

**AMS-4**

**Beta Particulate Monitor  
Technical Manual**

# AMS-4

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## SECTION 1. INTRODUCTION

### A. GENERAL DESCRIPTION

The Eberline AMS-4 Beta Particulate Air Monitor is a multiple microprocessor-based radiation detection instrument designed for the detection and measurement of airborne beta emitting particulate matter. It consists of a main processing unit and a sampling head. An integrated pump is available as an option.

The main processing unit acts as the central element which monitors all inputs and controls all outputs. Three serial ports support communications with the sampling head, printer, and host computer. In addition, the main processing unit provides a keyboard, display, and status lights.

An AMS-4 can be equipped with either a radial entry or an in-line sampling head depending on the user selected configuration. Both the radial inlet and in-line sampling heads have two microcomputer boards. These boards gather radiological counts from a beta/alpha sensitive detector and a gamma sensitive background detector. One of the boards also measures air flow volume. This information is then processed and sent by RS-485 serial communications to the main processing unit. The detector boards also annunciate the alarm horn and lights on the sampling head and monitor the alarm acknowledge and filter door switches.

This multiple microcomputer system provides a sophisticated and flexible means of acquiring and manipulating data and presenting operational conditions, current readings, and alarms on the alphanumeric vacuum fluorescent display and status indicator lights. The status indicators located on the front panel inform the user of Ready and Malfunction status. The LED bar graph display indicates the current Slow Concentration value as a percentage of the Slow Concentration Alarm setpoint. The red strobe on top of the unit, when active, indicates that one or more of the five enabled alarms have been exceeded. The alarms supported by the AMS-4 are Slow Concentration, Fast Concentration, Net Beta Count Rate, DAC Hour, and Stack Release Rate.

### B. SPECIFICATIONS

#### 1. Mechanical

- a. Overall dimensions:
  - Width with radial or gas head attached = 16.4 in. (41.6 cm)
  - Width with radial or gas head detached = 11.0 in. (27.9 cm)
  - Depth = 7.3 in. (18.5 cm)
  - Height without integrated pump = 12.8 in. (32.5 cm)

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Height with integrated pump = 21.6 in. (54.8 cm)

For further details, refer to the outline drawings in Section 4.



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- b. Weight:
  - Main processing unit = 7.4 lbs. (3.3 Kg)
  - Radial inlet sampling head = 5.9 lbs. (2.7 Kg)
  - Integrated pump option = 17.4 lbs. (7.9 Kg)
  - Noble gas sampling head = 9.6 lbs. (4.35 Kg)

### 2. Temperature

- a. Operating: 0°C to 50°C (32°F to 122°F)
- b. Storage: -20°C to 85°C (-4°F to 185°F)

### 3. Detectors

- a. Type: Sealed gas-proportional, Argon - CO<sub>2</sub> (radial and noble gas head), Neon - CO<sub>2</sub> (in-line head)
- b. Gas pressure: 600 Torr
- c. Maximum diameter: 2.11" (53.59 mm) radial and gas head, 1.49" (37.85 mm) in-line head
- d. Effective diameter: 1.75" (44.45 mm) radial and gas head, 1.12" (28.45 mm) in-line head.
- e. Window material: Mica
- f. Window density: 2-3 mg/cm<sup>2</sup>
- g. Efficiency (4π): <sup>99</sup>Tc = 9%, <sup>90</sup>Sr<sup>90</sup>Y = 18%  
<sup>85</sup>Kr = 6.4%, <sup>133</sup>Xe = 4.3% (noble gas head)

### 4. Voltages

- a. Input: 85-264 Vac or 105-370 Vdc, 1.0 Amp (120 Watts max.) typical at 50-60 Hz
- b. AC fuse: 1 Amp Slow Blow @ 120 Vac
- c. Output: +12 Vdc, 4.2 Amps maximum

### 5. Analog Output

- a. Output voltage: 0-5 Vdc

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- b. Output current: 40 mA, maximum
- c. Scale: 5 decades, logarithmic

### 6. Display

- a. 2 line x 20 character dot matrix vacuum fluorescent
- b. Character size: Height = 0.20 in. (5.05 mm); Width = 0.14 in. (3.55 mm)
- c. Character format: 5 x 7 dot matrix

### 7. Serial Ports

The AMS-4 provides three serial communications ports. The serial communications ports support a system host computer interface, printer interface, and communications with the sampling head. The host computer and printer ports have 9-pin D-type female connectors. The sampling head communications port has a 4-pin circular connector.

Host computer port: Binary-type uLAN and non uLAN protocol data format. uLAN protocol is 1 start bit, 8 data bits, 1 address marker bit, and 1 stop bit. Non uLAN protocol is 1 start bit, 8 data bits, and 1 stop bit. RS-232C (standard) or RS-485 (optional). User selected baud rates of 300, 600, 1200, 2400, 4800, 9600 and 19200 are available. The default baud rate is 19200. Refer to the *AMS-4 to Host Computer Binary Communications Protocol* (EIC document #13000-A38) for detailed communications information.

Printer port: ASCII data format. 1 start bit, 8 data bits, no parity and 1 stop bit. RS-232C. End of line terminator is carriage return-line feed. Baud rate is fixed at 9600. Printer busy signal input is DSR.

Sampling head communication port: Binary-type uLAN protocol data format. 1 start bit, 8 data bits, 1 address marker bit, and 1 stop bit. RS-485 only. The baud rate is fixed at 19.2K (19,200) baud.

## C. THEORY OF OPERATION

The basic electronics package of the AMS-4 main processing unit consists of an AMS-4 Front Panel Board acting as the Master Controller, a Bar Graph Board which provides front panel status lights, a version of the AMS-4 Analog Board, and a vacuum fluorescent display. The standard AMS-4 is supplied with a radial inlet head which can be removed. A fixed installation in-line head, required for stack and duct monitoring, is available as an

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option. All sampling heads contain similar electronics which include two Modular Detector Boards (MDB) and a Flow Sensor Board.

The AMS-4 Front Panel Board is the large board mounted to the hinged bracket in the AMS-4 main processing unit. The Bar Graph Board and the vacuum fluorescent display are mounted to the front cover. The AMS-4 Analog Board is mounted to the main chassis behind the Front Panel Board and below the power supply.

The AMS-4 Front Panel Board's responsibilities include: sending control information to the Modular Detector Boards located in the sampling head and retrieving count rate, flow rate, and status information from the MDB's; controlling the alphanumeric display; reading the keypad; sending concentration and status history to a host computer and printer; lighting the front panel LED bar graph display and the Ready and Malfunction lights to indicate instrument status; regulate the 0-5 volt analog output; and controlling the alarm strobe, horn, and status relays.

The AMS-4 Front Panel Board stores all of its calibration and configuration parameters plus the MDB's configuration parameters in non-volatile RAM (NVRAM). If power to the AMS-4 is disrupted, all calibration and operating parameters are downloaded by the Front Panel Board to the respective MDB's after power has been restored. Thus, recalibration or configuration of the instrument is not necessary after a power disruption. Refer to the Maintenance section of this manual (Section 3) for instructions on how to re-initialize the AMS-4 with the default operating parameters. Caution should be used when re-initializing the AMS-4 with default parameters since the calibration will be voided.

The MDB's provide the high voltage to the detectors in the AMS-4 sampling head and provide pulse amplification, discrimination, and counting. The high voltage portion of the MDB consists of an analog circuit, controlled by the microcontroller, which regulates the high voltage output and a step up transformer which is driven by a voltage controlled oscillator. The microcontroller, which is connected to the RS-485 bus, is instructed by the AMS-4 Front Panel Board to set the high voltage output to a predetermined value. The microcontroller then outputs a square wave, proportional in duty factor to the high voltage required, to the analog circuit. The analog circuit then adjusts to the required high voltage output. The pulse counting portion of the beta detector board has the capability to amplify pulses from the detector facing the filter paper, discriminate alpha pulses from beta pulses; and count the pulses separately for each of its two channels (one alpha and one beta). The background channel counts only the gamma background. Upon request from the AMS-4 Front Panel Board, the MDB's provide the counting results. The MDB's also monitor the remote Alarm Acknowledge switch, Filter Door position switch, the flow sensor output, plus control the horn and alarm light in the sampling head.

### 1. Operational Mode

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When the AMS-4 is first turned on the memory held time stamp which indicates the last time the 5 second calculations were performed is compared to the current time. If the elapsed time is less than 10 seconds, history accumulation is continued using the previous history values. This is done to prevent history accumulation from being terminated by a brief (less than 10 seconds) power disruption. If the elapsed time is greater than 10 seconds, all history files are cleared. The log data buffers are maintained regardless of this condition. The Front Panel Board will then initialize each of the MDBs in the sampling head with the correct operating parameters.

Following initialization, after a power-on in which history files were cleared, the monitor will begin accumulating count rate and flow rate data into its history files. This is indicated on the display with the message "Obtaining History." After five seconds, the monitor will have accumulated sufficient data in its history files to calculate the readings for the net beta count rate and the minimum detectable net count rate (MDNCR). After ten seconds, there will be sufficient data to calculate the readings for the fast alarm concentration (FAC) and the fast alarm minimum detectable concentration (MDC). After two minutes, there will be sufficient data to calculate the readings for the slow alarm concentration (SAC) and the slow alarm MDC. The derived air concentration (DAC) and release rate readings are based on the slow alarm concentration value. Any conditions affecting the slow alarm concentration will also affect these readings.

The monitor will display these readings as they become available. Those readings which cannot be performed because of insufficient data are displayed as "Wait for (reading)."

The AMS-4 will begin normal operation and the front panel ready light will be turned on when all of the user enabled alarms are considered to be "ready." Each of these readings are "ready", meaning alarm checking is enabled, after sufficient data has been gathered to perform the calculations for the specific readings and their associated alarm setpoints are greater than their associated minimum detectable readings. Any of the alarms, and thus alarm checking, can be disabled by setting its alarm setpoint to 0. The minimum detectable readings (MDC and MDNCR) also determine when and if alarm checking is enabled. If the minimum detectable reading is greater than its respective alarm setpoint alarm checking is disabled. The alarm in question will remain disabled until the minimum detectable reading is reduced or until the alarm setpoint is raised above the current minimum detectable reading.

Every five seconds, the minimum detectable concentration of the fast alarm is calculated using the last half of the total accumulated history available since the AMS-4 was turned on, filter changed, or history reset. This is continued until the accumulated history is equal to the fast alarm interval. At this time and thereafter the reading is calculated using the most recent histories dating back to the length of the fast alarm interval.

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Also calculated every five seconds is the minimum detectable beta net count rate reading. It is calculated using all of the total accumulated history since the AMS-4 was turned on, filter changed, or history reset. This is continued until the accumulated history is equal to the beta net count rate interval. At this time and thereafter the reading is calculated using the most recent histories dating back to the length of the beta net count rate interval (net alarm interval).

Every minute, the minimum detectable concentration of the slow alarm is calculated using the last half of the total accumulated history available since the AMS-4 was turned on, filter changed, or history reset. This is continued until the accumulated history is equal to the slow alarm interval. At this time and thereafter the reading is calculated using the most recent histories dating back to the length of the slow alarm interval.

The fast alarm concentration value is generally based on a shorter time interval of counting histories and therefore is more susceptible to large swings of concentration readings than the slow alarm concentration readings. Typical values for the fast alarm concentration interval is 60 seconds compared to 30 minutes for the slow concentration interval.

The fast and slow concentration readings are determined by comparing the count rate activity in the most recent alarm interval to the count rate activity in the previous alarm interval. The most recent interval of count rate values are subtracted from the previous interval of count rate values and the result is a differential of the two count rates. This is then used to calculate the corresponding concentration and then the DAC. In some cases it is possible that due to short half-lives of particles on the filter the most recent interval could have a lower count rate than the previous interval. This will result in a negative value for the differential concentration and therefore, the DAC. However, only positive DAC values are added to the sum of "Total DAC Hours."

## 2. Operational Displays

The AMS-4 provides the user with up to nine different pages of information that can be displayed while the unit is in the normal operational mode. The user can use the arrow keys on the keypad to scroll through each of the pages to display the particular page of interest. Only the numerical value of the displayed readings and their corresponding units are displayed. A legend of the currently displayed readings can be shown by pressing [Enter]. The following is a description of each display page.

Page One:

Slow Alarm Conc. (current slow alarm concentration, activity per volume of air)

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Slow Alarm Conc./DAC (current slow alarm concentration fraction of derived air concentration)

Page Two:

Sample Flow Rate

Total Flow Volume (since filter change or history reset)

Page Three:

DAC Alarm Setpoint (DAC hour alarm setpoint)

DAC Hours (since filter change or history reset)

Page Four:

Total Elapsed Time (since filter change of history reset)

Current Date/Time

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Page Five:

Slow Alarm Setpoint (concentration slow alarm setpoint)  
Slow Alarm MDC (slow alarm minimum detectable concentration)

Page Six:

Fast Alarm Setpoint (concentration fast alarm setpoint)  
Fast Alarm MDC (fast alarm minimum detectable concentration)

Page Seven:

Beta Alarm Setpoint (beta net count rate)  
Beta Alarm MDNCR (beta alarm minimum detectable net count rate)

Page Eight:

Fast Alarm Conc. (current fast alarm concentration, activity per volume of air)  
Beta Net Count Rate (current beta net count rate)

Page Nine (only displayed if stack flow rate parameter is non-zero):

Stack Alarm Setpoint (stack release rate alarm setpoint)  
Stack Release Rate (Activity per unit of time)

At the end of the operational displays all of the current abnormal operating conditions are listed. If all operating conditions are normal, the display will state INSTRUMENT STATUS NORMAL.

### **3. Operational Calculations and Alarm Determinations**

The AMS-4 supports five separate alarms, all of which the operator must specify the alarm setpoint. The Fast Alarm Concentration level and the Beta Net Count Rate are compared to their alarm setpoint every five seconds. The Slow Alarm Concentration, total DAC Hours, and the Release Rate are compared to their alarm setpoint every minute. Each time an alarm setpoint is changed it is immediately compared to the corresponding current reading to determine if an alarm condition exists.

