respond accurately to the gas to which it is 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 calibrated to carbon monoxide and then exposed to 35 PPM carbon monoxide, the reading will be 35 PPM.

The "CO Plus" sensor will also show a "relative response" to other interfering gases. When calibrated to carbon monoxide the relative response of the "CO Plus" sensor to hydrogen sulfide is a ratio of about 3.5 to 1.0. This means a concentration of about 10 PPM hydrogen sulfide would produce a "CO+" sensor reading of 10 X 3.5 or 35 PPM.

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+" gas alarms will be tripped any time the concentration of hydrogen sulfide exceeds the permissible exposure limit.

Note: Cross sensitivity of the "CO Plus" sensor to carbon monoxide, hydrogen sulfide and other common interfering gases is listed in Appendix E.

3.1.3 Choosing the correct calibration gas mixture

The best results are obtained when calibration is done using the same gas that is expected to be encountered while actually using the instrument.

Sensor performance, calibration gas strategies and "Propane Equivalent" calibration gas mixtures are discussed in greater detail in Appendix B. A listing of currently available Biosystems calibration gas mixtures is contained in Appendix D.

3.2 Fresh air "zero" calibration

The fresh air "zero" must be done in fresh, uncontaminated air. In this procedure the instrument automatically adjusts its oxygen, combustible gas, and toxic gas readings to match the concentrations present in fresh air (20.9 percent O_2, 0 percent LEL, 0 PPM toxic gas).

Since fresh air contains 20.9 percent oxygen, the fresh air “zero” calibration is the only calibration needed for the oxygen sensor in the PhD Ultra. Toxic and combustible gas sensors must also undergo span calibration to ensure accuracy.

If the PhD Ultra cannot be taken to an area where the air is fresh, or if it is not certain whether or not the air is uncontaminated, special procedures are required. These special procedures are discussed at greater length in Appendix C.

3.3 Functional (bump) test

The accuracy of the PhD Ultra may be verified at any time by performing a simple functional (bump) test.

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

(1) Turn the PhD Ultra 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 PhD Ultra is in Basic or Technician operating mode the fresh air readings should equal 20.9 % O_2, 0 % LEL or 0.0 % CH_4 (by volume), and 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, fresh air calibrate the instrument using the procedures discussed in section 3.4.1. below.

(4) Apply the calibration gas as shown above in figure 3.4.2.

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

(6) Note the readings. LEL and toxic readings are considered accurate when they are between 90%* and 120% of the expected concentration as given on the calibration gas cylinder. Oxygen readings should fall within ±0.5%/(vol.) of the expected concentration as given on the calibration gas cylinder.

Note: If LEL or toxic gas concentration readings are not between 90%* and 120% of the expected values during a functional (bump) test, the instrument must be adjusted using the "span" calibration procedures discussed in section 3.4.2 before further use.

*** The Canadian Standards Association (CSA) requires the instrument 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.**

⚠WARNING Always check the expiration date on calibration gas cylinder(s) prior to use. Expired calibration gas can lead to inaccurate and potentially dangerous readings.

Note: It is necessary to be in either the Basic or Technician operating mode to make calibration adjustments. When the instrument is operated in the Text Only “OK” mode a functional (bump) test is the procedure used to verify accuracy. If the readings are accurate, it is safe to use the instrument without further adjustment.

3.4 Auto-calibration

Biosystems one-button “Auto-Calibration” mode may be used to verify accuracy any time during normal operation while the instrument is being used in either the Basic or Technician operating mode.

Press the mode button three times in rapid succession to place the instrument in the “Auto-Calibration” mode. Adjustments are made automatically simply by pressing the on / off mode button.

Auto-calibration is a two step procedure. In the first step the PhD Ultra is taken to an area where the atmosphere is fresh and a "zero" adjustment is made automatically by pressing the on / off mode button. The second step is the sensor response or "span" calibration adjustment. In this step the accuracy of the PhD Ultra sensors is established by exposing them to known concentration calibration gas. Once again, the sensitivity or “span” is automatically adjusted.

3.4.1 Fresh air "zero" auto-calibration sequence

The fresh air zero procedure may only be done while the instrument is being operated in either the Technician or Basic operating mode.

(1) Turn the instrument on and make sure gas readings are given in numbers.

If readings are given in the form of “OK” text messages the instrument is currently being operated in the “Text Only” mode. It will be necessary to change to either the Basic or Technician operating mode. Switch modes (if necessary) by simultaneously holding down the "+" and"-" key. Each time the operating mode is changed, the LCD screen will briefly indicate the new operating mode.

(2) Wait at least three minutes after turning the instrument on to allow sensor readings to stabilize fully before initiating auto-calibration procedures.

(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 put it into the "Auto-Calibration" mode. A screen will briefly display the message "One button Auto-Calibration". This screen will be followed by the "Zero Calibration Adjustment" screen.

```
   One Button
Auto Calibration
```

```
Zero Calibration
MODE = Adjust  5
```

This screen also includes a timer that counts down the number of seconds left to initiate the adjustment.

(5) Press the mode button within five seconds to initiate the fresh air adjustment. An information screen will be briefly displayed while the adjustments are being made, and another when the adjustments have been completed.

```
Zero Calibration
* Please  Wait *
```

```
Zero Calibration
** Completed **
```

(6) If the mode button is not pushed within five seconds a fresh air zero adjustment will not be made. A message screen indicating that the zero values have not been changed will be briefly displayed, and the instrument will return to normal operation.

```
Zero Calibration
** Unchanged **
```

3.4.1.1 Reading "Too High" or "Too Low" for zero adjust

To reduce the chances of the PhD Ultra being inadvertently zero calibrated in contaminated air, only small adjustments are allowed through the use of the "One Button" auto-zero 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 zeroed using the "CAL" button on the instrument keypad and procedures discussed in Section 3.5.1 of this manual.

Once the instrument has been successfully zeroed using the "CAL" button, subsequent calibration adjustments may be made using the mode button and "One Button Auto Calibration" logic discussed in this section.

3.4.2 "Span" auto-calibration sequence

After successful completion of the "zero" auto-calibration adjustment the display will show the "Span Calibration Adjustment" screen.

```
Span Calibration
MODE = Adjust  5
```

This screen also includes a timer that counts down the number of seconds left to initiate the adjustment.

Note: If the MODE button is pressed at any time prior to completion of the calibration, the calibration procedure will be cancelled, no adjustments will be made and the instrument will return to normal operation.

⚠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. If a sensor has just been replaced, the stabilization period may be longer (see the chart in section 5.1).

```
Span Calibration
** Unchanged **
```

(1) Press the mode button within 5 seconds to initiate "span" auto-calibration. A screen will instruct you to "Apply Gas".

```
   Apply Gas
Mode = Cancel
```

The instrument will continue to display this screen until it determines that calibration gas has been applied. (Auto-span may be canceled at any time during the procedure by pressing the mode button.)

(2) Attach the cylinder of calibration gas, regulator, short section of tubing and calibration adapter to the PhD Ultra as shown in Figure 3.4.2.

⚠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.

CAUTION: The use of regulators with on/off valves may introduce contaminants into the gas cylinder and may lead to the breakdown of reactive gases prior to the cylinder expiration date. Biosystems strongly recommends the use of continuous fixed-flow regulators for all calibration procedures.

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

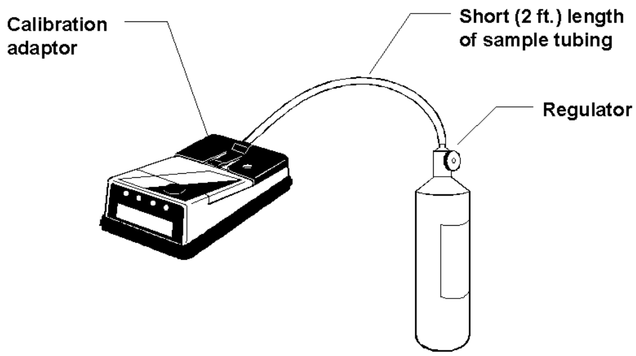


Figure 3.4.2. PhD Ultra calibration setup

The regulator will automatically begin to flow calibration gas as soon as it is screwed into the cylinder of gas. Be sure to use a 1.0 liter/minute regulator with the PhD Ultra.

(3) When the instrument detects that calibration gas has reached the sensors, the display will show the message “Please Wait”.

```
  Please Wait
```

(4) If the instrument determines that the calibration gas being used is a multi-component mixture the display will show the message “Multi Cal Gas Detected”.

```
   Multi Cal
  Gas Detected
```

The instrument will then show a succession of screens as each sensor that can be calibrated using the multi-component mixture is adjusted in turn. The entire span adjustment process is automatic.

```
   LEL Sensor
  Reading 46%
```

```
   LEL Sensor
Adjusted to 50%
```

```
   CO  Sensor
   Reading 48
```

```
   CO  Sensor
Adjusted to 50
```

```
  H2S  Sensor
  Reading  21
```

```
  H2S  Sensor
Adjusted to 25
```

(5) As each sensor is adjusted the screen indicates the concentration and type of test gas that is being used to calibrate the sensor.

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

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

```
Apply 50ppm CO
Mode = Cancel
```

When the instrument has detected that the proper gas has been applied the sensor will be adjusted.

```
   CO  Sensor
Adjusted to 50
```

(6) When all sensors currently installed have been successfully span adjusted, the display will announce “Auto Calibration Completed”. The instrument will then shut itself off.

```
Auto Calibration
   Completed
```

```
Begin SHUT DOWN
  Please Wait
```

(7) Remove all fittings from the PhD Ultra, and press the mode button to turn the instrument on and resume normal operation.

Note: It is possible to exit the auto-calibration mode 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 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.

3.5 Manual calibration procedure

It is also possible to calibrate the PhD Ultra manually using the four buttons on the instrument keypad.

3.5.1 Manual fresh air "zero" through keypad buttons

Note: The manual fresh air “zero” calibration procedure bypasses the PhD Ultra’s safeguards against calibration in a contaminated atmosphere. Be sure to perform this calibration in an area where the air is known to be fresh.

(1) Turn the instrument on.

(2) Wait at least three minutes after turning the instrument on to allow sensor readings to stabilize fully **before** initiating the fresh air zero procedure.

⚠**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. If a sensor has just been replaced, the stabilization period may be longer (see the chart in section 5.1).**

(3) Slide the belt clip towards the rear of the instrument exposing the four buttons on the instrument keypad.

(4) Verify that the instrument is in the Basic or Technician operating mode. To change operating modes simultaneously hold down the "+" and"-" keys.

Each time that the operating mode is changed, the LCD screen will briefly indicate the current operating mode.

(5) Make sure the instrument is located in an area where the air is known to be fresh.

(6) Press the keypad button marked "Cal". The fresh air calibration message will appear briefly on the instrument LCD.

```
FRESH AIR CAL
 ADJUSTMENT
```

(7) The fresh air calibration message will be followed by the zero-adjustment screen.

```
MODE = Cancel
 CAL = Adjust
```

(8) Press "Cal" to automatically zero the instrument. An information screen will be briefly displayed while the adjustments are being made, and another when the adjustments have been completed.

```
Zero Calibration
* Please  Wait *
```

```
Zero Calibration
** Completed **
```

(9) Pressing the mode button causes the calibration values in the memory to remain unchanged from the last time a fresh air adjustment was made. An information screen will be displayed briefly which verifies that the zero values have not been changed.

```
Zero Calibration
** Unchanged **
```

(10) After completion of the zero adjustment the PhD Ultra will automatically return to the gas reading screen display.

3.5.2 Span calibration using keypad buttons

Span calibration procedures using buttons on the instrument keypad are most useful when calibration of only a single sensor is desired. Span calibration using the keypad buttons may only be done while in the Basic or Technician operating mode.

(1) Turn the instrument on.

(2) Slide the belt clip towards the rear of the instrument exposing the four buttons on the instrument keypad.

(3) Verify that the instrument is in the Basic or Technician operating mode. To change operating modes simultaneously hold down the "+" and"-" keys.

Each time that the operating mode is changed, the LCD screen will briefly indicate the current operating mode.

(4) Turn the instrument off by pressing the mode button for three full seconds until the "release button" message appears in the screen.

(5) With the unit turned off, press and hold down the "Cal" button.