Every five seconds the Front Panel Board collects the gross count information from the beta, alpha, and background channel in addition to flow rate information from the flow channel. Calculations which involve the fast concentration, fast MDA, beta net count rate, and MDNCR are updated and re-displayed every five seconds. Calculations which pertain to the slow concentration and slow MDA are updated and

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re-displayed every minute. The Beta Background Counts, the background counts during the alarm interval, are determined by the following equation.

$$\text{Beta Background Counts} = (\text{Gamma Bkg} \cdot F_g) + (\text{Alpha} \cdot F_a) + (F_b \cdot \text{Alarm Time Interval})$$

Where:

Alarm Time Interval = User selected alarm time interval

Alpha = Alpha channel gross counts during the alarm time interval

Gamma Bkg = Gamma background channel counts during the alarm time interval

F<sub>a</sub> = Alpha subtraction factor

F<sub>b</sub> = Fixed beta background rate

F<sub>g</sub> = Gamma subtraction factor

Beta Net Counts are then determined by:

$$\text{Beta Net Counts} = \text{Beta Channel Counts} - \text{Beta Background Counts}$$

The Beta Net Count Rate results from:

$$\text{Beta Net Count Rate} = \frac{\text{Beta Net Counts}}{\text{Alarm Time Interval}}$$

This result is then compared to the user selected Beta Net Count Rate alarm setpoint, if enabled, to determine if a Beta Net Count Rate alarm condition is present.

The concentration alarm checking is performed for the Fast Alarm and Slow Alarm at intervals of five seconds and one minute, respectively, using the equation below. The appropriate Alarm Time Interval is used depending if it is a Fast or Slow Alarm calculation. The equation for the Particulate/Iodine head is shown.

$$\text{Fast/Slow Alarm Concentration} = \frac{\frac{\text{Beta Net Count Rate}_{\text{current}} - \text{Beta Net Count Rate}_{\text{previous}}}{\text{Beta Efficiency}}}{\frac{\text{Disintegration Rate}}{\text{Activity Unit}} \cdot \text{Flow Volume}}$$



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The same calculation for the Noble Gas head uses the following equation.

$$\text{Fast/Slow Alarm Concentration} = \frac{\frac{\text{Beta Net Count Rate}_{\text{current}}}{\text{Beta Efficiency}}}{\frac{\text{Disintegration Rate}}{\text{Activity Unit}} \bullet \text{Chamber Volume}}$$

This value is then compared to the appropriate user selected Concentration Alarm setpoint to determine if an alarm condition is present.

The minimum detectable activity (MDA) for both the Fast and Slow Concentration Alarms are determined, per NUREG-1400, by the following equations.

$$\text{Fast / Slow MDA} = \frac{4.65 \sqrt{\text{Beta Background Counts} + 3}}{K \bullet \text{Alarm Time Interval}}$$

$$K = \text{Efficiency} \bullet \frac{\text{Disintegration Rate}}{\text{Activity Unit}}$$

Where:

K = Sensitivity (count rate per activity unit)

The minimum detectable concentration (MDC) can then be determined as shown.

$$\text{Fast / Slow MDC} = \frac{\text{Fast / Slow MDA}}{\text{Flow Volume}}$$

Where:

Flow Volume = Total air flow through the filter during the alarm time interval.

The equivalent equation used with the Noble Gas head, which has a fixed chamber volume, is shown below.

$$\text{Fast / Slow MDC} = \frac{\text{Fast / Slow MDA}}{\text{Chamber Volume}}$$

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The minimum detectable net count rate (MDNCR) is determined, per NUREG-1400, using the following expression.

$$MDNCR = \frac{4.65 \sqrt{\text{Beta Background Counts} + 3}}{\text{Alarm Time Interval}}$$

$$\text{Release Rate} = \text{Slow Alarm Concentration} \bullet \text{Stack Flow Rate}$$

The Release Rate, in activity per unit time, is determined as shown:

### D. TEST MODE

When in the Test mode, the instrument allows the user to use the test and maintenance routines and all operating parameters are available for display and/or modification. While in this mode all counting operations continue as normal except when the Calibrate sub-menu items are selected. Due to the nature of the commands in the Calibrate sub-menu, all history accumulation is terminated while in the Calibration routines and the accumulated history is reset upon exiting.

The AMS-4 supports exponent number entry. To enter a number in exponent notation, key in the base number value then press either [+] or [-] to select a positive or negative exponent, then key in the exponent value.

The display prompts the operator with the name of the menu item ready for examination. If an item is selected from the main menu, the sub-menu name and its present variable or reading is displayed. The keyboard protocol is such that pressing the 9 key causes the display to advance to the next item, the 8 key causes the display to return to the previous item, and the Enter key causes entry into the displayed sub-menu. Once in the Test mode, the user may press the Menu key to "escape" from a sub-menu or return from the main menu to the Operate mode. The Edit and Enter keys allow modification of appropriate items.

To enter the Test mode, the user must press [Menu] on the keypad. The user is then prompted to enter the current test mode password. The default password is "0000." Specific instructions pertaining to changing the password from the default setting can be found in the Instrument Parameters section.

After the correct password is entered the user may scroll through the main menu by pressing the 9 and 8 keys. To select a menu item, use the arrow keys to display the menu item of interest and then press [Enter]. After [Enter] is pressed a listing of sub-menu items

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can be viewed by using the 9 and 8 keys. Pressing [8] while the first item of a sub-menu item is displayed will return the user to the main menu. The main menu items and their associated sub-menu items are listed below.

### 1. Instrument Status

To aid in troubleshooting, the Instrument Status menu is used to inform the user of abnormal operating conditions. If the user selects this menu item, all of the current abnormal operating conditions can be displayed by scrolling through the sub-menu using the 9 and 8 keys. If all operating conditions are normal the display will read "END OF LIST." The following is a list of the possible Instrument Status messages and a brief description of the cause.

#### NO FAST ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode), the fast alarm minimum detectable concentration is greater than the fast alarm setpoint, or there is insufficient history to perform the (fast) concentration calculation.

#### NO BETA ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode), the beta minimum detectable net count rate is greater than the beta net count rate alarm setpoint, or there is insufficient history to perform the net beta count rate calculation.

#### NO SLOW ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode), the fast alarm minimum detectable concentration is greater than the fast alarm setpoint, or there is insufficient history to perform the (slow) concentration calculation.

#### DETECTOR FAIL

The instrument has detected a communication failure, a high voltage failure, or the Modular Detector Board software is operating in a mode not supported by the AMS-4.

#### LOW FLOW FAIL, BELOW MIN FLOW

The current weighted average flow rate is less than the minimum flow rate.

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### HIGH FLOW FAIL, ABOVE MAX FLOW

The weighted average flow rate is greater than the maximum flow rate.

### LOW BETA FAIL, BELOW MIN BETA

The weighted average beta count rate is less than the minimum beta count rate.

### HIGH BETA FAIL, ABOVE MAX BETA

The weighted average beta count rate is greater than the maximum beta count rate.

### FILTER DOOR, OPEN OUT OF SERVICE

The filter door is open and the acknowledge key has been pressed, or the door has been open for more than ten seconds.

### CALIBRATE MODE

The host computer is performing a remote calibration of the instrument.

### FAST ALARM DETECTED

The fast alarm concentration is currently greater than the concentration fast alarm setpoint.

### BETA ALARM DETECTED

The beta net count rate is currently greater than the beta net count rate alarm setpoint.

### SLOW ALARM DETECTED

The slow alarm concentration is currently greater than the concentration slow alarm setpoint.

### RELEASE RATE ALARM DETECTED

The release rate is currently greater than the release rate alarm setpoint.

### DAC HOUR ALARM DETECTED

The accumulated DAC hours have exceeded the DAC hour alarm setpoint.

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### 2. Detector Status

This menu will display the current operating status of each detector board. If this item is selected the beta detector board status is displayed first. The background detector board status can be viewed by pressing the 9 key. Below is a listing of the possible detector status conditions and their meaning.

#### PAUSED

The Modular Detector Board has been commanded to pause counting. This is an abnormal condition which will cause an instrument failure. The instrument will continue to monitor the detector board. When this status no longer exists, the instrument will begin normal operation.

#### COUNTING

The Modular Detector Board is counting normally.

#### DONE

The Modular Detector Board is done counting. This status will most likely occur when a calibration is being performed by the Host computer. This is a normal status and will not cause an instrument failure.

#### HIGH VOLTAGE FAIL

The Modular Detector Board software has detected that the high voltage output is too high. This status will cause an instrument failure. The instrument will continue to monitor the detector board. When this status no longer exists, the instrument will resume normal operation.

#### LOW VOLTAGE FAIL

The Modular Detector Board software has detected that the high voltage output is too low. This status will cause an instrument failure. The instrument will continue to monitor the detector board. When this status no longer exists, the instrument will begin normal operation.

#### HAND PROBE CALIBRATE

The Modular Detector Board software has been placed in "hand probe calibration mode", an operating mode not supported by the AMS-4. This status will cause an instrument failure. The instrument will continue to monitor the detector board. When this status no longer exists, the instrument will begin normal operation. This error is

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most likely a result of jumper JP1-6 on the Modular Detector Board being in the wrong position. The correct jumper position is at JP1. Power to the board must be cycled off then back on before a change of jumper position is recognized.

### HAND PROBE MODE

The Modular Detector Board software has been placed in "hand probe mode" , an operating mode not supported by the AMS-4. This status will cause an instrument failure. The instrument will continue to monitor the detector board. When this status no longer exists, the instrument will begin normal operation. This error is most likely a result of jumper JP1-6 on the Modular Detector Board being in the wrong position. The correct jumper position is at JP1. Power to the board must be cycled off then back on before a change of jumper position is recognized.

### BAD TASK

A cyclic redundancy check (CRC) on a communications message to the Modular Detector Board indicates the message is invalid. This status will cause an instrument failure. The RESET command must be invoked from the Test menu to clear this status.

### COMMUNICATIONS FAIL

A communications message sent to the Modular Detector Board did not receive a response. This status will cause an instrument failure. The RESET command must be invoked from the Test menu to clear this status.

### CAN'T COUNT

The Modular Detector Board did not return new count data for a period of six seconds. This status will cause an instrument failure. The RESET command must be invoked from the Test menu to clear this status.

### COMMUNICATIONS HALT

If a communications message sent to a Modular Detector Board did not receive a response, the detector status of that MDB will be COMMUNICATIONS FAIL, which causes an overall instrument failure. The instrument doesn't attempt communications to the other detector board after one has failed, therefore communications have been "halted."

## 3. Instrument Parameters

The Front Panel Board maintains a master copy of all of the AMS-4 Instrument Parameters and stores them in non-volatile RAM. The Front Panel Board will use these

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parameters to perform its normal counting operations and alarm determinations. Instrument Parameters maintained by the Front Panel Board which may be edited by the user are shown below. Changes to the following parameters will cause an "Operate Parameters Change" to be logged to the history file: Sigma factor, alpha subtract factor, gamma subtract factor, fixed beta bkg, beta efficiency, fixed flow rate, stack flow rate, logging interval, log to printer, and minimum analog value.

### HEAD SELECTION PARAMETER

The AMS4 allows the selection of either a Derived Concentration Head, for particulates and Iodines, or a Noble Gas Head, for measuring noble gases in a fixed volume. These heads are interchangeable by the operator. The default value is Particulate/Iodine.

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### ALPHA SUBTRACT FACTOR (ALPHA SUBTRCT FACTOR)

This is the factor which determines the radon progeny counts to be subtracted from the beta channel based on the counts detected in the alpha channel. This is also known as the beta to alpha ratio. The alpha channel count rate is multiplied by the alpha subtraction factor. This value is then subtracted from the beta channel count rate to yield the net beta count rate. Valid choices for this factor are 0-100. This feature is disabled if set to 0. The default value is 2.75.

### GAMMA SUBTRACT FACTOR (GAMMA SUBTRCT FACTOR)

This is the factor which determines the counts to be subtracted from the beta channel based on the counts detected in the gamma (background) channel. This is also known as the beta to gamma ratio. The background channel count rate is multiplied by the gamma subtraction factor. This value is then subtracted from the beta channel count rate to yield the net beta count rate. Valid choices for this factor are 0-100. This feature is disabled if set to 0. The default value is 1.

### FIXED BETA BACKGROUND (FIXED BETA BKG)

This value determines the assumed background count rate to be subtracted from the beta channel. This parameter is available for the user to input the known background count rate if the AMS-4 is not equipped with a background detector or if the background detector is out of service. Under normal operating conditions, if the AMS-4 is equipped with a background subtraction detector, this parameter should be set to 0. The total number of counts subtracted as background from the beta channel is the sum of the Fixed Beta Background rate, the background channel count rate times the Gamma Subtract Factor, and the alpha channel count rate times the Alpha Subtract Factor. The Fixed Beta Background default value is 0.0.

### FIXED FLOW RATE

This parameter determines the flow rate to be used in the concentration calculations if the AMS-4 is not equipped with a flow sensor. In most situations the AMS-4 will have a flow sensor and the concentration calculations will be based on the measured readings. To disable concentration calculations based on the Fixed Flow Rate, set the parameter to 0.0. If the Fixed Flow Rate is set to any non-zero number, the actual flow measured by the flow sensor will be disregarded. Valid fixed flow rates are 0.3 to 4 ft<sup>3</sup>/ min (or the equivalent in other units). The default Fixed Flow Rate is 0.0.

### STACK FLOW RATE

When the AMS-4 is used to perform stack flow monitoring the user must enter the known Stack Flow Rate in volume per unit time. This parameter is multiplied by the



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Slow Alarm Concentration to yield Release Rate. The units of Stack Flow Rate are determined by the user's selections in the Instrument Parameter menu. Stack monitoring is disabled if Stack Flow Rate is set to 0. The default Stack Flow Rate value is 0.0.

### BETA EFFICIENCY

The beta efficiency is a  $4\pi$  value which is calculated by the AMS-4 during calibration. Beta efficiency is defined as the percentage of counts detected compared to the nominal total counts possible from a known beta source. The beta efficiency is expressed as a percentage # 100%. The default beta efficiency is 10%.

### LOGGING INTERVAL

The logging interval determines the elapsed time between slow alarm concentration entries into the log data buffer. Information stored in the log data buffer is used to generate reports and/or update a polling host computer. The valid choices are 0-60 minutes. The default logging interval is 1 minute.

### LOG TO PRINTER

The user can connect a serial printer to the AMS-4 printer port for the purpose of on-line printing of concentration logging and status changes. To activate this feature select the parameter Log To Printer "ON." This feature has no relation to the Print Log Buffer feature. Log To Printer need not be "ON" to enable the use of the Print Log Buffer feature. The default value of Log To Printer is OFF.

### INSTRUMENT ADDRESS

This value is used to set the system level address of the instrument. If the AMS-4 is used in a stand alone mode, without communication to a host computer, the setting of this value is irrelevant. This address is used to give each AMS-4 a unique Instrument Address. Host computer communication failures will occur if more than one instrument is set to the same Instrument Address. This address must be specified by the user and the address must match an active host computer polling address. If the Front Panel Board address is changed, the Host port will be re-initialized to accept messages sent to the new address only. The valid address range is 1 to 255. The default Instrument Address is 1.