(6) While holding down the "Cal" button, press the mode button to turn the PhD Ultra back on. The “Span Calibration” message will appear briefly on the screen. This message is followed by a screen showing the message “Cal = Span”.

```
Span Calibration
```

```
Cal   = Span
```

(7) Press the keypad button marked “Cal” to make a span adjustment. A screen will briefly display the message “Span Calibration; Mode = Cancel”.

```
SPAN CALIBRATION
Mode = Cancel
```

Press the mode button at any time to cancel the calibration mode.

The “Span Calibration” screen will be followed by another showing the first sensor to be adjusted.

```
SPAN CALIBRATION
    LEL = 0 %
```

(8) Attach the cylinder of calibration gas, regulator, short section of tubing and calibration adapter to the PhD Ultra as shown in **Figure 3.4.2.**

⚠**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: Make sure to use the calibration / sample draw adapter supplied with the hand aspirated sample draw assembly. Do not use the battery operated sample draw pump for this purpose.

(9) A Biosystems standard fixed flow regulator will automatically begin flowing gas at the correct flow rate as soon as it is fully screwed in. When the readings stabilize, use the "+" and "-" keys to raise or lower the readings to match the concentration printed on the calibration cylinder label.

(10) When the span calibration for a particular sensor is completed, advance to the next channel by pushing the "Cal" button.

(11) Make sure the correct cylinder of gas is attached before attempting to adjust the span! If the concentration of gas reaching the sensor is too low to allow the instrument to be adjusted, or if the wrong type of gas is applied to the sensor being adjusted, a screen will be displayed indicating that the span gas concentration is too low.

```
SPAN CALIBRATION
span gas too low
```

Verify that the flow rate of the regulator is 1.0 liters per minute. Replace the cylinder, or choose the correct sensor, and continue.

(12) When span calibration has been completed for all channels, press and hold the "Cal" button down until the information screen indicates that calibration is complete. The PhD Ultra will then turn itself off.

```
SPAN CALIBRATION
* * Complete * *
```

```
Begin SHUT DOWN
  Please Wait
```

Note: The "CAL" button must be held down until the screen indicates that span calibration has been successfully completed.

If the button is released before this message is displayed, span values will not be updated, and remain unchanged from the last time a span calibration was successfully completed.

Pressing the mode button at any time cancels the manual span calibration mode. A screen will announce "Span Calibration Unchanged". This will be followed by another announcing "Begin Shut Down, Please Wait". The instrument will then turn itself off.

```
Span Calibration
** Unchanged **
```

```
Begin SHUT DOWN
  Please Wait
```

Chapter 4 PhD Ultra Advanced Functions

4.1 PhD Ultra advanced features overview

PhD Ultra microprocessor circuitry makes a number of advanced features and capabilities possible. The four buttons located on the instrument keypad may be used to change alarm set-points, to change the kind or concentration of calibration gas used during auto-span calibration procedures, to assign an instrument ID number, or to make use of other PhD Ultra optional setup choices.

Use of keypad buttons to setup or reprogram the PhD Ultra is reserved for authorized personnel.

These techniques frequently require several buttons to be pressed and held at the same time.

Caution: Do not press any combination of buttons other than those listed below. Doing so may result in the loss of stored data in the PhD Ultra's datalogger memory.

4.2 Setting alarm levels

PhD Ultra gas alarms are user adjustable and may be set anywhere within the range of the sensor channel. When an alarm set point is exceeded a loud audible alarm sounds, and an individual bright red LED alarm light for each affected sensor blinks.

PhD Ultra alarms are normally self-resetting. Alarms cease as soon as readings drop below the alarm set point. It is possible, if desired, to set PhD Ultra alarms so that they "latch". When an alarm occurs with the alarms latched the visual and audible alarms will continue even after the atmospheric hazard has cleared. The instrument must be manually reset by pressing the mode button. Pressing the mode button silences the alarms and returns the instrument to normal operation.

Procedures for latching PhD Ultra alarms are given in Section 4.3.

4.2.1 Alarm adjustment sequence

Note: Factory default settings can be restored at any time during normal operation by using the procedures discussed in Section 4.2.2.

In many cases it is possible to comply with OSHA guidelines while using higher alarm points than those used by Biosystems. It is important to note that the default alarm point settings in the PhD Ultra are very conservative in order to maximize worker safety.

PhD Ultra default alarm setting are listed in Section 5 of Appendix B.

To enter the "Alarm Adjust" mode:

(1) Make sure the instrument is turned off.

(2) Slide the belt clip towards the rear of the instrument to expose the four buttons on the instrument keypad.

(3) While holding down the "Alarm" button, press the mode button to turn the PhD Ultra back on. The software version screen will be shown briefly. The screen will then show a number of screens to indicate that the instrument is loading sensor and instrument data.

```
Adjust Alarms
Loading Ins Data
```

Do not release the "Alarm" button until the "Adjust Alarms" message appears on the display screen.

```
Adjust Alarms
Mode = Cancel
```

This will be followed by a screen showing the first alarm point to be adjusted, which is typically the oxygen sensor alarm.

```
LO ALARM ADJUST
 O2 = 19.5 %
```

Note: Pressing the mode button at any time cancels the "Alarm Adjust" mode. The instrument will display a screen indicating "Adjust Alarms, Unchanged". This screen will be followed by another announcing "Begin Shut Down, Please Wait". The instrument will then turn itself off.

```
 Adjust Alarms
** Unchanged **
```

```
Begin SHUT DOWN
  Please Wait
```

(5) Press the "CAL" button to advance the display to the next available alarm adjustment option.

(6) When the desired alarm adjustment has been reached, use the "+" and "-" keys to raise or lower the alarm setting.

(7) When all alarm adjustments have been completed, press and hold the "Cal" button down until the screen advises you to "Release Button".

```
Release Button
Alarms Saved
```

An information screen will indicate when alarm adjustment is complete. This screen will be followed by another announcing "Begin Shut Down, Please Wait". The instrument will then turn itself off.

```
ADJUST ALARMS
* * COMPLETE * *
```

```
Begin SHUT DOWN
 Please Wait
```

4.2.2 Viewing current or restoring the factory default alarm settings

PhD Ultra alarm settings are set very conservatively at the factory. (**See Appendix B.**) Factory default settings may be restored at any time while the instrument is being operated in either Basic or Technician operating mode by doing the following:

(1) Turn the instrument on. Verify that the instrument is in Basic or Technician operating mode. Switch modes (if necessary) by simultaneously holding down the "+" and"-" keys. Each time that the operating mode is changed, the LCD screen will briefly indicate the current operating mode.

(2) Press the "ALM" button on the instrument key-pad. The display will briefly show the following screens:

```
   View/Set
    Alarms
```

```
ALARM SETTINGS
ADJUSTMENTS
```

These screens will be followed by two message screens that will cycle back and forth.

```
+ = View Default
Mode = Cancel
```

```
- = View Current
Mode = Cancel
```

4.2.2.1 Viewing current alarm settings

(1) Perform steps 1 and 2 above in section 4.2.2.

(2) Press "-" to view the current alarm settings. A screen will show the message "Current Alarm Settings". This screen will be followed by screens showing the specific alarm settings for each sensor that is currently recognized. These screens will be shown in continuous rotation. In the case of a PhD Ultra with combustible, oxygen, carbon monoxide, and hydrogen sulfide sensors installed, the following sequence of screens would be shown:

```
CURRENT ALARM
SETTINGS
```

Oxygen and combustible gas (LEL):

```
OXYGEN 19.5-22.0
LEL       10%
```

The ceiling alarm set-points for the toxic sensors currently installed:

```
CO  (CEIL) 35ppm
H2S (CEIL) 10ppm
```

The STEL and TWA alarm set points for the toxic sensor currently installed in toxic sensor position 1:

```
CO(STEL) 100 PPM
CO (TWA)  35 PPM
```

The STEL and TWA alarm set points for the toxic sensor currently installed in toxic sensor position 2:

```
H2S(STEL) 15 PPM
H2S (TWA) 10 PPM
```

The final screen in the sequence shows the message "Mode = Cancel". Pressing the mode button at any time returns the PhD Ultra to normal operation.

```

MODE = Cancel
```

4.2.2.2 Viewing or restoring factory default alarm settings

(1) Perform steps 1 and 2 above in section 4.2.2.

(2) Press "+" to view the factory default alarm settings for the sensors currently installed. A screen will show the message "Default Alarm Settings". This screen will be followed by several more showing the specific alarm settings for each type of sensor currently installed.

```
DEFAULT ALARM
SETTINGS
```

```
OXYGEN 19.5-22.0
LEL       10%
```

Etc.

The final screen in the sequence shows the message "Alarm = Defaults, Mode = Cancel".

```
ALARM = Defaults
MODE = Cancel
```

These screens will be shown in continuous rotation.

(3) Press the "ALM" button to restore the default alarms. The following screen will be shown:

```
DEFAULT SETTINGS
* * COMPLETE * *
```

(4) If the mode button is pushed, the current alarm settings will remain unchanged, and the display will show the following screen:

```
DEFAULT SETTINGS
 * UNCHANGED *
```

(5) After selection of the default or current alarm settings has been made, the PhD Ultra will return to normal operation and the display will revert to the current gas reading screen.

4.3 Instrument setup

The following options are controlled through the Instrument Setup mode:

Alarm latch
Security beep,
Toxic sensor decimal point,
Calibration gas settings
User ID number.

Each of these options is described in greater detail below.

To enter Instrument Setup mode:

(1) Make sure the instrument is turned off.

(2) Slide the belt clip towards the rear of the instrument to expose the four buttons on the instrument keypad.

(3) While holding down the "+" and "-" buttons, press the mode button to turn the PhD Ultra back on.

Do not release the "+" and "-" buttons until the "Instrument Setup" message appears on the display screen.

```
Instrument Setup
```

This will be followed by a series of screens showing the instrument serial number, current reminder setting, date and instrument ID number.

```
Serial No. 20409
Remind 30 days
```

```
22 MAY 2004
ID No. 5585
```

This screen will be followed by a screen showing the first instrument setup choices.

```
ALARM = Config.
CAL =Initialize
```

Note: Pressing the mode button at any time will return the instrument to normal operation. The instrument will display a screen indicating the setup is "Unchanged". This screen will be followed by another announcing "Begin Shut Down, Please Wait". The instrument will then turn itself off.

```
** Unchanged **
```

↓

```
Begin SHUT DOWN
  Please Wait
```

Press "ALM" to make configuration / setup choices.

4.3.1 Configuration setup choices

To enter the instrument configuration, follow steps 1-3 in section 4.3 above. Than press the ALM button.

The display will briefly show screens indicating the instrument is loading "Unit Setup" data from the currently installed sensors.

```
UNIT SETUP
Loading Tx1 Data
```

The screen will then display the first setup choice, which is the Tox1 Decimal point.

```
Tox1 decimal pt.
Disabled
```

Press the "CAL" button to advance the display to the next available setup option or press Mode to exit from the instrument setup screens.

4.3.2 Changing the precision of the toxic sensor read-out

The toxic decimal point settings will be the first screen shown after the PhD Ultra successfully loads the instrument configuration settings.

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

```
Tox1 decimal pt.
Disabled
```

Pressing the "+" button changes the setting. Pressing the "CAL" button advances to the second (Toxic 2) sensor channel.

4.3.3 Assigning an instrument identification number

To assign the instrument an ID number, first enter the configuration set up choices menu as described in section 4.3.1. Then press and release the "CAL" button to advance to the "ID Number" screen.

```
ID Number
 5585
```

Use the "+" and "-" keys to assign any five digit number between 1 and 25,000. Select "0" if no ID number is desired. Press the "CAL" button to move on to the next option.

Note: The instrument serial number is programmed into the PhD Ultra's memory and may not be changed. The instrument ID number may be set as needed by the user.

4.3.4"Alarm latch" command

To access the alarm latch settings, first enter the configuration set up choices menu as described in section 4.3.1. Then press and release the "CAL" button to advance to the "Alarm Latch" screen.

```
ALARM LATCH
DISABLED
```

PhD Ultra alarms are normally self-resetting, which means that the alarms cease as soon as reading drops below the alarm set point.

PhD Ultra alarms can be configured so that they "latch". In the latched condition, once an alarm occurs both visual and audible alarms continue to sound even after the atmospheric hazard has cleared. The instrument must be manually reset by pressing the mode button. Pressing the mode button silences the alarms and restores normal operation.

Press the "+" or "-" key to change the alarm latch setting.