### HOST BAUD RATE

The Host Baud Rate selection refers only to the system level baud rate for communications between the Host (Central) Computer and the AMS-4. The Baud Rate selected must be the same as the user selected host computer baud rate. If these two

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baud rates are not the same, communication errors between the AMS-4 and the host computer will occur. Valid Baud Rate selections for communications to the host computer are: 150, 300, 600, 1200, 2400, 4800, 9600, or 19,200 (19.2K) bits per second. The default host communications Baud Rate is 19,200.

### uLAN MODE

If this value is set to YES, uLAN protocol is utilized in communications with the host computer. (An address marker bit is utilized in the address frame of a message.) If set to NO, non-uLAN protocol is used. The default setting is NO (off).

### CALIBRATION COUNT TIME (CALIB. COUNT TIME)

The length of a measurement interval (in seconds) while operating in the TEST mode. This determines the count time when using the detector efficiency and high voltage adjust routines. Valid Calibration Count Time values are 1 to 9999 seconds. The default value is 30 seconds.

### CALIBRATION SOURCE ACTIVITY (CALIB. SOURCE ACT.)

This is the activity of the beta source used in the TEST mode to calculate Beta Efficiency. The value of this source will be displayed in the units selected previously by the Activity Units menu item (Bq, DPS, DPM, or nCi). Default value is 1.00 Bq.

### COUNT UNITS

The Count Units select the unit of measure used when displaying count rates. Valid choices are CPM (counts per minute) or CPS (counts per second). The default units are CPM.

### FLOW UNITS

The Flow Units select the unit of measure used when displaying sampled air flow volume. Valid choices are FT3 (cubic feet), M3 (cubic meters), CM3 (cubic centimeters), or L (liters). The default flow unit is CM3.

### ACTIVITY UNITS

The Activity Units select the unit of measure used when displaying or printing activity and concentration measurements. Valid choices are Bq (becquerel), DPS (disintegrations per second), DPM (disintegrations per minute), or  $\mu$ Ci (micro curies). The default units are  $\mu$ Ci.

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If Activity Units are changed, other constants which are affected are multiplied by the appropriate factor such that the relative value of the activity is unchanged. The users should be aware that for sources with backscatter, the  $2\pi$  emission rate will not calculate directly into becquerels or curies because the backscatter factor is unknown. The user must take this matter into account.

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### TIME UNITS

The Time Units select the unit of time used when displaying the rate of air flow volume. Valid choices are MIN (minute), H (hour), or SEC (seconds). As an example, if Flow Units = FT3 and time units = min, the sample flow rate is displayed in the units of ft<sup>3</sup>/min. The default time unit is MIN.

### MINIMUM ANALOG OUTPUT VALUE (MIN ANALOG VALUE)

This parameter defines the concentration which will be used as the minimum value of the analog output. The analog output will then have a five decade logarithmic range above the selected Min Analog Value. The following equation is used to determine the

$$\text{Analog Output (Vdc)} = \text{Log}_{10} \left( \frac{\text{Current Slow Alarm Concentration}}{\text{Minimum Analog Output Value}} \right)$$

analog output voltage.

The units of the analog output are determined by the user selected units for activity and flow. The analog output has the range of 0-5 Vdc with a resolution of 255 bits. If the user selected 1 Bq/ft<sup>3</sup> as the minimum value this will correspond to an output of 0 Vdc. As an example, a concentration of 10 Bq/ft<sup>3</sup> will result in an analog output of 1 Vdc, and a concentration of 100,000 Bq/ft<sup>3</sup> will result in an analog output of 5 Vdc. A concentration of 50,000 Bq/ft<sup>3</sup> will result in an analog output of 4.7 Vdc ( $\log_{10}(50,000) = 4.7$  Vdc). The default Min Analog Value is 1 Bq/ft<sup>3</sup>.

### KEYPAD BEEP

If Keypad Beep is selected as "on" a beep will be heard each time a key is pressed. This beeping can be defeated by selecting "off". The default setting is ON.

### PASSWORD 1 and PASSWORD 2

Passwords are a number, containing up to four digits, which the user must enter using the keypad in order to enter the TEST mode. The default password numbers are "0000." The user may initially change either password number if he or she wishes. Valid selections of Test Password numbers contain up to four digits of any combination. Password 1 has the highest level of access and is able to edit from any menu in the system. Password 2 has the lowest level of access and is only allowed the priviledge of viewing all of the available system information.

## 4. Fail Parameters

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The following are various types of checks which are performed to determine a failure condition. If one or more of the following Fail Parameters is out of limits, the AMS-4 will suspend history logging, store the change of status condition(s) in the history buffer, illuminate the front panel Malfunction light, and actuate the Fail relay (if equipped). History logging will continue after all Fail Parameters are within limits. At this time the Malfunction light will turn off, the Fail relay will de-activate, and normal operation will resume. Changes to any of the Fail Parameters will log an "Operate Parameter Change" message into the history log.

### MINIMUM FLOW RATE (MIN FLOW RATE)

This is the flow rate value at which a minimum flow rate failure is determined. A measured flow rate which is less than this value will cause a Malfunction condition. 0.3 ft<sup>3</sup>/min.

### MAXIMUM FLOW RATE (MAX FLOW RATE)

This is the flow rate value at which a maximum flow rate failure is determined. A measured Valid settings are 0.3 to 4 ft<sup>3</sup>/min or the equivalent in other flow units. The default setting is 4 ft<sup>3</sup>/min.

### FLOW WEIGHT FACTOR

This is the weighting factor used in the following equation. This function is used to dampen fluctuations in the flow readings which could be caused by pump pulsations. Using a weighting factor of 0 will disable any effect of the weighted averaging. The larger the weighting factor used, the more the dampening effect will be realized. The default setting is 0.

$$Flow\ Average_{new} = \frac{(WF \bullet Flow\ Average_{old}) + R_{new}}{WF + 1}$$

Where:

Flow Average<sub>new</sub> = New weighted flow rate average

Flow Average<sub>old</sub> = Previous weighted flow average

WF = Flow weight factor

R<sub>new</sub> = Current non-weighted flow rate

The response time (T<sub>r</sub>) for a given weighting factor can be calculated with the following equation:

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$$T_r = \frac{5 \text{ Seconds}}{\log\left(\left(\frac{1}{\text{Flow Weight Factor}}\right) + 1\right)}$$

#### MINIMUM BETA COUNT RATE ( MIN BETA COUNT RATE)

The minimum beta count rate parameter determines the count rate value at which a failure is determined after each five second counting interval. A beta channel count rate less than this value will cause a Malfunction condition. The minimum setting for minimum beta count rate is 0 CPM. Setting the value to 0 will disable checking of this error. The default value is 0 CPM.

#### MAXIMUM BETA COUNT RATE (MAX BETA COUNT RATE)

The maximum beta count rate parameter determines the count rate value at which a failure is determined. A beta channel count rate greater than this value will cause a Malfunction condition. The default value is 600,000 CPM.

#### BETA WEIGHT FACTOR

This is the weighting factor used in the following equation. This function is used to dampen fluctuations in the beta channel count rate readings. Using a weighting factor of 0 will disable any effect of the weighted averaging. The larger the weighting factor used, the more the dampening effect will be realized. The default setting is 0.

$$\text{Beta Count Rate Average}_{new} = \frac{(WF \bullet \text{Beta Count Rate Average}_{old}) + R_{new}}{WF + 1}$$

Where:

Beta Count Rate Average<sub>new</sub> = New weighted beta channel count rate average

Beta Count Rate Average<sub>old</sub> = Previous weighted beta channel count rate average

WF = Beta weight factor

R<sub>new</sub> = Current non-weighted beta channel count rate

The response time (T<sub>r</sub>) for a given weighting factor can be calculated with the

$$T_r = \frac{5 \text{ Seconds}}{\log\left(\left(\frac{1}{\text{B Weight Factor}}\right) + 1\right)}$$

following equation:

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## 5. Alarm Parameters

### SLOW CONCENTRATION ALARM INTERVAL (SLOW ALARM INTERVAL)

The Slow Alarm Interval determines the amount of history that is used in determining the slow concentration. When calculating the slow concentration value the last x minutes of total count rate information is compared to the previous x minutes of total count rate information, where x is the slow alarm interval in minutes. The resulting concentration is then compared to the concentration slow alarm setpoint to determine if an alarm exists. Valid choices for slow alarm interval are 1 to 120 minutes in one minute increments. If a non-even increment is entered, the entry will be rounded to the nearest whole increment. The default slow alarm interval is 30 minutes.

### SLOW CONCENTRATION ALARM SETPOINT (SLOW ALARM SETPOINT)

The Slow Concentration Alarm Setpoint determines the concentration at which a slow concentration alarm will occur. The amount of history used to make this determination is defined by the Slow Alarm Interval. An alarm will be posted if the current interval of slow alarm concentration history exceeds the concentration of the previous history interval by the value specified by the slow alarm setpoint. This condition is checked every minute. When the alarm is posted the local and remote horns will sound until the appropriate alarm acknowledge button is pressed. The alarm acknowledge key on the base unit will silence the local and remote horn, the alarm acknowledge switch on the sampling head will silence only the remote horn. Additionally, when an alarm occurs a change of status is logged into the history file, the alarm relay will actuate (if equipped), and both the local strobe and the alarm light on the sampling head will turn on. The strobe, remote alarm light, and alarm relay will continue to be active until the alarm condition ceases. The default slow alarm setpoint is 10.59 Bq/ft<sup>3</sup>.

### FAST CONCENTRATION ALARM INTERVAL (FAST ALARM INTERVAL)

The Fast Alarm Interval determines the amount of history that is used in determining the fast concentration. When calculating the fast concentration value the last x seconds of total count rate information is compared to the previous x seconds of total count rate information, where x is the fast alarm interval in seconds. The resulting concentration is then compared to the concentration fast alarm setpoint to determine if an alarm exists. Valid choices for fast alarm interval are 5 to 255 seconds in five second increments. If a non-even increment is entered, the entry will be rounded to the nearest whole increment. The default fast alarm interval is 5 seconds.

### FAST CONCENTRATION ALARM SETPOINT (FAST ALARM SETPOINT)



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The Fast Concentration Alarm Setpoint determines the concentration at which a fast concentration alarm will occur. The amount of history used to make this determination is defined by the Fast Alarm Interval. An alarm will be posted if the current interval of fast alarm concentration history exceeds the concentration of the previous history interval by the value specified by the fast alarm setpoint. This condition is checked every 5 seconds. When the alarm is posted the local and remote horns will sound until the appropriate alarm acknowledge button is pressed. The alarm acknowledge key on the base unit will silence the local and remote horn, the alarm acknowledge switch on the sampling head will silence only the remote horn. Additionally, when an alarm occurs a change of status is logged into the history file, the alarm relay will actuate (if equipped), and both the local strobe and the alarm light on the sampling head will turn on. The strobe, remote alarm light, and alarm relay will continue to be active until the alarm condition ceases. The default fast alarm setpoint is 1059.07 Bq/ft<sup>3</sup>.

### BETA NET COUNT RATE ALARM INTERVAL (NET ALARM INTERVAL)

The Net Alarm Interval dictates the amount of history that is used in determining the displayed Net Beta Count Rate. The last x seconds of count rate information is summed. The result is then divided by x, where x is the Net Alarm Interval in seconds. This value is then compared to the Beta Net Count Rate Alarm Setpoint. If the currently displayed Net Beta Count Rate is equal to or greater than the associated alarm setpoint, an alarm will be posted. Valid choices for Net Alarm Interval are 5 to 255 seconds in five second increments. If a non-even increment is entered, the entry will be rounded to the nearest whole increment. The default Net Alarm Interval is 60 seconds.

### BETA NET COUNT RATE ALARM SETPOINT (NET ALARM SETPOINT)

The Beta Net Count Rate Alarm Setpoint determines the beta net count rate at which an alarm will occur. The amount of history used to make this determination is defined by the Net Alarm Interval. An alarm will be posted if the current history interval of beta net count rate exceeds the beta net count rate of the previous history interval by the amount selected as the net alarm setpoint. This condition is checked every 5 seconds. When the alarm is posted the local and remote horns will sound until the appropriate alarm acknowledge button is pressed. The alarm acknowledge key on the base unit will silence the local and remote horn, the alarm acknowledge switch on the sampling head will silence only the remote horn. Additionally, when an alarm occurs a change of status is logged into the history file, the alarm relay will actuate (if equipped), and both the local strobe and the alarm light on the sampling head will turn on. The strobe, remote alarm light, and alarm relay will continue to be active until the alarm condition ceases. The default net alarm setpoint is 60,000 CPM.

### STACK ALARM SETPOINT

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The Stack Alarm (Release Rate) Setpoint determines the activity per unit time at which a Stack Alarm will occur. An alarm will be posted if the current release rate is equal to or greater than the alarm setpoint. This condition is checked every minute. When the alarm is posted the local and remote horns will sound until the appropriate alarm acknowledge button is pressed. The alarm acknowledge key on the base unit will silence both the local and the remote horns, the alarm acknowledge switch on the sampling head will silence only the remote horn. Additionally, when an alarm occurs a change of status is logged into the history file, the alarm relay will actuate (if equipped), and both the local strobe and the alarm light on the sampling head will turn on. The strobe, remote alarm light, and alarm relay will continue to be active until the alarm condition ceases. The Stack Alarm is disabled if the alarm setpoint is 0. The default Stack Alarm setpoint is 0.

### DAC HOUR ALARM SETPOINT

The DAC Hour Alarm Setpoint determines the total DAC hours at which a DAC hour alarm will occur. An alarm will be posted if the current total DAC hour reading is equal to or greater than the alarm setpoint. The DAC hour total is updated, then compared to the DAC hour Alarm Setpoint every minute. When the alarm is posted the local and remote horns will sound until the appropriate alarm acknowledge button is pressed. The alarm acknowledge key on the base unit will silence both the local and the remote horns, the alarm acknowledge switch on the sampling head will silence only the remote horn. Additionally, when an alarm occurs a change of status is logged into the history file, the alarm relay will actuate (if equipped), and both the local strobe and the alarm light on the sampling head will turn on. The strobe, remote alarm light, and alarm relay will continue to be active until the alarm condition ceases. The DAC Hour Alarm is disabled if the alarm setpoint is 0. The default DAC Hour Alarm setpoint is 0.

## 6. Detector Parameters

A change to any of the Detector Parameters will cause a "Detector Parameter Change" status to be logged to the history file.

### THRESHOLD (ALPHA, BETA, BKG)

This parameter allows the user to change the threshold setting for the selected detector channel. The threshold is displayed as a percentage of full scale. This parameter is made available to the user for testing purposes. However, changing the threshold setting could affect the instrument operation. In general, the default threshold values will produce optimum operation. The default threshold setting for the alpha channel is 45%. The default threshold setting for beta and background (bkg) channels are 6%.

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### HIGH VOLTAGE (BETA, BKG)

The user can edit the beta and background (bkg) detector high voltage power supply outputs. Theoretically, the high voltage output can be adjusted from 10 to 2,500 Vdc in 256 increments (approximately 9.8 volts per increment). When the user edits the high voltage setpoint from the keypad, the AMS-4 will set its displayed high voltage output to the nearest full increment. In any case, the high voltage value displayed after user editing will be within 5 volts of the edited value. The true measured high voltage output should be within  $\nabla$  20 Vdc of the displayed value. If it is not, refer to the Maintenance section for instructions on high voltage calibration. To protect the detectors from over-voltage, the AMS-4 software does not allow the user to set the high voltage to a value greater than 1900 Vdc. Changing the high voltage setpoint can drastically change the operating point selected by the calibration program. If the high voltage setpoint is adjusted it should be returned to the value selected during calibration or, if this value is unknown, the AMS-4 must be recalibrated. The default high voltage for both detectors is 10 Vdc.

### 7. Select DAC

The AMS-4 provides the DAC value for five isotopes, Cs<sup>137</sup> -  $6.00 \times 10^{-8}$   $\mu\text{Ci}/\text{cm}^3$ ; Co<sup>60</sup> -  $1.00 \times 10^{-8}$   $\mu\text{Ci}/\text{cm}^3$ ; Tc<sup>99</sup> -  $3.00 \times 10^{-7}$   $\mu\text{Ci}/\text{cm}^3$ ; Sr<sup>90</sup> -  $2.00 \times 10^{-9}$   $\mu\text{Ci}/\text{cm}^3$ ; and C<sup>14</sup> -  $2.97 \times 10^{-10}$   $\mu\text{Ci}/\text{cm}^3$ ; I<sup>123</sup> -  $3.00 \times 10^{-6}$   $\text{uCi}/\text{cm}^1$ ; I<sup>133</sup> -  $2.00 \times 10^{-8}$   $\text{uCi}/\text{cm}^1$ ; Kr<sup>85</sup> -  $1.00 \times 10^{-4}$   $\text{uCi}/\text{cm}^1$ ; Xe<sup>133</sup> -  $1.00 \times 10^{-4}$   $\text{uCi}/\text{cm}^1$ . The AMS-4 also provides one extra undefined isotope for the user to make a different isotope or a custom mix of isotopes. This new isotope may be added via the editing capabilities of the host program.

To select one of the predefined isotopes choose "SELECT DAC" from the main menu. Use the arrow keys to scroll to the isotope of interest, then press enter. The AMS-4 will then make all of the DAC calculations based upon the selected isotope. If the isotope selection is changed an "Instrument Parameter Change" status will be logged to the history file.

### 8. Date/Time

The Date/Time menu allows the user to view and edit the AMS-4 calendar/clock. If this menu item is selected the current instrument date is displayed as mm/dd/yy where mm is the month, dd is the day of the month, and yy is the last two digits of the year. To change the instrument date press [Edit], then enter the correct date. If the user does not wish to change the date press [Enter]. Press [9] to display the current time. The time is displayed in a 24 hour clock format (i.e. 3:30 pm is displayed as 15:30). The clock will display hh:mm:ss where hh is the hour, mm is minutes, and ss is

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seconds. To change the instrument clock press [Edit], then enter the correct time. If the user does not wish to change the time press [Enter]. The program will return to the main menu after the [Menu] key is pressed.

### 9. Print Log Buffer

The user may print a listing of the current Concentration or Status logs by connecting the appropriate serial printer to the AMS-4 printer port and selecting the Print Log Buffer menu item. The required communications format for the serial printer is listed in the Specifications section of this manual. The user must use the arrow keys to select either a Concentration or Status logging printout. After the selection is confirmed by pressing [Enter], the display will prompt the user to enter the start time and date followed by the ending time and date for the logged information of interest.

A printout of the Concentration log contains the time stamped readings for each logging interval of the Concentration Slow Alarm value and the flow volume. The Concentration log logging interval is determined by the logging interval selected in the Instrument Parameters menu. A printout of the Status log contains the time stamped status changes which occurred during the specified interval. Included with the Status log entries are the slow concentration value and the flow volume at the time of the status change. If the slow concentration is not enabled at the time of the status change, "Na" will be substituted for the slow concentration reading.

### 10. Calibrate

Parameters under the Calibrate menu can significantly affect the accuracy of the AMS-4 readings. Because of this any time one of these items is selected a scrolling message is posted to warn the user that entering this routine will terminate the current history logging and will start a new history log upon exiting. Pressing [Menu] at this point will return the user to the main menu without disturbing the history logging, pressing [Enter] will cause the AMS-4 to proceed with the selected routine. At this point the instrument enters an abnormal operating state, the Malfunction front panel light is illuminated and the Fail relay is actuated. This Malfunction condition will continue until the selected routine is exited. Upon exiting the AMS-4 will purge all previous history, similar to power on or after a filter paper change.

#### CALIBRATE FLOW

This is used to calibrate the flow sensor. For specific information regarding flow sensor calibration refer to the Maintenance section of this manual.

#### BETA EFFICIENCY

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The Beta Efficiency menu allows the AMS-4 to calculate the efficiency for the beta detector channel. For specific information regarding beta efficiency determination refer to the Maintenance section of this manual.

### SOURCE CHECKING

The Source Checking menu allows the AMS-4 to calculate the efficiency and the efficiency differential (from the stored efficiency) for the beta detector channel. For specific information regarding beta efficiency determination refer to the Maintenance section of this manual. This menu does not allow the user to save efficiency information.

### HIGH VOLTAGE ADJUST

The High Voltage Adjust feature allows the user to adjust the high voltage power supply output while viewing the current count rates of the selected detector channel. This is provided for users who wish to run a high voltage plateau without connecting the AMS-4 to a computer. After selecting this menu item the user may scroll through the sub-menu using the [9] and [8] keys to display the detector of interest, either beta or background (bkg), then press [Enter] to select. If the beta detector is selected the alpha counts will be displayed on the top line, the beta counts on the bottom line. The instrument will continually count for the amount of time specified by the Instrument Parameter Calib. Count Time. The time remaining in the counting interval is displayed as "T," the current high voltage is displayed as "HV." After each count time interval the average count rate during the counting interval is displayed. The high voltage can be adjusted at any time by pressing [9] or [8]. Each time an arrow key is pressed the high voltage setpoint will increment or decrement (depending on which key is pressed) approximately 10 volts. After changing the High Voltage output value the user must either return the High Voltage setpoint to the value previously selected by the last calibration or recalibrate the AMS-4.

### GAMMA FACTOR COUNT

This is a utility used to determine the appropriate Gamma Subtract Factor for a particular operating area. Due to varying gamma fields from location to location, it is recommended that the operator use this routine during initial set up in a particular area. When selected the instrument will count until both the beta channel and the background channel have at least 400 counts. Obtaining a minimum of 400 counts from each detector channel provide a statistical accuracy of at least  $\nabla$  10%. After the counts are summed, the total counts of the beta channel are divided by the total counts of the background channel. The instrument then displays the result. If the user wishes to save this factor as the Instrument Parameter Gamma Subtract Factor, press [Enter] to

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save. Pressing [Menu] will discard the value and the previous Gamma Subtract Factor will remain unchanged.

### 11. Test Inputs/Outputs

The AMS-4 provides several utilities which can be used to test instrument functions for proper operation. The following is a brief description of each.

#### VIEW LATEST

This utility allows the user to view the current count rates for each of the detector channels (beta, alpha, and background) and the current air flow sampling rate. The units of measure are determined by selections made in the Instrument Parameters menu.

#### PRINTER

This provides a way for the user to verify proper connection to a serial printer. Connect the printer to the AMS-4 printer port using the appropriate cable. Select "Printer" from the sub-menu. If the AMS-4 is communicating with the printer properly, the message "PRINT TEST OK" will be printed. If an error exists, verify that the printer is configured for the proper data format and baud rate (refer to the AMS-4 specifications in Section 1 of this manual). Also verify that the proper cable is being used. Please compare the wiring pinout of the cable being used to the printer cable diagram on the AMS-4 Interconnecting Cables drawing in the Drawings section of this manual.

#### KEYPAD

The Keypad check allows the user to verify proper keypad operation. The keys can be tested one at a time. The display will indicate which key was pressed. If [Menu] is pressed the instrument will terminate the keypad test routine.

#### OUTPUTS

This menu item allows the user to test the "local" outputs on the AMS-4 base unit. When the user selects this menu item the malfunction (fail) light, ready light, alarm strobe, horn, alarm relay (optional), malfunction (fail) relay (optional), LED bar display, and the 0-5 volt analog output can be tested one at a time to verify proper operation. When testing the LED bar display and the analog output press [Edit] and key in the value you wish to display or output, then press [Enter]. The LED bar display is intended to provide an approximate reading, therefore its accuracy is limited

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to  $\nabla$  5%. All outputs will return to their proper operational condition after exiting this routine.

### REMOTE OUTPUTS

This menu item allows the user to test the "remote" outputs on the AMS-4 sampling head. When the user selects this menu item the remote horn and remote alarm light can be tested one at a time to verify proper operation. All outputs will return to their proper operational condition after exiting this routine.

### REMOTE INPUTS

The remote input check menu allows the user to verify the operation of the switches in the sampling head. The inputs include the remote alarm acknowledge switch and the filter door switch. To test the switches select Remote Inputs from the main menu by pressing [Enter]. Use the arrow keys to scroll to the switch of interest. The current position of the switch is displayed. Actuate the switch being displayed and status will change.

## 12. Versions

This item will display the current program version in each computer controlled board installed in the AMS-4. These boards include the Front Panel Board, the Beta Detector Board, and the Background (bkg) Detector Board.

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### 13. Reset

The Reset feature can be used if the user wishes to clear the accumulated concentration history. Selecting Reset will not change any other operation parameters. A Reset is invoked after [Enter] is pressed while the display reads "RESET." During the reset process the message "PERFORMING RESET" is displayed. After the reset is complete "RESET COMPLETE" is displayed momentarily, then the display returns to the main menu.

### 14. Cold Start

Selecting the Cold Start item from the main menu will essentially set all operating parameters in the AMS-4 to their default values. In addition, all data stored in the History and Logging Buffers will be lost, user configured isotope DAC values will be lost, and the calibration of the AMS-4 will become void. If the user selects this command, the message "[ENTER] TO CONFIRM" is displayed. If the user wishes to issue the Cold Start command, press [Enter]. Pressing any other key will abort the command and return the user to the main menu. The user should use caution when issuing this command.



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### SECTION 2. OPERATING THE INSTRUMENT

#### A. INITIAL SETUP

The AMS-4 is tested and calibrated by the manufacturer and leaves the plant with controls and parameters set so that operation may begin in the customer's facility with a minimum of adjustment. The operational parameters may be inspected and changed if desired as indicated in Section 1 of this manual.

The operating thresholds, and detector high voltage operating points will be set during calibration. It should not be necessary to adjust these unless the user wishes to calibrate the instrument for an isotope which is different than the one used for calibration. Please refer to the calibration instructions in the Maintenance Section (Section 3) of this manual for further details.

Check instrument function as follows:

1. Verify the sampling head communications cable is connected to J3 on the rear chassis of the AMS-4 base unit.
2. Place a clean filter on the air inlet of the sampling head. Close the detector housing (filter door).
3. If the Integrated Pump Option is not installed connect a vacuum pump with a 0.3 to 4 CFM capacity to the sampling head. Turn the vacuum pump on.
4. Plug the power cord into the appropriate grounded AC receptacle which provides 85-264 Vac, at 50-60 Hz. Move the AC power switch located on the upper right portion of the rear panel to the ON position. If equipped with the integrated pump option, place the pump power switch on the rear panel to the ON position.
5. Following a few initialization messages the display will post the message "Obtaining History".
6. Press [Menu]. Enter the default password, 0000, followed by [Enter]. Use the arrow keys to scroll through the menu until "TEST INPUTS/OUTPUTS" is displayed. Press [Enter] to select. Scroll through the sub-menu and test the input and output functions as desired using the diagnostic routines provided. For further explanation of each diagnostic routine refer to Section 1.D.11 of this manual.
7. After input/output testing is complete, press [Menu] repeatedly until the AMS-4 returns to the operating mode.

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### B. ROUTINE MONITORING

Routine beta particulate monitoring using the AMS-4 begins with the user selecting the desired Instrument Parameters, Alarm Parameters, and Fail Parameters. These parameters are discussed at length in Section 1.D of this manual. The user is encouraged to read this section before continuing.

After the operating parameters are set and before a filter paper is in place the user should perform a Gamma Factor determination using the utility provided in the test menu. Place the sampling head in the position in which the monitoring is to be performed. Press [Menu] then enter the password. Select "Calibrate" from the main menu, then select "Gamma Factor Count" from the sub-menu. The instrument will then count until the beta and the background channels have at least 400 counts. The ratio of the beta channel counts to background channel counts is then determined. This factor, if updating is selected, will replace the Gamma Subtract Factor in the Instrument Parameters menu.

The user should then place a clean filter on the air intake of the sampling head. The vacuum pump and the AMS-4 can then be turned on. Beta particulate monitoring will begin automatically.

The AMS-4 will initially display the message "OBTAINING HISTORY". This message will remain posted until five seconds have elapsed. At this time a message is posted indicating the Beta Net Count Rate Alarm is enabled assuming the minimum detectable net count rate (MDNCR) is below the selected alarm setpoint. After ten seconds the Concentration Fast Alarm is enabled, provided that the Concentration Fast Alarm minimum detectable concentration (MDC) is less than the Concentration Fast Alarm setpoint. Similarly, the Concentration Slow Alarm is enabled after two minutes have elapsed. At this point the front panel Ready light is turned on. Any of the five alarms (fast concentration, slow concentration, net beta count rate, stack, or DAC hours) can be disabled by setting its corresponding alarm setpoint to 0.

The AMS-4 will continuously log history and update the display provided that no errors occur. Errors which will cause the AMS-4 to suspend history logging are described in Section 1.D.1. If the filter door is opened during history logging the display will prompt the user to close the door or to press the Alarm Acknowledge key if the filter paper was changed. If the filter door remains open for more than 10 seconds the instrument suspends logging. After the filter door is closed history will be reset and beta monitoring will resume.

### C. DISPLAYED STATUS CHANGES

During routine operation the AMS-4 will update the display any time that a status change occurs. The status change will remain posted on the display for several seconds, then the

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previous information will once again be displayed. While in the operational mode the user can use the arrow keys to scroll to the last display page and view all existing abnormal or current operating conditions. If the instrument is fully operational with no failed conditions the message "INSTRUMENT STATUS NORMAL" is displayed. Below is a list of possible displayed status change messages and a brief description of their meaning.