4.3.5 OK Latch - Text Only mode

To access the OK latch settings, first enter the configuration set up choices menu as described in section 4.3.1. Then press and release the "CAL" button to advance to the "OK Latch" screen.

```
OK LATCH
DISABLED
```

If an alarm condition occurs and clears while the PhD Ultra is operated in text-only mode with the OK latch enabled, 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.

If an alarm condition occurs and clears while the PhD Ultra is operated in text-only mode with the OK latch disabled, the PhD Ultra will automatically return to the OK display for the sensor that was in alarm.

Use the "+" or "-" keys to change the "OK Latch" setting.

4.3.6 Security beep

To access the security beep settings, first enter the configuration set up choices menu as described in section 4.3.1. Then press and release the "CAL" button to advance to the "Security Beep" screen.

```
Security Beep
     OFF
```

The security beep screen allows the PhD Ultra to be programmed to emit an audible alarm "beep" on a specified interval while the instrument is in operation. This periodic beep serves as a reminder that the instrument is on.

Use the "+" and "-" buttons to turn the security beep on or off.

```
Security Beep
On 00:30 min:sec
```

Once the security beep is turned on the screen will show an additional indicator message showing the minutes and seconds between beeps. Use the "+" and "-" keys to set the interval. (Setting the interval to "0" will turn the security beep off.)

4.3.7 Low temperature alarms

To access the low temperature alarms settings, first enter the configuration set up choices menu as described in section 4.3.1. Then press and release the "CAL" button to advance to the "Low Temp Alarms" screen.

```
LOW TEMP ALARMS
ENABLED
```

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

Press the "+" or "-" key to change the setting.

4.3.8 Operating mode

To change the operating mode, first enter the configuration set up choices menu as described in section 4.3.1. Then press and release the "CAL" button to advance to the "Operating Mode" screen.

```
 Operating Mode
** Technician **
```

Use the "+" or "-" buttons to choose the operating mode of the instrument when next turned on in normal operation.

See section 2.2 above for a detailed description of operating modes and functions.

4.3.9 Combustible sensor setting

The PhD Ultra 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 PhD Ultra configured to read in terms of percent by volume of methane (CH_4), the LEL sensor must be calibrated to the actual percent by volume of methane used in Biosystems 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 of the cylinder body. For example, Biosystems 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%.

To change this setting do the following:

(1) Move to the "Instrument Setup" screen as described in section 4.3.1 and use the 'CAL' key

to scroll through the setup options until you reach the combustible sensor screen.

```
Combust. Sensor
XX% LEL
```

(2) Press the "+" or "-" keys to change the combustible from reading in LEL to reading in CH4.

```
Combust. Sensor
XX% LEL
```

```
Combust. Sensor
X.X% CH4
```

(3) Press and hold the "CAL" key to save changes.

Note: Once the combustible sensor reading has been changed to %CH4, it will appear as such in all modes until it is changed back to reading in LEL.

4.3.9.1 Calibrating the combustible sensor in CH_4 mode.

With the PhD Ultra configured in the volume % methane (CH_4) mode, the LEL sensor will also be calibrated to the actual volume percent methane used in Biosystems calibration gas cylinders, not the %LEL value given on the label. The actual volume % CH_4 will be stamped on the side on the cylinder body with indelible ink. For example, Biosystems popular all-in-one mix of 54-9044E, with 50% LEL propane equivalent will list 1.62% CH_4 on the cylinder body. For easy reference, the actual volume % CH_4 for the following Biosystems LEL component mixtures is listed in the following table.

LEL Component Description	Volume % Methane (CH_4)
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 volume percent methane for Biosystems calibration gas cylinders.

4.3.10 Calibration gas concentration

Calibration gas concentration values may be viewed and adjusted through the instrument set up screens.

⚠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 PhD Ultra. Non-matching calibration gas and calibration gas value settings will lead to inaccurate and potentially dangerous readings.

To adjust the calibration gas concentration:

(1) Move to the "Instrument Setup" screen as described in section 4.3.1 and use the 'CAL' key to scroll through the setup options until you reach the "Calibration Gas" screen

If an LEL combustible gas sensor has been installed, the LEL sensor's calibration gas concentrations will be the first shown.

```
Calibration Gas
LEL is  50.0 %
```

This screen indicates the concentration and type of test gas that will be used to calibrate the instrument. In the example above the screen indicates that "50 % LEL span gas" will be used.

(2) Use the "+" and "-" buttons to change the concentration of the gas that will be used.

⚠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 PhD Ultra. Non-matching calibration gas and calibration gas value settings will lead to inaccurate and potentially dangerous readings.

(3) Press the "CAL" button to advance to the calibration gas that will be used for the next sensor currently installed. Once again, use the "+" and "-" buttons to make a change in the concentration of the calibration gas that will be used.

```
Calibration Gas
 CO  50.0 ppm
```

(3) Press and hold the "CAL" key to save changes.

4.3.10.1 "CO Plus" sensor calibration gas screen

The "CO Plus" sensor may be calibrated to either hydrogen sulfide or carbon monoxide.

⚠WARNING Do not use multi-component calibration gas mixtures containing both carbon monoxide and hydrogen sulfide when calibrating a PhD Ultra with a CO Plus sensor installed. Calibration of the CO Plus sensor with multi-component calibration gas mixtures containing both CO and H_2S may lead to inaccurate and potentially dangerous readings.

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

⚠WARNING 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 direct reading requirement must be used in the calibration of the instrument. If carbon monoxide is chosen in the calibration gas setting option, 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 option, 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 and potentially dangerous readings.

If the instrument recognizes a "CO Plus" sensor, the display will show the "CO Plus Calibration Gas" screen.

```
CO Plus Cal Gas:
Carbon Monoxide
```

Use the "+" button to change the calibration gas setting for the "CO Plus" sensor.

```
CO Plus Cal Gas:
Hydrogen Sulfide
```

Once the appropriate calibration gas selected, press the "CAL" button to advance to the next screen showing the concentration of the gas chosen to calibrate the "CO Plus" sensor.

```
CO Plus Cal Gas:
H2S 25.0 ppm
```

Use the "+" and "-" buttons to change the concentration of the gas that will be used.

4.3.11 Temperature Compensation

The PhD Ultra includes built-in temperature compensation curves that allow the instrument to give more accurate readings across a broad range of operating temperatures. Temperature compensation may be enabled or disabled by the user as needed.

Note: The default setting for temperature compensation is enabled. Biosystems discourages disabling the PhD Ultra's temperature compensation.

(1) Move to the "Instrument Setup" screen as described in section 4.3.1 and use the 'CAL' key to scroll through the setup options until you reach the "O2 Temp Comp" screen.

```
O2   Temp Comp
Adjust DISABLED
```

(2) Use the "+" and "-" buttons to change the setting.

4.3.12 Saving changes and exiting the Instrument Setup mode

When the PhD Ultra is properly configured, press and hold the "CAL" button to save the changes. The PhD Ultra will instruct you to release the button after about 3 seconds.

```
Release Button
```

A screen will briefly announce that changes have been made and the instrument setup has been updated.

```
**  Completed **
```

```
Begin SHUT DOWN
  Please Wait
```

```
     Saving
Instrument Data
```

The PhD Ultra will then turn itself off.

Pressing mode button to cancel the changes and save the previous configuration.

```
** Unchanged **
```

4.4 Re-initializing the PhD Ultra

During production, all PhD Ultra detectors are initially setup or programmed with the same standard or "default" configuration (unless the purchaser requests otherwise). The default configuration may be restored at any time by using the following procedure.

CAUTION: Re-initialization will clear the datalogger memory and cause the instrument to revert to the default configuration. Verify that any information needed from the datalogger has been extracted prior to re-initializing the instrument. If custom alarm and setup choices are in use, remember to reset the alarm settings and optional setup choices immediately following the re-initialization.

⚠WARNING Following initialization, the PhD Ultra must be calibrated before being put back into service. Failure to calibrate the instrument following re-initialization may result in inaccurate and potentially dangerous readings.

To re-initialize the PhD Ultra:

(1) Make sure the instrument is turned off.

(2) Slide the belt clip towards the rear of the instrument exposing the four buttons on the instrument keypad.

(3) With the instrument turned off, simultaneously press and hold down the "+" and "-" buttons.

(4) While holding down the "+" and "-" buttons, press the mode button to turn the PhD Ultra back on.

Do not release the "+" and "-" buttons until the "Instrument Setup" message appears on the display screen.

```
Instrument Setup
```

The display will then show the release date of the software currently installed and the user-assigned instrument ID number.

```
22 MAY 2004
Serial no. 20409
```

This screen will be followed by a screen showing the first instrument setup choices.

```
ALARM = Config.
CAL =Initialize
```

Note: Pressing the mode button at any time cancels the Instrument Setup mode. The instrument will display a screen indicating setup "Unchanged". This screen will be followed by another announcing "Begin Shut Down, Please Wait". The instrument will then turn itself off.

```
** Unchanged **
```

```
Begin SHUT DOWN
  Please Wait
```

(5) Press "Cal" to begin the re-initialization sequence. The display will briefly show the "Initialization Warning" screen.

```
Warning! Initial
Setup Values
```

This screen will be followed by the "Initialization" screen. Press Mode to cancel the initialization or

```
MODE = Cancel
CAL = Initialize
```

Press Mode to cancel the initialization or press the "Cal" button to re-initialize the PhD Ultra. The screen will briefly show the message "Initializing".

```
Initializing
```

(7) The instrument will turn itself off when re-initialization is complete.

4.5 Record keeping

4.5.1 PhD Ultra datalogging overview

Whenever the PhD Ultra is turned on, the datalogger automatically records 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.

If a sensor is changed or replaced, the PhD Ultra notes 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 PhD Ultra will still note the change in serial numbers of the sensors installed, and display the "Needs Cal" message.

The PhD Ultra can store the exposure values for up to 3,600 data intervals. This is enough for the storage of up to 60 hours of four gas monitoring broken into as many as 45 individual monitoring "sessions" when a one minute logging interval is specified. Using a longer datalogging interval increases the length of monitoring time for which data may be stored. For instance, if a datalogging interval of two minutes is selected 120 hours of monitoring data may be stored.

Datalogging is a "transparent" function that is continually in operation. As long as the datalogger has not been disabled, the instrument will begin recording data as soon as the instrument is turned on. The information stored by the datalogger may be downloaded to a Windows-compatible PC to create a permanent record, or directly displayed by the PhD Ultra.

4.5.2 Optional Datalink and Gas Detection Database Software Kit

Biosystems optional "Datalink" kits allows two-way communication between your PhD Ultra and an IBM compatible personal computer. Two kits are available: The "Datalink Software Kit" (part number 54-05-K0201) includes software, interface cable and reference manual. The "Datalink Kit" (part number 54-05-K0203) includes software, interface cable and reference manual as well as a "Datadock" fast charger / computer interface cradle.

Datalink software serves two basic functions: getting stored information out of the instrument and into your computer, and using files stored in your computer to setup or "program" your PhD Ultra.

It is important to note that it is not necessary to use the Datalink software to program your instrument. Configuration and setup options may be programmed directly by using the built-in buttons on the instrument keypad.

On the other hand, Datalink software has been designed to make programming, downloading, and data analysis as easy as pushing a button. The software allows optional instrument setups to be created by filling out forms right on the computer screen.

Most functions (such as downloading stored information from the instrument to your PC, or uploading configuration setup files from your PC to the instrument) are automatic.

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 through the computer monitor screen, or used to automatically 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 a spreadsheet format. Another option is to simply retain the downloaded records for later use.

Note: The material in this section is primarily designed to acquaint our customers with

"manual" PhD Ultra setup and download procedures. Consult the Datalink Reference Manual for complete instructions in the use of Datalink software.

4.5.3 Adjusting record keeping parameters

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

4.5.3.1 Entering the Datalogging Adjust mode

Turn on the PhD Ultra while holding down the "+" button. (The unit must be in the Technician mode prior to being turned on.) The Datalog Adjust screen will briefly appear followed by a screen with further instructions.

```
Datalog Adjust
```

↓

```
Cal  = Next Scrn
Mode = Exit
```

Press the Cal key to scroll through the adjustments that are available. The sample interval adjustment screen will be the first shown.

```
Interval   1:00
Duration    60hr
```

4.5.3.2 Adjusting the sampling interval

Whenever the PhD Ultra is turned on it immediately begins to monitor, calculate, and log exposure levels for the atmospheric hazards it is set up to detect.