### START FAST ALARM MONITORING

The elapsed time since power-on or reset is at least ten seconds, the fast alarm minimum detectable concentration is less than the fast alarm setpoint, and the fast alarm setpoint is greater than zero.

### START BETA ALARM MONITORING

The elapsed time since power-on or reset is at least five seconds, the beta minimum detectable net count rate is less than the beta net count rate alarm setpoint, and the beta net count rate alarm is greater than zero.

### START SLOW ALARM MONITORING

The elapsed time since power-on or reset is at least two-minutes, the fast alarm minimum detectable concentration is less than the slow alarm setpoint, and the slow alarm setpoint is greater than zero.

### NO FAST ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode) or the fast alarm minimum detectable concentration is greater than the fast alarm setpoint.

### NO BETA ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode) or the beta minimum detectable net count rate is greater than the beta net count rate alarm setpoint.

### NO SLOW ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode) or the slow alarm minimum detectable concentration is greater than the fast alarm setpoint.

### DETECTOR NORMAL

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The detector previously had a failure but is now operating normally.

#### FLOW RATE OK

The weighted average flow rate was out of limits, but is now within limits.

#### BETA COUNT RATE OK

The weighted average beta count rate was out of limits, but is now within limits.

#### NORMAL OPERATE MODE

The instrument was in calibrate mode but is now in normal operate mode.

#### FAST ALARM DETECTED

The fast alarm concentration is currently greater than the fast alarm concentration setpoint.

#### BETA ALARM DETECTED

The beta net count rate is currently greater than the beta net count rate alarm setpoint.

#### SLOW ALARM DETECTED

The slow alarm concentration is currently greater than the slow alarm concentration setpoint.

#### STACK ALARM DETECTED

The current stack release rate is greater than the stack alarm setpoint.

#### DAC ALARM DETECTED

The current DAC hour total is greater than the DAC hour alarm setpoint.

#### FAST ALARM CONDITION ENDED

The fast alarm concentration is no longer greater than the fast alarm concentration setpoint.

#### BETA ALARM CONDITION ENDED

The beta net count rate is no longer greater than the beta net count rate alarm setpoint.

#### SLOW ALARM CONDITION ENDED

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The slow alarm concentration is no longer greater than the slow alarm concentration setpoint.

STACK ALARM CONDITION ENDED

The current stack release rate is no longer greater than the stack alarm setpoint.

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### OPERATE PARAMETER CHANGE

A parameter affecting instrument operation has been changed, either from the host or from the keypad. A change of any of the following parameters causes this status to be logged:

ALPHA SUBTRACT FACTOR, GAMMA SUBTRACT FACTOR, FIXED BETA BKG, FIXED FLOW RATE, BETA EFFICIENCY, MIN FLOW RATE, MAX FLOW RATE, STACK FLOW RATE, FLOW WEIGHT FACTOR, MIN BETA COUNT RATE, MAX BETA COUNT RATE, BETA WEIGHT FACTOR, LOGGING INTERVAL, LOG TO PRINTER, MIN. ANALOG VALUE, SLOW ALARM INTERVAL, SLOW ALARM SETPOINT, FAST ALARM INTERVAL, FAST ALARM SETPOINT, NET ALARM INTERVAL, NET ALARM SETPOINT, STACK ALARM SETPOINT, DAC HOUR ALARM SETPOINT.

### DETECTOR PARAMETER CHANGE

A detector parameter (threshold or high voltage) has been changed.

### POWER INTERRUPT

The instrument experienced a power failure but power was restored within 10 seconds. History continues undisturbed following this condition.

## D. LOGGED STATUS CHANGES

Each time a status change occurs the condition, along with the associated time, date, current slow alarm concentration, and the total flow volume is entered into the log buffer. These status changes can be printed by selecting "Status" from the Print Log Buffer feature in the Test menu or they can be retrieved by the host computer. The following is a brief description of all possible logged status changes.

### START FAST ALARM MONITORING

The elapsed time since power-on or reset is at least ten seconds, the fast alarm minimum detectable concentration is less than the fast alarm setpoint, and the fast alarm setpoint is greater than zero.

### START BETA ALARM MONITORING

The elapsed time since power-on or reset is at least five seconds, the beta minimum detectable net count rate is less than the beta net count rate alarm setpoint, and the beta net count rate alarm is greater than zero.

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### START SLOW ALARM MONITORING

The elapsed time since power-on or reset is at least two-minutes, the slow alarm minimum detectable concentration is less than the slow alarm setpoint, and the slow alarm setpoint is greater than zero.

### NO FAST ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode) or the fast alarm minimum detectable concentration is greater than the fast alarm setpoint.

### NO BETA ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode) or the beta minimum detectable net count rate is greater than the beta net count rate alarm setpoint.

### NO SLOW ALARM MONITORING

A fail condition has occurred (flow fail, beta count rate fail, detector fail, filter door open, or calibrate mode) or the slow alarm minimum detectable concentration is greater than the slow alarm setpoint.

### DETECTOR FAIL

The instrument has detected a communication failure, a high voltage failure, or the Modular Detector Board software is operating in a mode not supported by the AMS-4.

### LOW FLOW FAIL BELOW MIN FLOW

The current weighted average flow rate is less than the minimum flow rate.

### HIGH FLOW FAIL ABOVE MAX FLOW

The weighted average flow rate is greater than the maximum flow rate.

### LOW BETA FAIL BELOW MIN BETA

The weighted average beta count rate is less than the minimum beta count rate.

### HIGH BETA FAIL ABOVE MAX BETA

The weighted average beta count rate is greater than the maximum beta count rate.



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### FILTER DOOR OPEN OUT OF SERVICE

The filter door is open and the acknowledge key has been pressed, or the door has been open for more than ten seconds.

### CALIBRATE MODE

The host computer is performing a remote calibration of the instrument, or the instrument has been placed in calibrate mode because of performing a source efficiency check, a flow calibration, or a high voltage adjustment.

### DETECTOR NORMAL

The detector previously had a failure but is now operating normally.

### FLOW RATE OK

The weighted average flow rate was out of limits, but is now within limits.

### BETA COUNT RATE OK

The weighted average beta count rate was out of limits, but is now within limits.

### FILTER DOOR CLOSED

The filter door was open but is now closed.

### NORMAL OPERATE MODE

The instrument was in calibrate mode but is now in normal operate mode.

### PRIMARY ACKNOWLEDGE

Following a fail or alarm condition the alarm acknowledge key on the keypad was pressed.

### REMOTE ACKNOWLEDGE

The alarm acknowledge switch on the remote head has been pressed when a fail condition or alarm condition currently exists or previously existed and the acknowledge switch was not pressed.

### FAST ALARM DETECTED

The fast alarm concentration is currently greater than the fast alarm concentration setpoint.

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### BETA ALARM DETECTED

The beta net count rate is currently greater than the beta net count rate alarm setpoint.

### SLOW ALARM DETECTED

The slow alarm concentration is currently greater than the slow alarm concentration setpoint.

### STACK ALARM DETECTED

The current stack release rate is greater than the stack alarm setpoint.

### DAC ALARM DETECTED

The current DAC hour total is greater than the DAC hour alarm setpoint.

### FAST ALARM CONDITION ENDED

The fast alarm concentration is no longer greater than the fast alarm concentration setpoint.

### BETA ALARM CONDITION ENDED

The beta net count rate is no longer greater than the beta net count rate alarm setpoint.

### SLOW ALARM CONDITION ENDED

The slow alarm concentration is no longer greater than the slow alarm concentration setpoint.

### STACK ALARM CONDITION ENDED

The current stack release rate is no longer greater than the stack alarm setpoint.

### OPERATE PARAMETER CHANGE

A parameter affecting instrument operation has been changed, either from the host, from the keypad. Changing the following parameters causes this status to be logged:

ALPHA SUBTRACT FACTOR, GAMMA SUBTRACT FACTOR, FIXED BETA BKG, FIXED FLOW RATE, BETA EFFICIENCY, MIN FLOW RATE, MAX FLOW RATE, STACK FLOW RATE, FLOW WEIGHT FACTOR, MIN BETA COUNT RATE, MAX BETA COUNT RATE, BETA WEIGHT FACTOR, LOGGING INTERVAL, LOG TO PRINTER, MIN. ANALOG VALUE, SLOW

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ALARM INTERVAL, SLOW ALARM SETPOINT, FAST ALARM INTERVAL, FAST ALARM SETPOINT, NET ALARM INTERVAL, NET ALARM SETPOINT, STACK ALARM SETPOINT, DAC HOUR ALARM SETPOINT.

### DETECTOR PARAMETER CHANGE

A detector parameter has been changed.

### POWER INTERRUPT

The instrument experienced a power failure but power was restored within 10 seconds. History continues undisturbed following this condition.

### RESET HISTORY

The five-second and one-minute history files have been flushed.

### FILTER DOOR OPEN

The filter door was opened. If the filter door is closed within ten seconds the monitor will continue operating as normal. If the acknowledge key is pressed while the filter door is open the monitors history will be reset. If the filter door is left open for 10 seconds or longer the monitor will go out of service until the door is closed. After the door is closed the history will be reset.

## E. RECOMMENDED INSTRUMENT PARAMETERS

To edit or view the Instrument Parameters, enter the test mode by pressing [Menu] and entering the current password. Use the [8] or [9] keys to scroll through the main menu until INSTRUMENT PARAMETERS appears on the display, then press [Enter]. Press [9] to advance through the Instrument Parameters sub-menu. To change any parameter value press [Edit], then key in the new value followed by [Enter].

Until the user is more familiar with the system, Eberline recommends that the following values be entered for each operating parameter.

Parameter	Recommended Value
Alpha Subtract Factor	2.75
Gamma Subtract Factor	1.0
Fixed Beta Bkg	0.0

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Parameter	Recommended Value
Fixed Flow Rate	0.0
Logging Interval	1 minute

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### SECTION 3. MAINTENANCE

#### A. GENERAL INFORMATION

The standard AMS-4 electronic package consists of one Front Panel Board, an Analog Board, and a Bar Graph Display Board. The sampling head board set is comprised of two Modular Detector Boards and a Flow Sensor Board. The Front Panel Board and the Modular Detector Boards have an 80C51FA microcontroller with an RS-485 communications interface.

The Front Panel Board acts as the "Master" controller and Modular Detector Boards are "slave" boards. The Front Panel Board downloads the operating parameters to the slave boards in the sampling head and retrieves information from them at the appropriate times. Each of the slave boards are uniquely identified by a communications address.

The Modular Detector Boards (MDBs) amplify the detector signals and discriminate the Alpha and Beta pulses. These pulses are then counted and stored into memory. The MDBs then provide the count rate data to the Master upon request. The amplifier gain is fixed to a nominal value and the thresholds are adjusted under software control by the on-board microcontroller. The threshold levels can only be changed from the TEST menu by editing the Detector Parameters, or by using the Host Computer program.

The high voltage adjustment on the MDBs is also controlled by the on-board microcontroller. The high voltage output can be adjusted from the TEST menu using High Voltage Adjust (located under Calibrate), by editing Detector Parameters, or by using the Host Computer program. The MDBs do have a high voltage calibration potentiometer. For proper calibration of the high voltage output refer to Section 3.C. of this manual.

The Flow Sensor Board outputs a frequency which is proportional to the measured air flow. This frequency is then counted by one of the MDBs. The Front Panel Board retrieves this information and converts it into flow rate. The Flow Sensor Board and air manifold needle valve located in the sampling head should be checked for accuracy each time the AMS-4 is calibrated. Details regarding flow sensor calibration are located in Section 3.E. of this manual.

#### B. TROUBLESHOOTING

Some common sources of trouble are as follows:

1. Low count rate due to loss of gas through a ruptured detector face. If a detector face is ruptured the detector must be replaced.

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2. Excessive count rate may be due to moisture on the detector board, moisture on the coax cable connections or in the detector anode clip, or radioactive contamination of the detector or surrounding areas. Contamination may usually be removed with a soft brush or water rinse but the user should exercise caution as the mica window on the detector is very fragile.
3. A low or no count condition may be due to a loss of high voltage. Check the high voltage output with a high voltage probe and voltmeter. Refer to Modular Detector Board (Section 8) for detailed information concerning the high voltage output circuitry.
4. Electronic problems in the logic or counting circuits are most easily traced through substitution or swapping of the failed boards. Individual integrated circuits are mounted in sockets to facilitate troubleshooting.
5. When communicating with Eberline concerning improper instrument operation, provide the program names and versions of all computer controlled boards in the AMS-4. These items may be viewed in the MENU mode by selecting the Version menu item.
6. Any time that an EPROM which has a different version number than the previous EPROM is installed into the Front Panel Board all operating parameters are reset when the unit is first turned on. This will cause the AMS-4 to operate using the default parameters. The user should reconfigure AMS-4 according the previous operating parameters before the monitor is returned to service.

### C. HIGH VOLTAGE CALIBRATION

The measured high voltage output of each MDB should be within  $\pm 20$  volts of their respective displayed high voltage setpoints. If the high voltage outputs are not within this range the user might consider doing a high voltage calibration. The user should be aware that calibrating the high voltage outputs will change the plateau operating point selected by the instrument calibration program. The AMS-4 should be completely recalibrated after the high voltage output is calibrated.

To calibrate the high voltage output the user must remove the detector(s) and measure high voltage at the anode clip or open the sampling head and detach the MDB from its bracket. The high voltage can then be measured at the point the coax cable is connected. Use a high voltage probe and a voltmeter to measure the high voltage output and record this value. With the AMS-4 turned off, remove the jumper at position 1 of JP1-6 on the MDB. Turn the power to the AMS-4 on and measure the high voltage. Adjust the potentiometer R10 until the high voltage output is 1250 Vdc  $\pm 5$  Vdc. Replace the jumper on position 1 at JP1-6. Turn the power off, then back on. The user should then set the high voltage operating point back to its previously measured value. When entering the previously measured value, the AMS-4 will round this value to the nearest setpoint.

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### D. COMPUTER CALIBRATION - RADIAL HEAD

Calibration of the AMS-4 is most easily performed through the use of the Host Computer program. This program is used as a tool for determining the optimum operating high voltage point for each of the two detectors and for determining beta detector efficiency.

The program also contains editing tools for changing Host, Instrument, Operate, and Detector parameter files, and the DAC isotope list. Included are utilities which allow the user to perform various functions regarding the history buffer.

This program runs on an IBM PC/XT personal computer or compatible clone which has CGA, EGA, or VGA graphics capability, and runs DOS version 3.3 or any higher version number operating system.