The datalogger samples continuously, so the data stream must be broken into discreet intervals to be recorded. The datalogging interval defines the frequency of the breaks in the data stream. The interval may be set anywhere between one second and one hour as described below. The default datalogging interval is 1 minute.

There is a finite amount of memory storage available in the PhD Ultra. Once the memory is "full", the PhD Ultra will begin to write the new data over the oldest data. In this way, the newest data is always conserved. Different sensor configurations and/or datalogging intervals may increase or decrease the length of time before old data is overwritten. A longer sampling interval will allow the retention of more hours of data before old data is overwritten making the PhD Ultra ideal for long-term sampling projects.

Note: Calculations that are made on an ongoing basis (i.e. TWA, STEL, Ceilings, and Peak exposure values) are updated at regular intervals by the PhD Ultra microprocessor. Adjustments to the datalogging interval do not effect the way in which TWA, STEL, Ceiling, and Peak exposure values are calculated.

To modify the datalogger interval, first enter the datalogging adjust mode as described in section 4.5.3.1. Once the interval adjustment screen is reached, use the "+" and "-" keys to adjust the interval to any value between one second and one hour. The PhD Ultra is capable of logging 3600 points of data. The "Duration" indicates the number of hours at the current interval setting before the oldest data will be overwritten by new data. For instance, using the default datalogger interval setting of 1 minute will allow 60 hours of data to be recorded before the PhD Ultra memory is full. If an interval value of 30 seconds is selected, the duration will be cut in half, and the memory will be filled in 30 hours as shown below:

```
Interval   0:30
Duration    30hr
```

Once the memory is "full", the PhD Ultra will begin to write the new data over the oldest data. In the example above, that means that new data will start replacing old data after 30 hours of monitoring.

Selecting a longer sampling interval will allow more data to be retained before the oldest data is overwritten. If an interval of 15 minutes is selected, the detector is able to log 900 hours of monitoring data, making the PhD Ultra ideal for long-term sampling projects.

If datalogging is not desired, reduce the interval setting to :00:00 to deactivate the datalogger.

```
Datalogger OFF
```

To quit and save the new settings press and hold the "CAL" button. Release the "CAL" button when the instrument instructs you to release it. The screen will then show that the datalogger adjustments have been saved. Pressing the mode button at any point in the procedure will return the settings to their former levels. To proceed to other adjustments, press and release the "CAL" button at any time.

4.5.3.3 Setting the time and date

To access the time and date settings, first enter the datalogger adjust mode as discussed in section 4.5.3.1. Then press and release the Cal button twice to reach the time and date settings. The Time and Date Screen accesses the PhD Ultra's internal real-time clock and calendar date. A cursor will highlight the value to be adjusted. Pressing the "+" and "-" buttons will change the value. Pressing the "Alarm" button will advance the cursor to the next unit.

```
Time 11:50
Date 22 MAY 04
```

To quit and save the new settings press and hold the “CAL” button. Release the “CAL” button when the instrument instructs you to release it. The screen will then show that the datalogger adjustments have been saved. Pressing the mode button at any point in the procedure will return the settings to their former levels. To proceed to other adjustments, press and release the “CAL” button at any time.

4.5.3.4 Setting the communication rate

To access the communications rate settings, first enter the datalogger adjust mode as discussed in section 4.5.3.1. Then press and release the Cal button three times to reach the communications rate settings. This screen is used to set the speed or “Baud rate” at which the PhD Ultra sends information to your personal computer or printer. There are two communication rate settings, “Turbo” (38,200 Baud) or “Standard” (9,600 Baud).

Most personal computers are able to transmit and receive at the higher rate. Since communication at the slower rate requires a greater amount of time to download the same amount of data, the “Turbo” rate should normally be selected.

If the PC is unable to establish communication with the PhD Ultra at the higher communication rate, the software is designed to “time out” the attempt, and display a message on the computer monitor indicating that the software is “unable to communicate with instrument”.

Note: At least one additional attempt to download data should be made before making a decision to modify the communication rate. Check all connections before making a second attempt.

Selecting the “Standard” rate allows successful communication with nearly all personal computers. Pressing the “+” and “-” toggles the communication rate setting between turbo and standard.

```
COMMUNICATION
Rate = Turbo
```

↓↑

```
COMMUNICATION
Rate = Standard
```

Note: Both the PhD Ultra *and* the Datalink software must be modified when a change is made to the communication rate.

If the instrument is set to one rate while the software is set to the other, proper communication will not be possible. The software communication rate setting can be modified through the “PC Setup” screen as discussed in the PhD Ultra Datalink manual.

To quit and save the new settings press and hold the “CAL” button. Release the “CAL” button when the instrument instructs you to release it. The screen will then show that the datalogger adjustments have been saved. Pressing the mode button at any point in the procedure will return the settings to their former levels. To proceed to other adjustments, press and release the “CAL” button at any time.

4.5.3.5 Clear datalogger memory via push-buttons

To clear the datalogger memory, first enter the datalogger adjust mode as discussed in section 4.5.3.1. Then press and release the CAL button until the following screen is shown:

```
Alarm=ERASE DATA
Mode = Exit
```

The PhD Ultra can store the monitoring results for up to 3,600 data intervals in instrument memory at any time. When monitoring data is downloaded to a personal computer, the entire contents of the memory are transmitted. That means the amount of time required for downloading is dependent on the amount of recorded information in the instrument memory. Once monitoring data has been successfully downloaded to the PC, there is usually no reason to retain it in instrument memory.

Caution: Make sure that any session information that will be needed later is safely downloaded and stored prior to clearing the instrument memory. Once session data has been cleared from the datalogger memory, it will no longer be retrievable.

Press the “Alarm” button to erase data. The instrument will display a screen asking you to confirm that you wish to proceed.

```
To Confirm
Press +
```

Press the “+” button to proceed with clearing the datalogger. The instrument will display a screen indicating that the instrument is erasing monitoring records.

```
 * Datalogger *
ERASING RECORDS
```

A screen will announce when the datalogger has been erased.

```
 * Datalogger *
 *** Erased ***
```

Note: This procedure only clears data recorded during monitoring sessions. Alarm settings, calibration adjustments, user names and locations and feature settings are not affected by this procedure.

4.5.3.6 Exiting the Datalogging Adjust mode

When the PhD Ultra is properly configured, press and hold the CAL button to save the changes. You will be instructed to release the CAL button.

```
Release Button
```

A screen will briefly announce that changes have been made and the configuration updated. The PhD Ultra will then shut itself down.

```
Datalogger
Adjustment Saved
```

```
Begin SHUT DOWN
  Please Wait
```

To exit from the datalogger configuration screens without making or accepting any changes, press the mode button at any time.

```
   Datalogger
** Unchanged **
```

4.5.4 Downloading recorded data

PhD Ultra record keeping capabilities are most useful when used together with Biosystems' PC Based "Datalink" Gas Detector Database Software.

Although downloading the recorded data to a computer file offers the most complete way to examine the data, it is not necessary to interface the instrument with a computer in order to review the data through the LCD or download directly to a serial printer. Reviewing recorded data directly through the instrument display screen allows the user to answer two very important questions:

(1) Were my workers using their instruments?

(2) Did the atmosphere have any problems?

4.5.4.1 Viewing data

The Record Keeping Data Transfer mode is entered by turning the PhD Ultra on while holding down the "-" key. The unit must be in the Technician mode prior to being turned on to access record keeping. **Change modes if necessary as discussed in Section 2.2.4.**

The Record Keeping Data Transfer screen will be shown followed briefly.

```
Datalogger
View/Transfer
```

After a few seconds, the following screen will be shown:

```
 + = To Screen
```

Press the + button to view data. The display will briefly shows the following screen.

```
+/-=Next Session
CAL = View Data
```

Press "+" to view the most recent monitoring session. Press "-" to view the oldest monitoring session in the datalogger memory. After a few seconds, the PhD Ultra will automatically show the most recent monitoring session.

```
#1    14:46-14:52
      20 MAY 04
```

The numbers in this screen signify the session number (1), the time the session was started and completed, (14:46 - 14:52), and the date of the monitoring session (May 20, 2004). If a location has been entered, it will also be shown.

Use the "+" and "-" keys to select the appropriate session, then press the "CAL" button to view the readings from session "1".

The instrument will automatically cycle between two peak reading screens, one for oxygen, and one for the other gases being measured. The oxygen peak reading screen shows both the high (HI) and low (LO) readings.

```
PEAK    LO    HI
 O2   20.6  20.9
```

↓

```
PEAK   LEL CO H2S
         0  0   0
```

Following the peak readings screen for the LEL and toxic sensors, the PhD Ultra will show the following screen:

```
CAL = View
List of Sessions
```

Press "CAL" to return to the list of monitoring sessions.

Press the mode button at any time to exit the Data Transfer / Record Keeping mode and turn the PhD Ultra off.

4.5.5 Entering user ID and monitoring location identification number

It is possible to assign alphanumeric identification codes of up to 13 characters each to specify the user or location name for the monitoring sessions. This information is automatically added to all downloaded records and reports for the session.

It is possible to enter up to 10 users and up to 15 locations in the instrument memory by using Biosystems' Datalink software to upload the lists from a personal computer. It is also possible to modify the current user name and monitoring location directly through use of buttons on the instrument keypad.

Once the lists are in the instrument memory it is possible to "scroll" through the available choices and either pick the appropriate name and location from the list. New information may also be entered, but will not be retained in the location or user list for future use.

This ID feature is available for use while the instrument is operated in any of the normal operating modes (Text Only, Basic, or Technician).

Note: Datalink software versions 1.35 and lower do not support all location / user ID features. Contact Biosystems to obtain updated software.

Press the "+" key while monitoring in the normal gas reading screen to review or modify user or location ID. The PhD Ultra will briefly display the "Set User / Location" screen.

```
Location/User ID
      Set
```

This instrument will then alternate between the following two screens:

```
 - = List Set
 MODE = Cancel
```

↓↑

```
 + = Custom Set
 MODE = Cancel
```

The "List Set" choice is used to choose from names and locations already in the instrument memory. The "Custom Set" choice is used to modify the "current" user ID or location information.

4.5.5.1 List Set: Select user / location information from the list

Press the "–" key to display the list of the users currently in the instrument memory. The first screen will show the name that the instrument has identified as the current user on the top row, with the name of the first user on the list in the instrument memory on the second row.

```
ID = Jeff Emond
 1   H. Anderson
```

The "+" and "–" keys are used to scroll through the list. Up to 10 names may be stored at any time.

```
ID = Jeff Emond
 4 Robert Burt
```

When the correct user ID is shown on the bottom row, press the "ALM" button to make it the current user. The new current user name will be displayed on the top row.

```
ID = Robert Burt
 4 Robert Burt
```

Once the user ID is set, press the mode button to display the list of locations currently in the instrument memory. The first screen will show the current monitoring location on the top row, with the name of the first location on the list in the instrument memory on the second row.

```
ID = Furnace Pit
 1 Oxygen Tank
```

The "+" and "–" keys are used to scroll through the list. Up to 15 locations may be stored at any time.

```
ID = Furnace Pit
14 Boiler
```

When the correct location ID is shown on the bottom row, press the "ALM" button to make it the current location. The new current location name will be displayed on the top row.

```
ID = Boiler
14 Boiler
```

Press the mode button to accept the current location ID and return to normal operation.

4.5.5.2 Custom Set: Enter new or modify user / location information

Follow the instructions above in section 4.5.5. Then press the "+" key. The PhD Ultra will briefly display the "User ID Set" before moving on to the current user screen.

```
 User ID Set
```

If a user has been assigned, the user's name will be shown. If a use has not been assigned, the space after "ID=" will be blank.

```
ID=LARS B
    ^
```

or

```
ID=
    ^
```

The arrow on the bottom line indicates the position of the cursor. The "+" and "-" keys are used to scroll through the letters and numbers. Press the "+" key once and the letter A will be shown.

```
ID=A
   ^
```

Continue to use the "+"and "-" keys until the appropriate letter or number is shown.

```
ID=P
   ^
```

Once the appropriate letter is shown, press the "ALM" button to move to the next letter to the right. The cursor will move right by one position. To move the cursor left by one position, press the 'CAL" button.

```
ID=P
    ^
```

Continue entering the letters until the new name is shown.

```
ID=PAUL G
```

Press the mode button at any time to move on to the location screens.

```
Location Set
```

If a location has not been assigned, the screen will be blank other than showing "ID="

```
ID=
  ^
```
or
```
ID=MIDDLETOWN
  ^
```

Follow the directions above for the user name and enter the location name. Once the location has been entered, press the mode button to save the monitoring location and return to normal operation.

Note: Only the current user name and monitoring location can be modified through the instrument keypad. Modification of the user name and location lists in instrument memory requires use of Biosystems' Datalink Software and connection with a personal computer as discussed in the PhD Ultra Datalink Manual.

4.5.6 Downloading recorded data to a computer

PhD Ultra record keeping capabilities are most useful when used together with Biosystems Datalink Gas Detector Database Software for use with IBM compatible Personal Computers. To download data to a personal computer:

(1) Make sure the PhD Ultra is turned off.

(2) Connect the PhD Ultra Datadock RS-232 cable to an available COM port on your computer.

(3) Slip the PhD Ultra into the Datadock.

(4) Load Biosystems PhD Ultra Datalink software on your personal computer.

(5) Choose "Retrieve Data from Instrument" from the "Datalogger" menu.

(6) The Datalink software will automatically "wake up" the PhD Ultra, and initiate data transfer.

(7) When downloading is complete the PhD Ultra will shut itself back off.

Consult the Datalink Owner's Manual for instructions on how to review, store and export data, generate reports, or make use of other advanced features for the examination and storage of data.

4.5.7 Display "Service Due" dates

PhD Ultra Datalink software may be used to assign an optional "Service Due" date for each sensor. Any time after this date is passed a "Service Due" message will be displayed whenever the instrument is first turned on. Pressing the mode button acknowledges the message and allows normal operation. The message will continue to be displayed each time the instrument is turned on until a new service due date is assigned. Since this information is stored directly with the sensor EEPROM, a service due alarm will be activated even if the sensor is removed from one instrument and installed in another.

Service due dates may be reviewed either via Datalink software or by using buttons on the instrument keypad to display the dates directly on the instrument LCD.

Note: It is not possible to assign a new service due date through the instrument keypad. Changing or assigning a new service due date may only by done via personal computer and PhD Ultra Datalink software.

Service due dates may be reviewed by pressing the "-" button at any time while the instrument is being used in a normal operating mode. A screen will indicate as the instrument begins to display the assigned dates.

```
SENSOR SERVICE
EXPIRATION DATES
```

This screen will be followed others showing the assigned service due date for each sensor currently installed. These screens will continue to be shown in rotation.

```
Next O2 Service
Due on 01 JAN 04
```

↓

```
Next LEL Service
Due on 01 JAN 04
```

↓

etc.

If no service due date has been assigned, the screen will indicate that the warning has been disabled.

```
Next O2 Service
DISABLED
```

Pressing the mode button at any time returns the instrument to normal operation.

4.6 Passcode Overview

The PhD Ultra has an option that when enabled, requires that a passcode be entered before any of the advanced features or the automatic span calibration can be activated. This passcode is a 4 digit number which can be set to any number from "0 0 0 1" to "9 9 9 9".

To enter passcode options, turn the PhD Ultra on while holding down both the "+" and "ALM" buttons. When you hear an audible beep from the alarm let go of the "+" and "ALM" buttons. The Setup Passcode screen will be shown briefly followed by the Enter Passcode screen.

```
**  Setup     **
**  Passcode  **
```

```
 Enter Passcode
    0 0 0 0
```

To continue in the passcode setup option, enter the passcode. If this is the first time entering the passcode option or the passcode has been saved as "0 0 0 0", press CAL to move on to the next screen. Otherwise, enter the passcode by using the "+" and "-" buttons to adjust the digit in each place. The "ALM" button is used to move from place to place. The digit which is blinking is the number which can be modified with the "+" or "-" button.

```
Enter Passcode
   6 4 5 7
```

Once the passcode has been entered, press the "CAL" button. The display will toggle back and forth between the following screens.

```
   PassCode
CAL= Code On/Off
```

```
   PassCode
ALM= Change Code
```

4.6.1.1 Changing the passcode

First enter passcode options as described above in section 4.6. Once the PassCode options are shown, press ALM. The Enter New Code screen will be shown.

```
Enter New Code
   0 0 0 0
```

Enter the new passcode by using the "+" and "-" buttons to adjust the digit in each place. The "ALM" button is used to move from place to place. The digit which is blinking is the number which can be modified with the "+" or "-" button.

```
Enter New Code
   6 4 5 7
```

Once the passcode has been entered, press CAL. The instrument will prompt you to verify the new passcode by entering it a second time.

```
Verify New Code
   0 0 0 0
```

Enter the new passcode.

```
Verify New Code
   6 4 5 7
```

Press the "CAL" button to accept. A screen will quickly appear stating that the new passcode has been saved.

```
New PassCode
   Saved
```

4.6.1.2 Enable/disable the passcode

To enable or disable the passcode option, first enter passcode options as described above in section 4.6. Once the PassCode options are shown, press "CAL". The following screen will appear displaying the current status of the passcode option.

```
PassCode
Enabled
```

To disable the passcode option press the "-" button.

```
PassCode
Disabled
```

To enable the passcode option press the "+" button.

Press the "CAL" button to save the new setting. Press the mode button to cancel. If the mode button is pressed then a screen will be displayed which states "Code Setting Unchanged" the instrument will then shutdown.

4.7 Software / Flash Upload

For instruments with software versions greater than 3.40, the instrument software in the PhD Ultra may be updated at any time. New software will be available through the biosystems website at http://www.biosystems.com.

Once the new software is downloaded from the Internet, it must then be uploaded into the instrument through the PhD Ultra Datadock.

Note: Instruments with software prior to version 3.40 must be returned to Biosystems for the software upgrade. Once the instrument is updated with a version greater than version 3.39, it may then be updated as discussed below.

CAUTION The PhD Ultra's datalogger memory will be wiped clean when the new software is uploaded. Be sure to download any instrument data that you may need in the future prior to uploading the new flash.

The Flash download is a two-step download process that will prepare your PC to update the flash program of your PhD Ultra. To install the files:

1. Close all applications (except the internet connection) that are currently running on your computer.
2. Go to www.biosystems.com and select the Technical Information icon from the entry screen.
3. Click on Software Downloads.
4. Select PhD Ultra.
5. Follow the directions given on the screen to download the flash utility program and then the flash file itself.

Chapter 5 Trouble-shooting and repair

Repair procedures may only be performed by authorized personnel!

5.1 Changing PhD Ultra sensors

The PhD Ultra is designed to recognize the "Smart Sensors" that are currently installed. Once a sensor is recognized, the instrument automatically sets itself up with the appropriate alarm settings for the sensor. The instrument automatically notices 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 PhD Ultra must be recalibrated before being returned to service following any sensor change.

The PhD Ultra must be turned off prior to removing or replacing sensors. A Phillips screwdriver is used to remove the three screws securing the sensor cover to the PhD Ultra case.

To replace a sensor:

(1) Make sure the PhD Ultra is turned off.

(2) Remove the three philips screws from the sensor cover and remove the sensor cover.

For replacement of existing sensors perform steps A3 and A4.

(A3) From the outer surface of the sensor cover gently push out, with a flat blade screwdriver, the metal screen, gasket/spacer, filter/snap ring assembly in the position above the sensor(s) to be replaced and discard it. The metal screen is not to be reused and its absence will not affect performance.

(A4) Remove any remaining traces of adhesive from the recessed hole in the sensor cover. Then proceed to step C5 or D5 depending on the sensor type.

For first time sensor installation perform steps B3 and B4.

(B3) From the outer surface of the sensor cover, push out yellow dust cap with a blunt tool.

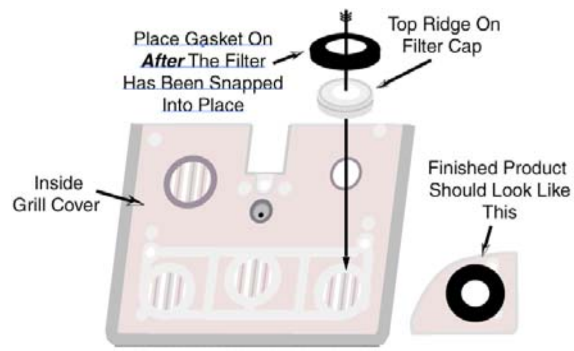
(B4) Remove sensor blank from the sensor compartment. Then proceed to step C5 or D5 depending on the sensor type.

For Sensors O_2, LEL, CO, CO Plus, H_2S, NO perform step C5

(C5) Place the new filter/snap ring assembly, with ridge side up, onto the recessed hole in the sensor cover. Firmly press into place. Then peel the backing paper from the new rubber gasket and place, adhesive side down, centered over the newly mounted filter/snap ring assembly. Now proceed to step 6.

For Reactive Gas Sensors: SO_2, NO_2, PH_3, HCN, Cl_2, ClO_2 perform step D5.

(D5) Place the new teflon spacer onto the recessed hole in the sensor cover. Firmly press into place. For optimal sensor response, there is no sensor cover-mounted, external filter element used with these sensors. Now proceed to step 6.



(6) Press the replacement sensor into place.

(7) Replace the sensor cap.

(8) The new sensor must be allowed to stabilize prior to use. The following chart gives a breakdown by sensor type with the required stability period for current PhD Ultra 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 NiCad unit, it may be placed in a powered charger for the duration of the stabilization period.

Sensor	Stabilization Period
Oxygen (54-04-90)	1 hour
LEL (54-04-80)	5 minutes
All PhD Ultra toxic sensors except those shown below	15 minutes
54-04-04 NH_3 Sensor 54-04-06 NO Sensor	24 hours

9. The PhD Ultra will automatically recognize the changes that have been made upon turn on and display the "Warning Needs Cal" message.
10. Recalibrate the PhD Ultra with calibration gas appropriate for the new sensor before the instrument is put back into service.

PhD Ultra programming includes safeguards to recognize maladjusted sensors. If the settings on the new sensor are significantly different from those of the old 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 procedure, 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 3.5 of this manual.

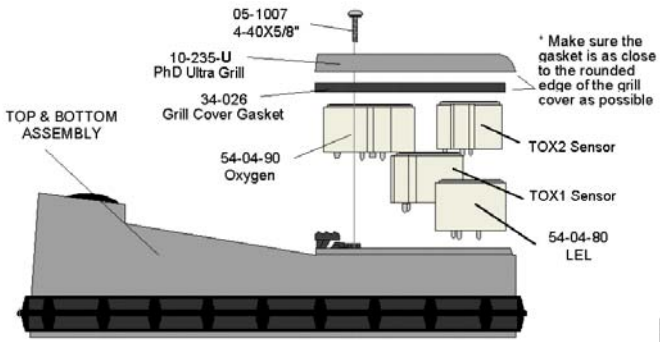


Figure 5.1.1. PhD Ultra sensor compartment cover and sensors

5.2 Troubleshooting

There are a few troubleshooting and repair procedures that can be done in the field.

5.2.1 Re-booting the microprocessor software

Occasionally it may be necessary to re-boot or "cold start" the PhD Ultra microprocessor software. Disconnecting the battery, static discharge, or use of keypad push-buttons in unauthorized combinations may occasionally cause the microprocessor to lockup or "crash". In this event it may be necessary re-boot the microprocessor before the PhD Ultra can be turned back on and put back into normal operation.

The most significant symptom of a microprocessor lock-up is the inability to turn the instrument back on in the normal manner. The inability to turn the instrument on may also result from a dead battery.

Make sure the NiCad battery is recharged, or the alkaline batteries are replaced before attempting to re-boot.

To re-boot the microprocessor:

(1) Remove the snap-in battery pack. (Make sure to pull the battery pack completely free from the instrument.)

(2) Replace the battery pack.

(3) If the re-boot procedure has been successful, the instrument should resume normal operation.

If the re-boot is unsuccessful and the instrument is a NiCad model, try the procedure again while the instrument is connected to a 110 VAC power source through the battery charger.

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

The PhD Ultra is Classified by Underwriters Laboratories, Inc., the Canadian Standards Association, and European Community Certification as to Intrinsic Safety for use in Hazardous Locations Class I, Groups A, B, C, and D. This classification is void while the PhD Ultra is operated while connected to the battery charger in hazardous areas.

5.2.2 Specific problems

5.2.2.1 Problem: Unit will not turn on

Possible causes:

Battery discharged, microprocessor / software malfunction.