#### 1. Connecting The Computer

To connect the AMS-4 to a computer, connect the cable (Eberline Part Number CA-41-80) from the serial port of the computer (COM1, or COM2) to the Central Computer serial communications port on the AMS-4.

#### 2. Preparing The Instrument

To begin calibration the AMS-4 should be in the Operate mode. If RS-232 level communications are to be used by the computer the AMS-4 must also be using RS-232 communications. The proper configuration for RS-232 communications requires that a MAX233 chip be installed in socket A27 and socket A29 must be vacant on the AMS-4 Front Panel Board (the large board inside of the base unit). If RS-485 level communications are to be used by the computer the AMS-4 must also be using RS-485 communications. The proper configuration for RS-485 communications requires that socket A27 be vacant and a LTC485, DS3695 or equivalent chip must be installed in socket A29 of the Front Panel Board.

#### 3. Starting The Program

Load DOS into the memory of the computer (boot the computer). Insert the diskette containing the AMS-4 calibration computer program in the diskette drive of the computer. Change directory to the root directory of the diskette. For example type: A: <enter>; CD \ <enter>. Now type the name of the AMS-4 Host Computer program, which is "AMS4HOST".

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When using a monochrome display the user must type "AMS4HOST BW" to display properly. A space must be included between AMS4HOST and BW.

After having typed the name of the program, the program will load into the computer's memory. This can take a minute or so depending on the speed of the computer. After loading into memory, the AMS-4 copyright logo will be displayed (you can limit the time the logo is displayed by pressing any key on the computer keyboard).

### 4. Performing A Computer Calibration

Select "Edit" from the main menu, then "Detector Parameters" from the sub-menu. Verify the *Detector Parameters* are set as follows: The beta and background channel thresholds to 6%, the alpha channel threshold to 45%. All the above parameters are printed on the calibration report. Press [Esc] to continue.

Select "Calibrate" from the main menu, then "Calibrate instrument" from the sub-menu. An informational message is displayed. Press a key to continue. Now an "entry box" will prompt the user to enter the instrument serial number. Enter the serial number as it appears on the serial number tag of the instrument. After entering the serial number, an entry box will prompt for the user ID. Enter a name or employee ID, etc.

Configure the Plateau Parameter file with all pertinent information and desired calibration parameters. Typical values are: Start Voltage 1300, Stop Voltage 1750, and Step Voltage 10, Maximum Count Rate 500 CPS (30,000 CPM). **Note:** The maximum count rate value will depend on the activity of the calibration source.

A prompt will appear to perform a background plateau, this is optional and may be run if so desired. Next, select "Yes" when prompted to perform a Source Plateau on the Beta detector. Several calculations are required to determine the count time and calibration source activity.

A source which has a minimum active area diameter of 40 mm (1.57") must be used. If the source used has an active area of greater than 40 mm use the following equation to determine the ratio of the open area diameter to the diameter of the active source area and thus, the source shielding factor. Note the diameter of the filter paper opening of the radial head is 40.64mm or 1.6".

$$\text{Source Shielding Factor} = \frac{(40.64\text{mm})^2 \text{ Dia. of Filter Paper Opening}}{(\text{Diameter of Source Active Area})^2}$$



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If backscatter of the source is a factor, then use the following equation to determine the calibration source activity. Use only the CPM value of the source in the calculation. The result is the effective DPM value.

Install Equation Editor and double-click here to view equation.

Example: If the  $2\pi$  value of the source is 80,000 CPM and the Source Shielding Factor is 0.86 (source active dia.= 44mm), then 137,600 should be entered as the calibration source activity.

$$\text{Source Count Time (seconds)} = \frac{9,000,000}{\text{Calibration Source Activity}}$$

Use the following equation to determine the appropriate Source Count Time. Using this equation will ensure a 2% counting accuracy. Enter the calculated Source Count Time. The user is then prompted to enter the source field information, in this case the beta isotope and the effective  $4\pi$  activity of the source to be used. The source activity value entered must be the effective  $4\pi$  activity value and must include any effects due to backscatter or shielding by the filter paper holder.

Place the specified beta source in the center of the air manifold with the active side facing the detector assembly. Wait 20 to 30 seconds until the high voltage settles to the starting voltage, then press a key to continue. The displayed count rate values for the source plateau subtract out the values obtained during background plateau and thus net count rates are displayed. After the plateau is complete press [Enter] to continue.

The source plateau is now displayed. Use the computer arrow keys to position the cursor at the operating point you wish to use, then press [F2] to select the point. The high voltage operating point should always be selected at or just above the knee of the beta channel curve, at a point where the alpha channel count rate is less than 5% of the beta channel count rate. After the beta detector high voltage operating point is selected, press [Enter] to continue the calibration.

The next step is to perform a source plateau on the background (gamma) detector and determine the proper high voltage operating point. Select the desired count time (30 to 60 seconds is adequate for a 5-10 mR/h  $^{137}\text{Cs}$  field). When prompted, enter the source field information. Place the sampling head in a  $^{137}\text{Cs}$  or other gamma field of about 5-10 mR/h. After the Background Detector plateau is complete press [Enter] to continue.

Use the computer arrow keys to position the cursor at the desired high voltage operating point, then press [F2] to select. The selected high voltage operating point should always be at or just above the knee of the high voltage plateau.

Beta efficiency must then be determined. Edit the beta efficiency source information file with the parameters of the source to be used. All information entered will be

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printed on the calibration report. The computer will automatically perform a half-life correction to the calibration source activity based on the last calibration date and the entered calibration source half-life. A half-life correction is not performed if the half-life parameter is set to 0. It is imperative that the calibration source activity value (effective  $4\pi$  activity) be determined by the method discussed above. The calibration program will use the corrected source activity value when determining the beta efficiency. After the proper parameters are entered, press [Esc] to continue. Select "Save and Exit" if you wish to save changes. Enter the background count time, typically 60 seconds. The computer prompts the user to remove all radioactive sources from the area in preparation for a background count. Press a key to continue. The background count rate will now be determined. After the background accumulation is complete the program prompts the user to enter the source counting time. Position the calibration beta source in the center of the air manifold with the active side of the source facing the detector housing. Press a key to continue. The source count is now conducted and the detector efficiency is determined.

The calibration is now complete. The high voltage operating points and the beta efficiency determined during the calibration are automatically downloaded to the AMS-4. Connect a printer which has graphics capability to the parallel port of the computer and print the calibration report. This report includes an AMS-4 certificate of calibration, which includes the selected operation parameters and beta efficiency determination. Also included are the beta detector source plateau data and graph; the background detector source plateau data and graph; and the background plateau data.

The alpha subtraction factor may vary slightly depending on the particulate being measured. The default value of the alpha subtraction factor is 2.75. The user may wish to change this factor if their environment causes the ratio of beta counts to alpha counts, while filter activity is in equilibrium, to be significantly different. The alpha subtraction factor can be determined by running a scaler count while the filter activity is in equilibrium and dividing the beta channel counts by the alpha channel counts. The scaler count utility is located under the main menu item "Util" of the AMS-4 Host Computer program.

### **E. COMPUTER CALIBRATION - IN-LINE HEAD**

Calibration of the AMS-4 is most easily performed through the use of the Host Computer program. This program is used as a tool for determining the optimum operating high voltage point for each of the two detectors and for determining beta detector efficiency.

The program also contains editing tools for changing Host, Instrument, Operate, and Detector parameter files, and the DAC isotope list. Included are utilities which allow the user to perform various functions regarding the history buffer.

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This program runs on an IBM PC/XT personal computer or compatible clone which has CGA, EGA, or VGA graphics capability, and runs DOS version 3.3 or any higher version number operating system.

### 1. Connecting The Computer

To connect the AMS-4 to a computer, connect the cable (Eberline Part Number CA-41-80) from the serial port of the computer (COM1, or COM2) to the Central Computer serial communications port on the AMS-4.

### 2. Preparing The Instrument

To begin calibration the AMS-4 should be in the Operate mode. If RS-232 level communications are to be used by the computer, the AMS-4 must also be using RS-232 communications. The proper configuration for RS-232 communications requires that a MAX233 chip be installed in socket A27 and socket A29 must be vacant on the AMS-4 Front Panel Board (the large board inside of the base unit). If RS-485 level communications are to be used by the computer the AMS-4 must also be using RS-485 communications. The proper configuration for RS-485 communications requires that socket A27 be vacant and a LTC485, DS3695 or equivalent chip must be installed in socket A29 of the Front Panel Board.

**NOTE:** The AMS-4 In-line head originally shipped with Eberline # TUPR2 (LND part # 49730) detector tubes. Later in production TUPR4 (LND part # 49742) tubes were implemented. These detector tubes are not interchangeable, each head assembly must have two of same tube type. It is necessary to identify which type detector is installed prior to calibration. Examine the high voltage settings listed on the last calibration certificate or check the detector parameters on the AMS-4, by using the arrow keys to select *DETECTOR PARAMETERS* from the main menu. Press [ENTER] to select. Use the arrow keys to scroll through the sub-menu. If Beta and Bkg high voltage settings are around 800-1000Vdc then most likely the TUPR2 detectors are installed. If Beta and Bkg high voltage settings are around 1300-1500Vdc then most likely the TUPR4 detectors are installed. Otherwise if not certain of detector type, remove one of the detectors, note the LND number and compare to the numbers above. Units shipped after the first quarter of 1994 used the TUPR4 tubes exclusively.

Verify the Beta High Voltage and Bkg High Voltage is set around 800 Vdc for the **TUPR2** detectors. Verify the Beta High Voltage and Bkg High Voltage is set around 1200 Vdc for the **TUPR4** detectors.

### 3. Starting The Program

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Load DOS into the memory of the computer (boot the computer). Insert the diskette containing the AMS-4 calibration computer program in the diskette drive of the computer. Change directory to the root directory of the diskette. For example type: A: <enter>; CD \ <enter>. Now type the name of the AMS-4 Host Computer program, which is "AMS4HOST".

When using a monochrome display the user must type "AMS4HOST BW" to display properly. A space must be included between AMS4HOST and BW.

After having typed the name of the program, the program will load into the computer's memory. This can take a minute or so depending on the speed of the computer. After loading into memory, the AMS-4 copyright logo will be displayed (you can limit the time the logo is displayed by pressing any key on the computer keyboard).

### 4. Performing A Computer Calibration

Select "Edit" from the main menu, then "Detector Parameters" from the sub-menu. Set the threshold levels as shown below for the applicable detector tube. All the above parameters are printed on the calibration report. Press [Esc] to continue.

Select "Calibrate" from the main menu, then "Calibrate instrument" from the sub-menu.

An informational message is displayed. Press a key to continue. Now an "entry box" will prompt the user to enter the instrument serial number. Enter the serial number as it appears on the serial number tag of the instrument. After entering the serial number, an entry box will prompt for the user ID. Enter a name or employee ID, etc.

The Plateau Parameter File will be displayed to allow editing the plateau start, stop and step voltages. Set the plateau voltages and detector parameters as follows:

#### **For use with Eberline Part #TUPR2 (LND Part #49730) detector tubes only:**

Plateau Start Voltage: 800	Alpha Threshold: 45%
Plateau Stop Voltage: 950	Beta Threshold: 3%
Plateau Step Voltage: 10	Bkg Threshold: 3%

#### **For use with Eberline Part #TUPR4 (LND Part #49742) detector tubes only:**

Plateau Start Voltage: 1350	Alpha Threshold: 45%
Plateau Stop Voltage: 1650	Beta Threshold: 6%
Plateau Step Voltage: 10	Bkg Threshold: 6%

If necessary, change by entering "Y" to the prompt: "Do you wish to change any of the above?" Enter new values as instructed. When values are as indicated, enter "N" to the "Do you wish to change any of the above?" prompt.

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A prompt will appear to perform a background plateau, this is optional and may be run if so desired. Next, select "Yes" when prompted to perform a Source Plateau on the Beta detector. Several calculations are required to determine the count time and calibration source activity.

The plateau should be performed using a 47mm (1 7/8") <sup>99</sup>Tc source with an activity of at least 80,000 CPM (2π). When prompted to enter the count time in seconds, use the following equations to determine the actual "Calibration Source Activity" and then the "Source Count Time". Note the diameter of the filter paper opening of the in-line head

$$\text{Source Shielding Factor} = \frac{(28.96\text{mm})^2 \text{ Dia. of Filter Paper Opening}}{(\text{Diameter of Source Active Area})^2}$$

is 1.14" or 28.96mm.

Calibration Source Activity: Due to the shielding of the head assembly, the calibrated DPM value of the source cannot be used. Therefore, use the following equations to determine the value to enter as the Calibration Source Activity. Use only the CPM

$$\text{Calibration Source Activity} = (\text{Source Shielding Factor})(2 \bullet \text{Source CPM value})$$

value of the source in the calculation. The result is the effective DPM value.

Example: If the source used has a CPM (2π) value of 90,000, and the source shielding factor = 0.44 (source active dia.= 44mm), then corresponding Calibration Source Activity value would be 79,200.

Source Count Time: Use the following equation to determine the appropriate Source

$$\text{Source Count Time (seconds)} = \frac{9,000,000}{\text{Calibration Source Activity}}$$

Count Time.

After entering the calculated source count time, an entry box will prompt for the source info. Input the isotope and source serial number as should appear on the calibration report.

Position the <sup>99</sup>Tc source disc in the filter paper holding ring with the active side facing the detector. Pause about 20 seconds for the high voltage to settle, then press [Enter] to continue. After the source plateau is complete, press [Enter] to display a graph of the source plateau. Use the computer arrow keys to position the cursor at the optimum high voltage operating point, then press [Enter] to select the point. The high voltage operating point should always be selected at or just above the knee of the beta channel curve, at a point where the alpha channel count rate is less than 5% of the beta channel count rate. After the beta detector high voltage operating point is selected, press [Enter] to continue the calibration. Remove the source disc from the head assembly.

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### NOTE:

If the appropriate operating point is not found because the "Plateau Stop Voltage" was too low, increase the "Plateau Stop Voltage" by 50 Vdc and repeat the plateau. Repeat as necessary. The detectors can be permanently damaged by over-voltage conditions. Do not apply higher voltages to the detectors than is necessary for finding the plateau. If you hear the detector discharging, terminate the plateau immediately.

The next step is to perform a source plateau on the background (gamma) detector and determine the proper high voltage operating point. Select the desired count time, 60 seconds is adequate when using a 5-10 mR/h  $^{137}\text{Cs}$  field. When prompted, enter the source field information. Place the sampling head in a 5-10 mR/h  $^{137}\text{Cs}$  or other gamma field. If using a point source, the exposure should be from the side of the sampling head. After the background detector plateau is complete press [Enter] to continue. Use the computer arrow keys to position the cursor at the high voltage operating point you wish to use, then press [F2] to select. The high voltage operating point should be at or just above the knee of the high voltage plateau.