Solution(s):

Take the instrument to a non-hazardous location. If equipped with an alkaline battery pack replace the batteries and attempt to turn on. If equipped with a rechargeable NiCad battery pack, plug the PhD Ultra into the battery charger for several minutes. With the instrument still connected to the battery charger, attempt to turn the detector on. If this works, the battery needs to be recharged or replaced.

If the instrument still fails to turn on, re-boot the microprocessor using the procedures discussed in Section 5.2.1. If the instrument still fails to turn on, return to factory for repair.

5.2.2.2 Problem: Unit will not turn off

Possible causes:

Software malfunction, low or bad battery, faulty on / off mode switch.

Solution(s):

Hold mode button down for thirty seconds. This should turn the instrument off. **Take the instrument to a non-hazardous location.** If equipped with an alkaline battery pack replace the batteries and attempt to turn the instrument back on. If equipped with a NiCad battery pack plug the PhD Ultra into the battery charger for several minutes. With the instrument still connected to the battery charger, attempt to turn the detector on. If this works, the battery needs to be recharged or replaced. If the instrument still fails to turn on, re-boot the microprocessor using the procedures discussed in Section 5.2.1. If the instrument still fails to turn on, return to factory for repair.

5.2.2.3 Problem: Sensor readings unstable in a known fresh air environment

Possible causes:

Loose connection, bad sensor, improper calibration, calibration gas has expired.

Solution(s):

Check that the sensor is firmly in place. Check calibration gas dating. Recalibrate sensor. Replace sensor if necessary.

5.2.2.4 Problem: "X" appears in place of reading for sensor

Possible causes:

Sensor failure. Loose connection.

Solution(s):

Check to see sensor is firmly in place. Recalibrate. Replace sensor if necessary.

5.2.2.5 Problem: Display is blank

Possible causes:

Battery voltage is too low. Operating temperature is too low. Bad LCD display assembly. Microprocessor locked-up or "crashed".

Solution(s):

Take the instrument to a non-hazardous location. If cold, allow instrument to warm up to room temperature. If equipped with an alkaline battery pack replace the batteries and attempt to turn the instrument back on. If equipped with a NiCad battery pack plug the PhD Ultra into the battery charger for several minutes. With the instrument still connected to the battery charger, attempt to turn the detector on. If this works, the battery needs to be recharged or replaced. If the instrument still fails to turn on, re-boot the microprocessor using the procedures discussed in Section 5.2.1. If the instrument still fails to turn on, return to factory for repair.

5.2.2.6 Problem: No audible alarm

Possible causes:

Loose connection, alarm failure.

Solution(s):

Return to factory for repair.

5.2.2.7 Problem: Keypad buttons (+,-, Cal, Alarm) don't work

Possible causes:

Not in Basic or Technician mode, microprocessor locked-up or "crashed", loose connection, switch failure.

Solution(s)

Switch to Technician operating mode. Take the instrument to a non-hazardous location. If equipped with an alkaline battery pack replace the batteries and attempt to turn the instrument back on. If equipped with a NiCad battery pack plug the PhD Ultra into the battery charger for several minutes. With the instrument still connected to the battery charger, attempt to turn the detector on. If this works, the battery needs to be recharged or replaced. If the instrument still fails to turn on, re-boot the microprocessor using the procedures discussed in Section 5.2.1. If keypad buttons still fail to function, return to factory for repair.

5.2.2.8 Problem: Can't make a "One Button" auto zero adjustment (LCD shows "Too High" or "Too Low" for zero adjust)

Possible causes:

The atmosphere in which the instrument is located is contaminated (or was contaminated at the time the instrument was last zeroed); instrument is still attached to calibration fittings; a new sensor has just been installed; instrument has been dropped or banged since last turned on.

Solution(s):

Remove any calibration gas fittings, take the instrument to fresh air and allow readings to stabilize. Perform a manual fresh air zero adjustment using buttons on the instrument keypad as discussed in Section 3.5.1.

5.3 Changing the PhD Ultra microprocessor PROM chip

The PhD Ultra is a microprocessor-controlled design. A Programmable Read Only Memory (PROM) chip located on the main circuit board is used to program the instrument. New microprocessor software versions are installed by removing the old PROM chip, and replacing it with the newer version.

Note: PROM chip replacement requires opening the instrument and removing an electronic component located on the main circuit board of the detector. This procedure should not be done by unauthorized persons. In many cases it may be better to return the detector to the factory for this procedure.

To replace the PhD Ultra PROM chip:

(1) Make sure that the PhD Ultra is turned off.

(2) Remove the battery pack.

(3) Remove the sensor grill cover by removing the three screws on the front of the instrument to access the sensor compartment.

(4) Gently pull all of the sensors out of their sockets.

(5) Remove the 6 screws holding the instrument case together as shown in **Figure 5.3.1** and separate the two halves of the case. (Be careful to note which screws are equipped with O-rings, and which are used to secure the weather cover snaps.)

(6) Carefully remove the main circuit board and liquid crystal display assembly from the instrument housing.

(7) Disconnect the three-wire plug that connects the main board to the audible alarm.

(8) Turn the main circuit board over to locate the PROM chip in its socket. Note the exact orientation of the chip in the socket.

Note: The PROM chip is located on the same side of the main circuit board as the four light emitting diodes (LEDs) and LCD ribbon connector. The PROM is located in a socket near the upper right hand corner of the board as shown in Figure 5.3.2. The reference designator (an electronic component indicator number printed on the main circuit board) is "U23".

(9) Use the chip extraction tool supplied with the replacement PROM to remove the old PROM chip. (It is usually best to gently rock the tool back and forth to loosen the PROM from the socket rather than pulling it straight out.)

Note: Biosystems strongly recommends use of a PROM removal tool or "chip puller" to remove the old PROM. A chip puller should have been supplied with your replacement PROM. Do not use small screwdrivers or other non-recommended devices to remove the old PROM! Use of non-recommended devices can easily cause damage to the PROM socket.

Chip pullers are readily available from most local electronic supply stores or may be obtained directly from Biosystems.

(10) Insert the new PROM chip into the socket. Be careful to properly align the flat corner of the chip with the flat corner of the PROM socket.

(11) Reinstall the main board. Make sure the ribbon cable connecting the main board to the meter display board and the audible alarm connector are properly attached.

Be careful not to crimp any wires as the main board is reattached.

(12) Reassemble the case, being careful the protective gasket is properly positioned between the two sections of the instrument case. Make sure that all screws, snaps, and O-rings are properly positioned.

(13) Replace the battery pack.

(14) Re-initialize the PhD Ultra as discussed in Section 4.4 of this manual.

(15) Verify that all configuration, alarm and service due settings are correct.

(14) Calibrate the instrument before returning to service!

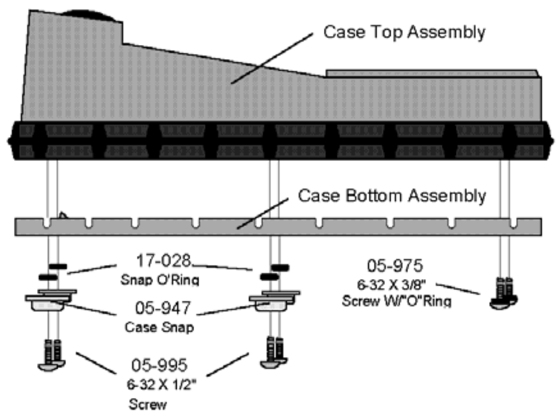
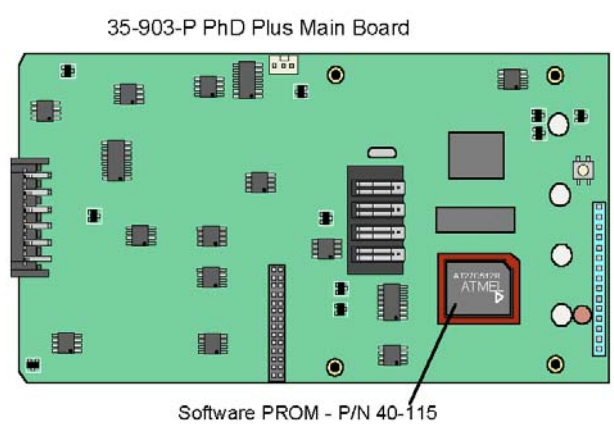


Figure 5.3.1. PhD Ultra upper and lower case assembly



5.3.2. PhD Ultra main circuit board (showing placement of software PROM)

5.4 Motorized pump maintenance

Use of the optional motorized sample draw pump (part number 54-05-A0101) allows the PhD Ultra to continuously monitor remote locations. The slip-on pump obtains power directly from the PhD Ultra battery, and runs continuously as long as the instrument is turned on. The instrument constantly monitors the pump for proper performance. (A flashing "P" indicator is the upper left corner of the

LCD display indicates that the pump is attached and in normal operation.)

The sample draw pump includes a unique pressure sensor designed to protect the PhD Ultra 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: **Never perform remote sampling with the PhD Ultra 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, contaminants may cause damage to the pump, sensors and internal components of the PhD Ultra.**

Procedures for proper use of the motorized sample pump are contained in Chapter 2. Replacement of sample probe filters is discussed in Section 2.4.3.1.

As an additional safeguard, the pump also contains an internally housed particulate filter. If the pump is operated without the sample probe assembly in place, or in particularly dirty atmosphere, this internal filter can become clogged and periodically require replacement. Standard accessories included with every 54-05-A0101 motorized pump include a package of 10 replacement 61-001 filters.

5.4.1 Internal pump filter replacement

Use the following procedure for replacing the internal pump filter:

(1) Remove the three bottom screws from the pump assembly and disassemble the upper and lower sections of the pump case as shown in **Figure 5.4.3.**

(2) Remove the two pieces of tubing from the filter cap by gently twisting and pulling until the ends are free.

(3) Remove the filter cap and replace the used 61-001 filter.

(4) Reattach the filter cap and tubing. Make sure the tubing is secure to the filter cap **before** reassembling the pump case.

(5) Reassemble the upper and lower sections of the pump case. Do not over-tighten the three screws!

Proper pump operation must be verified before the pump is put back into service.

Use the following procedure to verify pump performance:

(1) Attach the pump to your PhD Ultra and turn the instrument on. Wait for the instrument to complete the self-test sequence.

(2) Verify that the pump is operating normally, and that a flashing "P" indicating proper pump performance may be seen in the upper left hand corner of the instrument LCD.

(3) Remove the hose and probe assembly from the pump (if currently attached) then cover the pump inlet with a finger. If there are no leaks in the internal pneumatics the pump should go into a low-flow alarm and shut down, and the audible and visual low flow alarms should be activated. A message screen will identify that there is a low pump flow condition. A second screen will advise you to remove the blockage and press "mode" to resume operation.

(4) Press "mode" to reset the pump and continue the test.

(5) Reattach the hose and probe assembly. Cover the end of the sample probe tube, and verify once again that the pump shuts down and that the low flow alarms are activated.

(6) Press "mode" to reset the pump and resume normal operation.

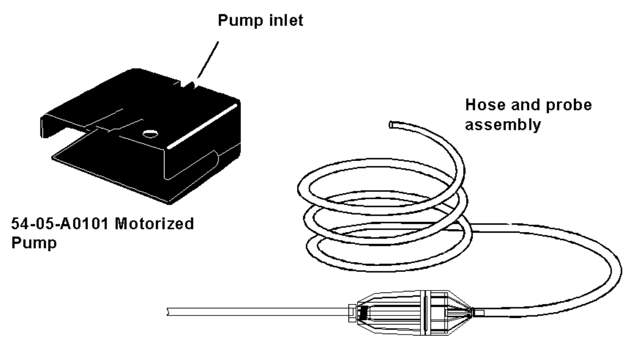


Figure 5.4.1. Motorized sample draw pump and probe assembly

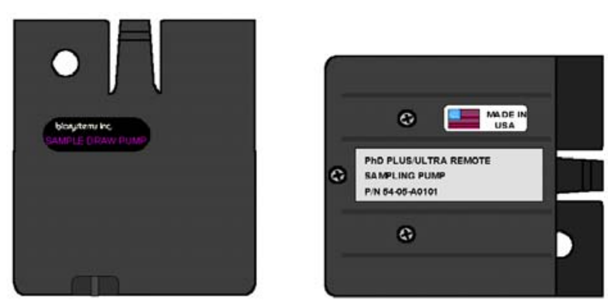


Figure 5.4.2. Top and bottom views of motorized 54-05-A0101 sample pump case

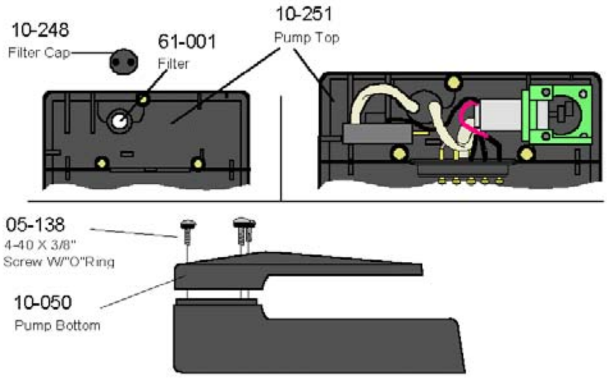


Figure 5.4.3. Cutaway views of 54-05-A0101 motorized pump showing major component assemblies

5.4.2 Specific problems with motorized pump

5.4.2.1 Pump will not turn on

Possible causes:

Pump is not properly attached to the instrument. Instrument is not turned on. Instrument battery doesn't have enough power for pump operation.

Solution(s):

Make sure pump is properly attached to instrument (it may be necessary to remove the instrument weather cover until the pump is attached), recharge or replace instrument battery pack.

5.4.2.2 Can't resume normal operation after a "Low Flow" shut down

Possible causes:

Sample probe or internal pump filters need replacement, sample hose kinked, sample probe and probe assembly contains fluids.

Solution(s):

Turn off PhD Ultra, remove pump, disconnect sample probe and hose assembly, allow any trapped fluids to drain; replace filters as necessary, examine hose to make sure there are no kinks blocking normal flow.

5.5 Returning your PhD Ultra to Biosystems for service or repair

Please contact the Biosystems Service Department at (860) 344-1079 to obtain a "Return Authorization" number prior to shipment. A Biosystems Service representative will record all relevant information or special instructions at that time.

To insure safe transport please use the original PhD Ultra packing materials, or other packing materials which similarly protect the instrument and accessories.

Note: The return authorization number must be clearly marked on the outside of the box.

Prominently showing the return authorization number on the outside of the box ensures that it is 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: It is usually best to return the instrument together with all accessories such as spare battery packs, chargers, and optional sample drawing pumps.

Please contact the Biosystems Service Department at (860) 344-1079 if you require any additional information.

Thank you for choosing the PhD Ultra, and thank you for choosing Biosystems.

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.

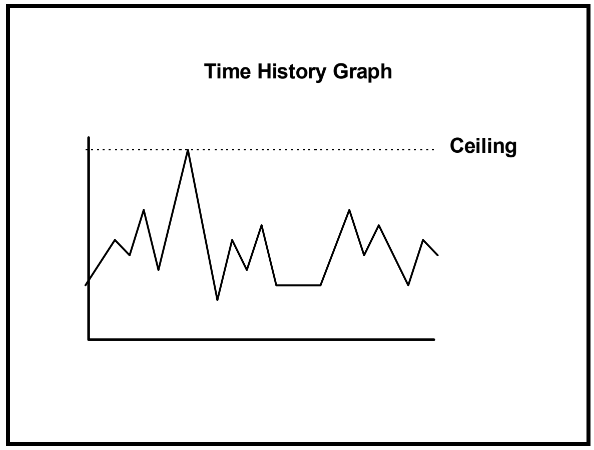
Hydrogen sulfide (H_2S) is a good example of an acutely toxic substance which is immediately lethal at relatively low concentrations. Exposure to a 1,000 ppm (parts per million) concentration of H_2S in air produces rapid paralysis of the respiratory system, cardiac arrest, and death within minutes.

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 PhD Ultra design.

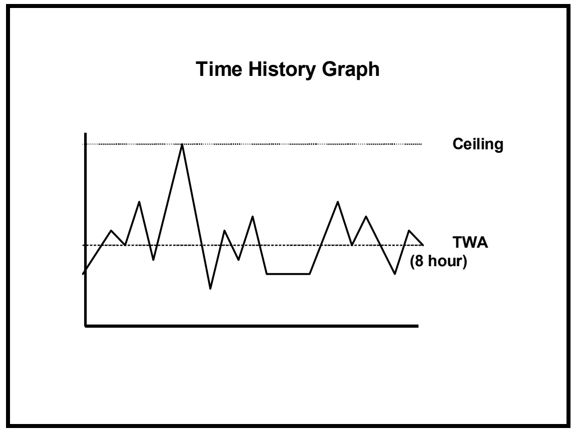
1. Ceiling level:

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):

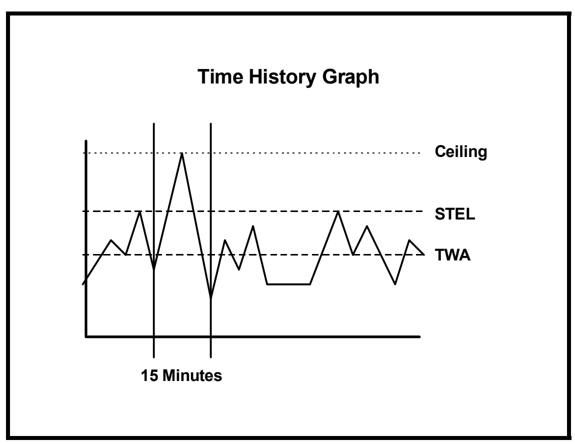
The maximum average concentration to which an unprotected worker may be exposed over an eight hour working day. During this time, STEL and ceiling concentration limits may not be exceeded.



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 How to determine where to set your alarms

1. Oxygen alarms

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

Oxygen deficiency is the leading cause of worker fatality during confined space entry. All confined spaces must be tested for oxygen deficiency before entry. Normal fresh air contains 20.9 percent O2. Any environment in which the oxygen concentration is less than 19.5 percent has been determined by OSHA to be oxygen deficient. The normal PhD Ultra low-alarm setting for oxygen deficiency is 19.5 percent.

Common causes of this hazard are bacterial action, displacement of oxygen by other gases, oxidation (rusting), consumption (burning), or absorption by materials such as wet activated carbon.

The PhD Ultra will also alarm for an excess of oxygen. Too much oxygen in an environment can result in an increased flammability hazard. The new OSHA standard for confined space entry (29 CFR 1910.146) requires that oxygen concentrations not exceed 23.5 percent. The normal setting for the high oxygen alarm is 23.5 percent.

2. Combustible gas alarms

As an environment becomes contaminated with combustible gases or vapors, concentrations can climb until they eventually reach ignitable or explosive levels. The minimum amount of a combustible gas or vapor in air which will explosively burn if a source of ignition is present is the Lower Explosive Limit (LEL) concentration. PhD Ultra combustible gas readings are given in percent LEL, with a range of zero to one-hundred percent explosive. The PhD Ultra combustible gas sensor is non-specific and responds to all combustible gases and vapors.

Combustible sensors contain two coils of fine wire coated with a ceramic material to form beads. These two beads are strung onto the opposite arms of a balanced Wheatstone Bridge circuit. The "active" bead is additionally coated with a palladium based material that allows catalyzed combustion to occur on the surface of the bead. The palladium catalyst is not consumed in the combustion reaction, it simply enables it to occur. It is not necessary for the combustible vapor to be present in LEL concentrations in order for this reaction to occur. Even trace amounts of combustible gas present in the air surrounding the sensor will be catalytically burned on the surface of the bead.

The "reference" bead lacks the palladium outer coating but in other respects exactly resembles the active bead. A voltage is applied across the active and reference elements, causing them to heat. If combustible vapors are present, the active bead will be heated by the reaction to a higher temperature. The temperature of the untreated reference bead is unaffected by the presence of gas. The difference between the temperatures of the two beads will be proportional to the amount of combustible gas present.

Since the two beads are strung on the opposite arms of a Wheatstone Bridge electrical circuit, the difference in temperature between the beads is perceived by the instrument as a change in electrical resistance.

It is important to note that catalytic "hot bead" type combustible sensors require the presence of oxygen (at least 8 - 10 percent by volume) in order to detect accurately. A combustible sensor in a 100 percent pure combustible gas or vapor environment will produce a reading of zero percent LEL.

The amount of heat produced by the combustion of a particular gas on the active bead will reflect the "Heat of Combustion" for that gas. Heats of combustion may vary from one combustible gas to another. For this reason readings may vary between equivalent concentrations of different combustible gases.

A combustible gas and vapor reading instrument may be calibrated to any number of different gases or vapors. If an instrument is only going to be used for a single type of gas over and over again, it is usually best to calibrate the instrument to that particular hazard. If the instrument is calibrated to a particular gas it will be accurate for that gas. This is what is illustrated in **Figure 2.1.**

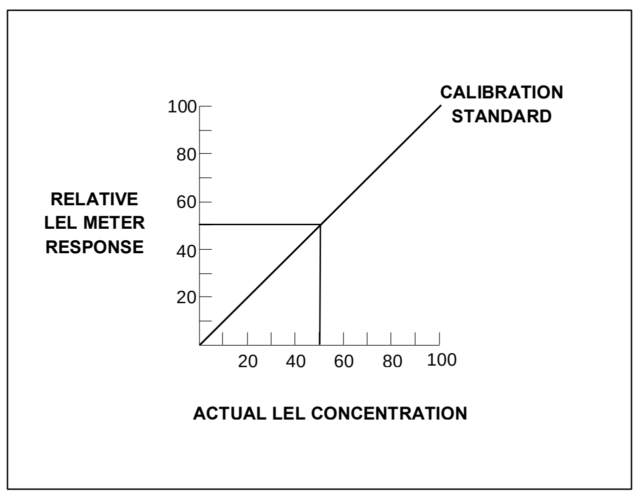


Figure 2.1. Combustible sensor response to the gas used to calibrate the sensor

Note that in a properly calibrated instrument, a concentration of 50 percent LEL produces a meter response (reading) of 50 percent LEL.

The **Figure 2.2** illustrates what may be seen when a combustible reading instrument is used to monitor gases other than the one to which it was calibrated. The chart shows the "relative response curves" of the instrument to several different gases.

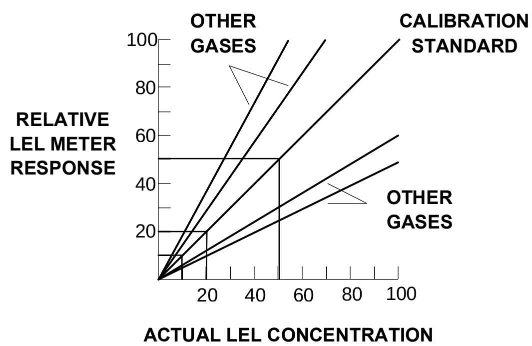


Figure 2.2. Relative response curves

Note that the response to the gas to which the instrument was calibrated, the "calibration standard", is still precisely accurate. For the other gases the responses are a little off.

In the case of some gases the readings are a little high. This results in the instrument going into alarm a little bit early. This type of error is not dangerous, since it results in workers exiting the affected area sooner than they absolutely have to.

Gases which produce lower relative readings than the calibration standard can result in a more potentially dangerous sort of error. In the chart example above the "worst case" gas only produces a meter reading of 50 percent LEL even when the actual concentration is 100 percent explosive. If the alarm were set to go off when the display reads 50 percent LEL, the alarm would sound simultaneously with the explosion!

If on the other hand the alarm is set to go off when the display reads 20 percent LEL, a 50 percent concentration of the same "worst case" gas is enough to cause an alarm.

It may be seen from the graph that the amount of relative error decreases the lower the alarm point is set. If the alarm point is set at 10 percent LEL, the differences due to relative response of the combustible sensor are minimal.

When it is not possible to calibrate directly to the gas to be measured, or when the combustible gas is an unknown, an alarm set point of 10 percent LEL or less should be selected.

In the new standard for "Permit Required Confined Space Entry" (29 CFR 1910.146) OSHA has determined that a combustible hazard exists whenever the concentration of combustible gas or vapor exceeds 10 percent LEL. Per this standard confined spaces with concentrations which exceed 10 percent LEL may not be entered. Likewise, workers are required to immediately leave anytime readings exceed 10 percent LEL.

The standard combustible alarm set-point for the PhD Ultra is 10 percent LEL.