Beta efficiency must then be determined. Edit the beta efficiency source information file with the parameters of the source to be used. All information entered will be printed on the calibration report. The computer will automatically perform a half-life correction to the calibration source activity based on the last calibration date and source half-life input. A half-life correction is not performed if the half-life parameter is set to 0. The activity units should be set to DPM. It is imperative that the calibration source activity value (effective  $4\pi$  activity) be determined by the method discussed above. The calibration program will use the corrected source activity value when determining the beta efficiency. After the proper parameters are entered, press [Esc] to continue. Select "Save and Exit" if you wish to save changes. Enter the background count time, typically 60 seconds. The computer prompts the user to remove all radioactive sources from the area in preparation for a background count. Press a key to continue. The background count rate will now be determined. After the background accumulation is complete the program prompts the user to enter the source counting time, typically 60 seconds. Position the calibration beta source in the center of the air manifold with the active side of the source facing the detector housing. Press a key to continue. The source count is now conducted and the detector efficiency is determined.

The calibration is now complete. The high voltage operating points and the beta efficiency determined during the calibration are automatically downloaded to the AMS-4. Connect a printer which has graphics capability to the parallel port of the computer and print the calibration report. This report includes an AMS-4 certificate of calibration, which includes the selected operation parameters and beta efficiency

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determination. Also included are the beta detector source plateau data and graph; the background detector source plateau data and graph; and the background plateau data.

The alpha subtraction factor may vary slightly depending on the particulate being measured. The default value of the alpha subtraction factor is 2.75. The user may wish to change this factor if their environment causes the ratio of beta counts to alpha counts, while filter activity is in equilibrium, to be significantly different. The alpha subtraction factor can be determined by running a scaler count while the filter activity is in equilibrium and dividing the beta channel counts by the alpha channel counts. The scaler count utility is located under the main menu item "Util" of the AMS-4 Host Computer program.

### **F. COMPUTER CALIBRATION - NOBLE GAS HEAD**

Calibration of the AMS-4 is most easily performed through the use of the Host Computer program. This program is used as a tool for determining the optimum operating high voltage point for each of the two detectors and for determining beta detector efficiency.

The program also contains editing tools for changing Host, Instrument, Operate, and Detector parameter files, and the DAC isotope list. Included are utilities which allow the user to perform various functions regarding the history buffer.

This program runs on an IBM PC/XT personal computer or compatible clone which has CGA, EGA, or VGA graphics capability, and runs DOS version 3.3 or any higher version number operating system.

#### **1. Connecting The Computer**

To connect the AMS-4 to a computer, connect the cable (Eberline Part Number CA-41-80) from the serial port of the computer (COM1, or COM2) to the Central Computer serial communications port on the AMS-4.

#### **2. Preparing The Instrument**

To begin calibration the AMS-4 should be in the Operate mode. If RS-232 level communications are to be used by the computer the AMS-4 must also be using RS-232 communications. The proper configuration for RS-232 communications requires that a MAX233 chip be installed in socket A27 and socket A29 must be vacant on the AMS-4 Front Panel Board (the large board inside of the base unit). If RS-485 level communications are to be used by the computer the AMS-4 must also be using RS-485 communications. The proper configuration for RS-485 communications requires that

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socket A27 be vacant and a LTC485, DS3695 or equivalent chip be installed in socket A29 of the Front Panel Board.

### 3. Starting The Program

Load DOS into the memory of the computer (boot the computer). Insert the diskette containing the AMS-4 calibration computer program in the diskette drive of the computer. Change directory to the root directory of the diskette. For example type: A: <enter>; CD \ <enter>. Now type the name of the AMS-4 Host Computer program, which is "AMS4HOST".

When using a monochrome display the user must type "AMS4HOST BW" to display properly. A space must be included between AMS4HOST and BW.

After having typed the name of the program, the program will load into the computer's memory. This can take a minute or so depending on the speed of the computer. After loading into memory, the AMS-4 copyright logo will be displayed (you can limit the time the logo is displayed by pressing any key on the computer keyboard).

### 4. Performing A Computer Calibration

Select "Edit" from the main menu, then "Detector Parameters" from the sub-menu. Verify the *Detector Parameters* are set as follows: The beta and background channel thresholds to 6%, the alpha channel threshold to 45%. All the above parameters are printed on the calibration report. Press [Esc] to continue.

Select "Calibrate" from the main menu, then "Calibrate instrument" from the sub-menu. An informational message is displayed. Press a key to continue. Now an "entry box" will prompt the user to enter the instrument serial number. Enter the serial number as it appears on the serial number tag of the instrument. After entering the serial number, an entry box will prompt for the user ID. Enter a name or employee ID, etc.

Configure the *Plateau Parameter* file with all pertinent information and desired calibration parameters. Typical values are: Start Voltage 1300, Stop Voltage 1750, and Step Voltage 10, Maximum Count Rate 1000 CPS (60,000 CPM), using the AMS4 OPT11 source.

Verify the *Detector Parameters* are set as follows: The beta and background channel thresholds to 6%, the alpha channel threshold to 45%. All the above parameters are printed on the calibration report. Press [Esc] to continue.



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A prompt will appear to perform a background plateau, this is optional and may be run if so desired. Otherwise, the next step is to perform a source plateau on the beta detector (inner detector of the chamber). Select "Yes" when prompted to perform a Source Plateau on the Beta detector. Enter the source count time, typically 60 seconds if using the AMS4 OPT11 source. The user is then prompted to enter the source field information, in this case the beta isotope and the  $4\pi$  activity of the source (AMS4 OPT11) to be used. Since it is impractical to perform radioactive gas calibrations on the AMS-4 Noble Gas Sampling Head every time calibration is required, Eberline has performed a primary gas calibration with  $^{85}\text{Kr}$  and  $^{133}\text{Xe}$  and transferred the primary calibration to a  $^{99}\text{Tc}$  solid source so that AMS-4s can be easily field calibrated. The  $^{99}\text{Tc}$  Noble Gas Calibration Transfer Standard source is available from Eberline as an option to the AMS-4, part number AMS4 OPT11. This primary calibration is documented in Eberline Engineering Document 12000-A67.

The AMS4 OPT11 source consists of approximately 400K dpm  $^{99}\text{Tc}$  source plated onto a rod which is mounted in a fixture which guarantees a consistent geometry when inserted in the gas chamber. Place the beta source rod through the hose barb at the end of the gas chamber. Verify that the source index cap is resting against the rear of the chamber, this ensures proper positioning of the source in the chamber. Wait 20 to 30 seconds until the high voltage settles to the starting voltage, then press a key to continue.

After the plateau is complete press [Enter] to continue. The source plateau is now displayed. Use the computer arrow keys to position the cursor at the operating point you wish to use, then press [F2] to select the point. The high voltage operating point should always be selected at or just above the knee of the beta channel curve, at a point where the alpha channel count rate is less than 5% of the beta channel count rate. After the beta detector high voltage operating point is selected, press [Enter] to continue the calibration. Remove the source from the chamber.

The next step is to perform a source plateau on the background (gamma) detector and determine the proper high voltage operating point. Enter the desired count time (30 to 60 seconds is adequate for a 5-10 mR/h  $^{137}\text{Cs}$  field). When prompted, enter the source field information. Place the sampling head in a  $^{137}\text{Cs}$  or other gamma field of about 5-10 mR/h. If using a point source, the exposure should be from the side of the sampling head. After the Background Detector plateau is complete press [Enter] to continue. Use the computer arrow keys to position the cursor at the optimum high voltage operating point, then press [F2] to select. The selected high voltage operating point should always be at or just above the knee of the high voltage plateau.

Beta efficiency must then be determined. Edit the beta efficiency source information file with the parameters of the same source (AMS4 OPT11) used to run the source plateau on the beta detector. All information entered will be printed on the calibration report. The computer will automatically perform a half-life correction to the

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calibration source activity based on the last calibration date and the entered calibration source half-life. A half-life correction is not performed if the half-life parameter is set to 0.

The calibration program will use the corrected source activity value when determining the beta efficiency. After the proper parameters are entered, press [Esc] to continue. Select "Save and Exit" if you wish to save changes. Enter the background count time, typically 60 seconds. The computer prompts the user to remove all radioactive sources from the area in preparation for a background count. Press a key to continue. The background count rate will now be determined. After the background accumulation is complete the program prompts the user to enter the source counting time. Typically 60 seconds is sufficient. Place the beta source rod (AMS4 OPT11) through the hose barb at the end of the gas chamber. Verify that the source index cap is resting against the rear of the chamber, to ensure proper positioning of the source in the chamber. Press a key to continue. The source count is now conducted and the detector efficiency is determined.

The efficiency must now be adjusted to establish the desired noble gas efficiency. For a  $^{85}\text{Kr}$  calibration, multiply the  $^{99}\text{Tc}$  source efficiency by 1.338 and enter the new efficiency manually into the AMS-4. For a  $^{133}\text{Xe}$  calibration, multiply the  $^{99}\text{Tc}$  source efficiency by 0.917 and enter the new efficiency manually into the AMS-4.

**NOTE:** The correction factor for  $^{85}\text{Kr}$  is greater than the  $^{133}\text{Xe}$  correction factor since  $^{85}\text{Kr}$  (250 keV, 100%) is a stronger beta emitter than  $^{133}\text{Xe}$  ( $E_{\text{avg}} = 100$  keV, 100%). The relationship between the solid source efficiency and the gas efficiency has no direct bearing (other than as a transfer standard) since the counting geometries are very dissimilar between the two. Using the transfer standard efficiency correction factors provides a calibration referenced to standard temperature (22°C) and pressure (760 mm Hg).

The calibration is now complete. The high voltage operating points and the beta efficiency determined during the calibration are automatically downloaded to the AMS-4. Connect a printer which has graphics capability to the parallel port of the computer and print the calibration report. This report provides an AMS-4 certificate of calibration, which includes the selected operation parameters and beta efficiency determination. Also included are the beta detector source plateau data and graph; the background detector source plateau data and graph; and the background plateau data.

## G. MANUAL CALIBRATION - RADIAL HEAD

### 1. Initial Setup

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Prior to a manual AMS-4 calibration there are a number of parameters that must be configured. The following is a list of parameters which must be set to the required values. Several calculations may be required to determine these parameters.

### INSTRUMENT PARAMETERS

#### Calib. Source Act.

The magnitude of calibration source value. Units are determined by Instrument Parameter selection. The value entered must be the effective  $4\pi$  activity value and must include any effects due to backscatter or shielding by the filter paper holder. A source which has a minimum active area diameter of 40mm (1.57") must be used. If the source used has an active area of greater than 40mm use the following equation to determine the ratio of the open area diameter to the diameter of the active source area and thus, the source shielding factor. Note the diameter of the filter paper opening of the radial head is 40.64mm or 1.6".

$$\text{Source Shielding Factor} = \frac{(40.64\text{mm})^2 \text{ Dia. of Filter Paper Opening}}{(\text{Diameter of Source Active Area})^2}$$

If backscatter of the source is a factor, then use the following equation to determine the calibration source activity. Use only the CPM value of the source in the calculation. The result is the effective DPM value and should be input as the *Calib. Source Act.*

$$\text{Calibration Source Activity} = (\text{Source Shielding Factor})(2 \bullet \text{Source CPM value})$$

parameter.

Example: If the  $2\pi$  value of the source is 80,000 CPM and the Source Shielding Factor is 0.86 (source active dia.= 44mm), then 137,600 should be entered as the calibration source activity.

#### Calib. Count Time

Use the following equation to determine the appropriate Source Count Time. This count time interval will be used during the background and source plateau. Enter this

$$\text{Source Count Time (seconds)} = \frac{9,000,000}{\text{Calibration Source Activity}}$$

result as the *Calib. Count Time* parameter.

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### DETECTOR PARAMETERS

Set the beta and background (bkg) channel thresholds to 6%. Set the alpha channel thresholds to 45%. If average background count rates without a filter paper in place exceed 100 counts per minute in the beta and background channels, raise the threshold. If the alpha channel background count rate exceeds 5 counts per minute, raise the threshold.

### 2. Selecting The High Voltage

The first step in the calibration process is to determine the high voltage operating point for the beta detector. This can be done using the High Voltage Adjust routine located under *Calibrate* in the Test menu. After selecting High Voltage Adjust and Beta Detector press the [8] or [9] key until the displayed high voltage reading is about 1300 Vdc. Place the beta calibration source in the filter paper holder with the active area facing the detectors. Record the source readings for the alpha and beta channels. The alpha reading is on the top display line, beta reading is on the bottom line. Press the [8] key to increase the high voltage and wait for the reading to be displayed. Continue running the source plateau until the high voltage is about 1750 Vdc.

Graph the results with the high voltage on the x-axis and the count rate on the y-axis. Select the beta detector high voltage operating point at or just above the knee of the plateau. At the selected operating point the alpha channel count rate should be less than 5% of the beta channel count rate. Use the arrow keys to set the high voltage to the proper value. Remove the beta source.

Select High Voltage Adjust - Background Detector. Perform a source plateau in the same manner described above. Place the centerline of the detectors within the sampling head in a  $^{137}\text{Cs}$  field of 5-10 mR/h. Graph the results with the high voltage on the x-axis and the count rate on the y-axis. Select the background detector high voltage operating point at or just above the knee of the plateau.

### 3. Beta Efficiency

Select Beta Efficiency from the Calibrate sub-menu. Remove all sources from the area. The AMS-4 will count for the amount of time specified by the instrument parameter "Cal.Count Time." The count rate obtained will determine the background. After the background count is complete place the beta calibration source in the filter paper holder with the active side facing the detectors. Press a key and the source count rate will be determined. The AMS-4 will then determine the  $4\pi$  efficiency relative to the calibration source used. Press [Enter] to store this value, otherwise press [Menu] to discard.

## H. MANUAL CALIBRATION - IN-LINE HEAD

### 1. Initial Setup

Prior to a manual AMS-4 calibration there are a number of parameters that must be configured. The following is a list of parameters which must be set in the AMS-4.

#### NOTE:

The AMS-4 In-line head originally shipped with Eberline # TUPR2 (LND part # 49730) detector tubes. Later in production TUPR4 (LND part # 49742) tubes were implemented. These detector tubes are not interchangeable, each head assembly must have two of same tube type. It is necessary to identify which type detector is installed prior to calibration. Examine the high voltage settings on the last calibration certificate or check the detector parameters on the AMS-4. Use the arrow keys to select Detector Parameters from the main menu. Press [ENTER] to select. Use the arrow keys to scroll through the sub-menu. If Beta and Bkg high voltage settings are around 800-1000Vdc then most likely TUPR2 detectors are installed. If Beta and Bkg high voltage settings are around 1300-1500Vdc then most likely TUPR4 detectors are installed. Otherwise if not certain of detector type, remove one of the detectors, note the LND number and compare to the numbers above. Units shipped after the first quarter of 1994 used the TUPR4 tubes exclusively.