2.1. Calculating relative responses

There are theoretical ways to estimate the relative response of a sensor calibrated on one combustible gas to exposure to another gas. This is done 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".

It is very important to treat gas concentration calculations based on theoretical relative response ratios cautiously. Correction factors for PhD Ultra combustible gas sensors:

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

2.1.1. Using correction factors

As an illustration, consider a PhD Ultra 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 concentration.

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 Reading	**Correction Factor**	**Actual 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 Reading	**Correction** Factor	**Actual** Concentration

2. Effects of contaminants on combustible sensors

Combustible sensors may be affected by exposure to silicone containing substances (found in many lubricants and hydraulic fluids), the tetra-ethyl-lead in "leaded" gasoline, and halogenated hydrocarbons (Freons®, or solvents such as trichloroethylene and methylene chloride). High concentrations of hydrogen sulfide may also damage the sensor.

If sensitivity of the combustible sensor is lost due to poisoning, it tends to be lost first with regards to methane!

A partially poisoned sensor might still respond accurately to propane while showing a dangerously reduced response to methane.

2.3. Choosing the right calibration gas for combustible sensors

The best results are obtained when calibration is done using the same gas that is expected to be encountered while actually using the instrument. When not sure what combustible gases might be encountered, it is important to choose a calibration gas that will provide a level of sensitivity which is typical of the widest range of combustible gases.

Propane provides a sensor response which is more typical of the wide range of combustible gases and vapors than any other calibration mixture. The only drawback to using propane based calibration gas mixtures is that a partially poisoned sensor might still respond accurately to propane while showing a dangerously reduced response to methane.

Use of Biosystems' "Propane Equivalent" calibration mixtures guards against this potentially dangerous sort of calibration error.

Biosystems' "Propane Equivalent" calibration mixtures are based on methane, but in concentrations which are designed to produce a level of sensitivity "equivalent" to that provided by a mixture which contains a 50% LEL concentration of propane. Because Biosystems' equivalent mixtures are based on methane, any loss of sensitivity to methane is detected (and can be corrected) immediately.

Use of other gases such as pentane or hexane to calibrate the instrument should be reserved for situations where these are either the gases predominantly present, or where the relative response to the calibration gas closely approximates that of the actual gas to be measured.

Verifying accuracy before each day's use insures that proper sensitivity is maintained over the life of the combustible sensor.

3. Toxic gas alarms

The PhD Ultra has three separate alarm points for toxic gases: Ceiling, STEL, and TWA.

OSHA has assigned some, but not all, toxic substances with a ceiling or "Peak" exposure 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.

The Time Weighted Average (or TWA) is 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.

OSHA has assigned some, but not all, toxic substances with a Short Term Exposure Limit. 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.

The table below shows the highest levels at which these alarms should be set. If OSHA has not determined a ceiling value, for greatest safety the PhD Ultra ceiling alarm should be set at the same value as the STEL alarm. If OSHA has not determined a STEL value, the PhD Ultra STEL alarm should be set at the same value as the TWA.

4. U. S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits for select toxic gases:

In the following table "NA" indicates no value has been assigned by OSHA.

Note: Customers should be aware that OSHA permissible exposure limits may be subject to change.

Recent court decisions have affected the enforcement of permissible exposure limits published or modified since the initial enactment of OSHA in 1971. The following table shows the OSHA permissible exposure limits as published in the 1989 edition of the Code of Federal Regulations (29 CFR 1910.1000). It is recommended that customers verify that the values given below are correct and current before using them to update their alarm set-points.

OSHA (1989) Permissible Exposure Limits:

Gas	Ceiling	STEL	TWA
CO	200 ppm	NA	35 ppm
H2S	NA	15 ppm	10 ppm
SO2	NA	5.0 ppm	2.0 ppm

5. PhD Ultra default alarm settings

The most conservative possible way to set alarms is the method used by Biosystems for the PhD Ultra default alarm settings. The Ceiling alarm is set at the factory

at the 8 hour TWA level (when this is given). With this setting, it is unlikely that either the STEL or TWA alarm will ever be activated. For other values, contact Biosystems or your authorized distributor.

Gas	Ceiling	TWA	STEL
CO	35 ppm	35 ppm	100 ppm
H_2S	10 ppm	10 ppm	15 ppm
SO_2	2.0 ppm	2.0 ppm	5.0 ppm
Cl_2	0.5 ppm	0.5 ppm	1.0 ppm
HCN	4.7 ppm	4.7 ppm	4.7 ppm
NH_3	25 ppm	25 ppm	35 ppm
NO	25 ppm	25 ppm	25 ppm
NO_2	1.0 ppm	1.0 ppm	1.0 ppm
Oxygen (O_2)		Low alarm: 19.5%	High alarm: 22.0%
Combustible gas		10 % LEL	

Biosystems PhD Ultra default alarm settings

Note: When a "CO Plus" sensor is installed the default alarm settings are automatically assigned on the basis of the calibration gas selected for use. If carbon monoxide is selected as the calibration gas, carbon monoxide alarm settings are automatically assigned. If hydrogen sulfide is selected as the calibration gas, hydrogen sulfide alarm settings are automatically assigned.

Appendix C How to calibrate your PhD Ultra in contaminated air

Calibration of the PhD Ultra is a two-step process. The first step is to expose the sensors to contaminate-free air with an oxygen concentration of 20.9% and perform a fresh air calibration.

Unfortunately, there are some locations which are never completely free of contaminants. An example would be a furnace intensive area which always has a background concentration of a few ppm CO. To make calibration easy in this case, it is necessary to use special calibration "Zero Contaminant" gas. This gas cylinder, Biosystems part number 9039, is used in conjunction with the sample draw calibration adapter. Flow the zero contaminant gas across the sensors for a minute, just as if you were doing a span calibration. Then do the fresh air calibration steps described in Chapter 3 of the owners manual.

Appendix D Suggested Calibration Gases

⚠**WARNING Use of non-standard calibration gas and/or calibration kit components when calibrating the PhD Ultra 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 PhD Ultra calibration. Customers are strongly urged to use only Biosystems calibration materials when calibrating their PhD Ultra.

1. Mixtures currently available:

Because combustible gas sensors have different responses to different combustible gases (see **Appendix B**), Biosystems offers several choices for combustible calibration gas.

Carbon monoxide, sulfur dioxide, and hydrogen sulfide are all currently available from Biosystems in small (103 or 58 liter), disposable, standard calibration gas cylinders.

Please note: Biosystems EZ Cal™ multi-component calibration gas mixtures are available for use with many common PhD Ultra detector configurations. The calibration gas supplied in Confined Space Kits is normally an all-in-one mixture <u>when one is available</u>. If an all-in-one mixture is not desired, please order the PhD Ultra and calibration materials separately.

Part Number	Calibration gas mixture	Comments
54-9045E	EZ Cal™ Value Pack multi-component calibration gas (CO 50 ppm, propane equivalent 50% LEL, in air)	Only for use with 54-12-022 “Value Pack” style fixed flow rate regulator.
54-9041	EZ Cal™ multi-component gas (CO 50 ppm, methane 50% LEL, in air)	
54-9042E	EZ Cal™ multi-component gas (CO 50 ppm, propane equivalent 50% LEL, in air)	Recommended for general purpose use for instruments with CO and LEL sensors installed.
54-9043	EZ Cal™ multi-component gas (CO 50 ppm, H_2S 25 ppm, methane 50% LEL, in air)	Not for use with “CO Plus” sensors.
54-9044E	EZ Cal™ multi-component gas (CO 50 ppm, H_2S 25 ppm, propane equivalent 50% LEL, in air)	Not for use with “CO Plus” sensors. Recommended for general purpose use for instruments with CO, H_2S and LEL sensors installed.
54-9031	Methane (CH_4) (2.5% by volume = 50% LEL in air)	Use when monitoring for presence of methane or natural gas only.
54-9032	Propane (C_3H_8) (1.1% percent by volume = 50% LEL in air)	Use when monitoring for presence of propane or gases with similar response ratios only.
54-9032E	Propane (propane equivalent 50% LEL, in air)	Recommended for use for general purpose combustible gas monitoring.
54-9038	n - Hexane (C_6H_{14}) (0.3% by volume = 25% LEL in air)	Use when monitoring for presence of hexane or gases with similar response ratios only.
54-9033	Carbon monoxide (CO) (50 ppm in air)	
54-9034	Hydrogen sulfide (H_2S) (25 ppm in nitrogen)	
54-9037	Sulfur dioxide (SO_2) (10 ppm in nitrogen)	
54-9039	Zero air (20.9 % oxygen in nitrogen)	Use for fresh air calibration in contaminated areas.

Appendix E PhD Ultra Toxic Sensor Cross Sensitivity Data[1]

The table below lists the cross sensitivity of electrochemical toxic sensors used in Biosystems portable gas detectors to gases other than their target gas. Depending on the nature of the reaction each gas has with the sensor, the effect can either decrease the signal (negative cross sensitivity) or increase the signal; (positive cross sensitivity). Each figure represents the reaction of the sensor to 100 ppm of gas, thus providing a percentage sensitivity to that gas relative to its target gas.

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	CO	H_2S	SO_2	NO	NO_2	Cl_2	H_2	HCN	HCl	NH_3	Ethyl-ene	PH_3
Carbon monoxide (CO)	100	< 3	0	< 10	≤ - 20	< 10	< 40	< 15	0	0	< 100	
Hydrogen sulfide (H_2S)	< 10	100	< 20	0	~ – 20	~ – 20	< 0.1	0	0	0	0	
"CO Plus" (Cal to CO)	100	~ 350	~ 50	~ 25	– 60	~ – 40	< 40	~ 40	~ 5			
"CO Plus" (Cal to H_2S)	25	100	~ 15	~ 6	– 15	~ – 10	< 15	~ 10	~ 1			
Sulfur dioxide (SO_2)	0	0	100	0	~ –100	- 5	0	< 50	0	0	0	
Nitric oxide (NO)	0	~ 35	~ 5	100	< 40	0	0	0	≤ 15	0	0	
Nitrogen dioxide (NO_2)	0	~ – 20	< – 0.5	0	100	≈100	0	0	0	0	0	
Chlorine (Cl_2)	0	~ – 20	0	0	120	100	0	0	0	0	0	
Hydrogen cyanide (HCN)	< 3	~600	~ 395	0	~ – 120	~ – 140	0	100	~ 35	- 5	~ 25	
Phosphine (PH3)	-	~ 25						< 0.1			≤ 2	100
Ammonia(NH3) (-04 Version)	0	~ 100	~ 60	~ 20	0	~ 50	0	~ 5	0	100		

[1]Data derived in part from City Technology Limited, Product Data Handbook Oct. 1, 1992

Appendix F Calibration Frequency

One of the most common questions that we are asked at Biosystems 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 any significant loss of sensitivity.

A lot of sensors indeed do last that long with only minimal loss of sensitivity. However, there are a number of reasons why a sensor may unexpectedly lose additional sensitivity or even fail to respond to gas. Such reasons include desiccation, poisoning, physical restriction of airflow, overexposure, leakage, and mechanical damage due to dropping or immersion.

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 are 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 the instrument 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 Verifications of Accuracy

We are often asked whether there are any circumstances in which the period between accuracy checks may be lengthened.

Biosystems is not the only manufacturer to be asked this question! One of the professional organizations to which Biosystems 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. Biosystems procedures closely follow these guidelines.

If your operating procedures do not permit daily checking of the sensors, Biosystems recommends the following procedure to establish a safe and prudent accuracy check schedule for your Biosystems 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 Biosystems gas detectors offer a one button auto calibration feature. This feature allows you to calibrate a Biosystems 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 Biosystems' 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.

All of Biosystems Applications Notes are located on the Biosystems website at

http://www.biosystems.com

Appendix G Biosystems Standard Warranty Gas Detection Products

General

Biosystems LLC (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.

Damages to any Biosystems 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 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 with transportation and shipping charges prepaid to Biosystems at its manufacturing location in Middletown, Connecticut, or to a Biosystems Authorized Warranty Service Center. 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, Toxi/Oxy Plus, Toxi/Oxy Ultra, ToxiVision, Ex Chek	As long as the instrument is in service
Toxi/Oxy Pro, MultiPro	2 years from date of purchase
Toxi Limited	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	90 days after activation or 90 days 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
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 Biosystems Instrument Service department) void Biosystems' Standard Warranty as it applies to the replacement of combustible gas sensors.**