Verify the Beta High Voltage and Bkg High Voltage is set around 800Vdc for the **TUPR2** detectors. Verify the Beta High Voltage and Bkg High Voltage is set around 1300Vdc for the **TUPR4** detectors.

#### INSTRUMENT PARAMETERS

##### Calib. Count Time

This count time interval will be used during the background and source plateau. Suggested minimum value in seconds:  $t = 9,000,000 / \text{effective } 4\pi \text{ activity (DPM) of calibration source to be used.}$

##### Calib. Source Act.

The magnitude of calibration source value. Units are determined by Instrument Parameter selection. The value entered must be the effective  $4\pi$  activity value and must include any effects due to backscatter or shielding by the filter paper holder. A source which has a minimum active area diameter of 40 mm (1.57") must be used. If the source used has an active area of greater than 40 mm use the following equation to

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determine the ratio of the open area diameter to the diameter of the active source area

$$\text{Source Shielding Factor} = \frac{(28.96\text{mm})^2 \text{ Dia. of Filter Paper Opening}}{(\text{Diameter of Source Active Area})^2}$$

and thus, the source shielding factor.

If backscatter of the source is a factor, then twice the  $2\pi$  emission rate, multiplied by the Source Shielding Factor should be entered as the calibration source activity. Example: If the  $2\pi$  value of the source is 80,000 CPM and the Source Shielding Factor is 0.44 (source active dia. = 44mm), then 70,400 should be entered as the calibration source activity.

### DETECTOR PARAMETERS

Set the beta, background (bkg) and alpha channel thresholds to the following depending on which detector tube is installed. If average background count rates without a filter paper in place exceed 100 counts per minute in the beta and background channels, raise the threshold. If the alpha channel background count rate exceeds 5 counts per minute, raise the threshold.

#### **For use with Eberline Part # TUPR2 (LND Part #49730) detector tubes only:**

Alpha Threshold: 45%  
Beta Threshold: 3%  
Bkg Threshold: 3%

#### **For use with Eberline Part # TUPR4 (LND Part #49742) detector tubes only:**

Alpha Threshold: 45%  
Beta Threshold: 6%  
Bkg Threshold: 6%

## 2. Selecting The High Voltage

The first step in the calibration process is to determine the high voltage operating point for the beta detector. This can be done by running plateaus on the detectors using the High Voltage Adjust routine located under *Calibrate* of the Test menu. After selecting High Voltage Adjust and Beta Detector press the [8] or [9] key until the displayed high voltage reading is about 800 Vdc for the TUPR2 or 1300 Vdc for the TUPR4. Place the beta calibration source in the filter paper holder with the active area facing the detectors. Run a source high voltage plateau by recording the source readings for the alpha and beta channels. The alpha reading is on the top display line, beta reading is on the bottom line. Press the [8] key to increase the high voltage and wait for the reading to be displayed. Continue running the source plateau in this manner until the high voltage is about 1000 Vdc for the TUPR2 or about 1750 Vdc for the TUPR4.

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Graph the results with the high voltage on the x-axis and the count rate on the y-axis. Select the beta detector high voltage operating point at or just above the knee of the plateau. At the selected operating point the alpha channel count rate should be less than 5% of the beta channel count rate. Use the arrow keys to set the high voltage to the proper value. Remove the beta source.

Select High Voltage Adjust - Background Detector. Perform a source plateau in the same manner as described above for the beta detector. Place the centerline of the detectors within the sampling head in a  $^{137}\text{Cs}$  field of 5-10 mR/h. Run a source high voltage plateau in the same manner the previous plateau was taken. Graph the results with the high voltage on the x-axis and the count rate on the y-axis. Select the background detector high voltage operating point at or just above the knee of the plateau.

### 3. Beta Efficiency

Select Beta Efficiency from the Calibrate sub-menu. Remove all sources from the area. The AMS-4 will count for the amount of time specified by the instrument parameter "Cal.Count Time." The count rate obtained will determine the background. After the background count is complete place the beta calibration source in the filter paper holder with the active side facing the detectors. Press a key and the source count rate will be determined. The AMS-4 will then determine the  $4\pi$  efficiency relative to the calibration source used. Press [Enter] to store this value, otherwise press [Menu] to discard.

## I. MANUAL CALIBRATION - NOBLE GAS SAMPLING HEAD

### 1. Initial Setup

Prior to a manual AMS-4 calibration there are a number of parameters that must be configured. The following is a list of parameters in the AMS-4 which must be assigned values.

#### INSTRUMENT PARAMETERS

##### Calib. Count Time

This count time interval will be used during the background and source plateau. Typically 30 to 60 seconds depending on the source activity.

## AMS-4

Calib. Source Act.

The magnitude of calibration source value. Units are determined by Instrument Parameter selection. The value entered must be the  $4\pi$  activity value.

### DETECTOR PARAMETERS

Set the beta and background (bkg) channel thresholds to 6%. Set the alpha channel thresholds to 45%. If average background count rates without a filter paper in place exceed 100 counts per minute in the beta and background channels, raise the threshold. If the alpha channel background count rate exceeds 5 counts per minute, raise the threshold.

#### 2. Selecting The High Voltage

The first step in the calibration process is to determine the high voltage operating point for the beta detector. This can be done using the High Voltage Adjust routine located under *Calibrate* in the Test menu. After selecting High Voltage Adjust and Beta Detector press the [8] or [9] key until the displayed high voltage reading is about 1300Vdc.

Since it is impractical to perform radioactive gas calibrations on the AMS-4 Noble Gas Sampling Head every time calibration is required, Eberline has performed a primary gas calibration with  $^{85}\text{Kr}$  and  $^{133}\text{Xe}$  and transferred the primary calibration to a  $^{99}\text{Tc}$  solid source so that AMS-4s can be easily field calibrated. This  $^{99}\text{Tc}$  Noble Gas Calibration Transfer Standard source is available from Eberline as an AMS-4 option, part number AMS4 OPT11. This primary calibration is documented in Eberline Engineering Document 12000-A67.

The AMS4 OPT11 source consists of approximately 400K dpm  $^{99}\text{Tc}$  source plated onto a rod which is mounted in a fixture which guarantees a consistent geometry when inserted in the gas chamber. Place the beta source rod through the hose barb at the end of the gas chamber. Verify that the source index cap is resting against the rear of the chamber, this ensures proper positioning of the source in the chamber. Run a source high voltage plateau by recording the source readings for the alpha and beta channels at each high voltage setting. The alpha reading is on the top display line, beta reading is on the bottom line. Press the [8] key to increase the high voltage and wait for the next reading to be displayed. Continue running the source plateau in this manner until the high voltage is about 1750Vdc. Graph the results with the high voltage on the x-axis and the count rate on the y-axis. Select the beta detector high voltage operating point at or just above the knee of the plateau. At the selected operating point the alpha channel count rate should be less than 5% of the beta channel count rate. Use the arrow keys to set the high voltage to the proper value. Remove the beta source.



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Select High Voltage Adjust - Background Detector. The next step is to perform a source plateau on the background (gamma) detector in the same manner as the previous plateau. Enter the source field information. Place the sampling head in a  $^{137}\text{Cs}$  or other gamma field of about 5-10 mR/h. If using a point source, the exposure should be from the side of the sampling head. Graph the results with the high voltage on the x-axis and the count rate on the y-axis. Select the background detector high voltage operating point at or just above the knee of the plateau. At the selected operating point the alpha channel count rate should be less than 5% of the beta channel count rate. Use the arrow keys to set the high voltage to the proper value.

### 3. Beta Efficiency

Select Beta Efficiency from the Calibrate sub-menu. Remove all sources from the area. The AMS-4 will count for the amount of time specified by the instrument parameter "Cal.Count Time." The count rate obtained will determine the background. After the background count is complete, place the beta source rod (AMS4 OPT11) through the hose barb at the end of the gas chamber. Verify that the source index cap is resting against the rear of the chamber. Press a key and the source count rate will be determined. The AMS-4 will then calculate the  $4\pi$  efficiency relative to the calibration source used.

The efficiency must now be adjusted to establish the desired noble gas efficiency. For a  $^{85}\text{Kr}$  calibration, multiply the  $^{99}\text{Tc}$  source efficiency by 1.338 and enter the new efficiency manually into the AMS-4. For a  $^{133}\text{Xe}$  calibration, multiply the  $^{99}\text{Tc}$  source efficiency by 0.917 and enter the new efficiency manually into the AMS-4.

**NOTE:** The correction factor for  $^{85}\text{Kr}$  is greater than the  $^{133}\text{Xe}$  correction factor since  $^{85}\text{Kr}$  (250 keV, 100%) is a stronger beta emitter than  $^{133}\text{Xe}$  ( $E_{\text{avg}} = 100$  keV, 100%). The relationship between the solid source efficiency and the gas efficiency has no direct bearing (other than as a transfer standard) since the counting geometries are very dissimilar between the two. Using the transfer standard efficiency correction factors provides a calibration referenced to standard temperature (22°C) and pressure (760 mm Hg).

## J. FLOW SENSOR CALIBRATION

The mass flow sensor should be recalibrated each time a radiological calibration is performed. A vacuum pump with a capacity of 1-4 CFM (28-113 lpm) is recommended for the calibration. The user must select CALIBRATE from the AMS-4 Test menu. From the sub-menu select CALIBRATE FLOW. Open the sampling head. Using a DVM, adjust potentiometer R11 on the Flow Sensor Board until the "O" terminal of A3 (LM317) is 10.00 Vdc  $\nabla$  0.02 Vdc with respect to ground. Turn the vacuum pump off, then press any key to

#### AMS-4

continue. Adjust potentiometer R6 until the displayed count rate is 2000 CPS  $\nabla$  10 CPS. Press a key to continue.

Place a highly accurate mass flow meter in-line between the vacuum pump and sampling head. Turn on the pump and measure the air flow rate through the sampling head. Press [Edit] then enter this value into the AMS-4 as the pump flow rate. The air manifold valve must now be adjusted. This small brass valve is located on the black nylon air manifold in the radial inlet head. It is mounted on a rectangular aluminum block in the in-line head. Adjust the air manifold valve until the count rate on the bottom display line is within  $\nabla$  2% of the count rate on the top display line. Press a key to continue and the flow calibration is now complete.

## **SECTION 4. DRAWINGS**



































## AMS-4

AMS-4 Noble Gas Head Plumbing Diagram, 11562-C131

**AMS-4**

AMS-4 Noble Gas Head Schematic, 11562-C130

**AMS-4**

AMS-4 Interconnecting Cables, 11562-D85



## AMS-4

### SECTION 5. AVAILABLE OPTIONS

**The following is a list of the features included with a standard AMS-4:**

1. Two sealed gas-proportional detectors. One monitors the filter paper counting beta particles and alpha particles due to radon daughters. The other detector measures ambient gamma background.
2. Mass Air Flow Sensor.
3. RS-232 host computer interface including computer controlled calibration through the use of a user provided IBM PC/XT compatible computer.
4. Wide range voltage input. 85-264 Vac, 50-60 Hz.
5. Serial printer interface which prints on-line readings and status changes or selected history logs.
6. 0-5 Volt, five decade logarithmic analog output.
7. Large red alarm strobe.

If the customer wishes, the following options may be purchased. The Eberline part number is shown in parentheses. Due to the configuration of the AMS-4 if you would like to purchase both the relay option and the RS-485 option, order option 5 rather than option 3 and option 4.

#### **A. INTEGRATED PUMP OPTION (AMS4 OPT1)**

The Integrated Pump option consists of a 2.1 CFM (60 LPM) unregulated vacuum pump mounted into a bolt-on module. Power to the vacuum pump is provided by the AMS-4 base unit. The pump is 110 Vac, 60 Hz, single phase.

#### **B. PORTABLE SERIAL PRINTER (AMS4 OPT2)**

This option includes a small, lightweight, battery powered thermal serial printer, five rolls of thermal printer paper, and an interconnecting cable. This printer can easily be carried to the AMS-4 for the purpose of printing the concentration or status change history. The AMS-4 stores the most recent 2000 entries of concentration or status change history. Setting the configuration DIP switches is required. Set switches 1, 2, and 6 ON (down). Set switches 3, 4, and 5 OFF (up).

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### C. OUTPUT RELAY OPTION (AMS4 OPT3)

The Output Relay option provides an Alarm and a Fail relay output. Each of the relays have normally open (NO), common (C), and normally closed (NC) contacts. The relays have UL and CSA ratings of 15A @ 30 Vdc resistive and 120 Vac resistive, 1/3 HP @ 120 Vac, and 1/2 HP @ 250 Vac.

### D. RS-485 HOST COMMUNICATIONS (AMS4 OPT4)

This option gives the AMS-4 system network capability. Multiple AMS-4's can be connected on a common RS-485 bus with a host computer. A host computer then retrieves the history information. If the host computer goes off-line the AMS-4 will store up to 2000 of the most recent entries of concentration or status change history. This history is then downloaded to the host computer after the host comes back on-line. Additionally, the AMS-4 stores up to ten days of hourly concentration data. This data includes the minimum, maximum, and average readings during the hour.

### E. OUTPUT RELAYS AND RS-485 COMMUNICATIONS (AMS4 OPT5)

This option is a combination of options 3 and 4. Because of the way the options are installed in the AMS-4 it is not possible to install options 3 and 4 separately. If the user wishes to have both options, option 5 must be ordered.

### F. EXTENSION CABLE & AIR TUBING (AMS4 OPT6)

This option is provided for users using the radial entry sampling head who wish to remote it from the base unit. When ordering this option, the user must specify the desired length. This option has a base cost, plus a fixed cost per linear foot. The recommended maximum length of the extension kit is 50 feet.

### G. IN-LINE SAMPLING HEAD (AMS4 OPT7)

The in-line sampling head option is offered to users who wish to monitor beta particulate which is being drawn through a tube. The in-line head is contained in a waterproof enclosure and is suitable for wall mounting. Connection to the inlet of the in-line head is a 1-1/4" O.D. Swagelok connector. The outlet, which is to be connected to a vacuum pump, is a 3/8" hose barb fitting. The length of the communications cable (Eberline Part Number CA-96-XXFT) between the sampling head and base unit must be specified by the user. The



## AMS-4

"XX" portion of the cable part number specifies the cable length, in feet. The maximum length is 1,000 feet.

### H. NOBLE GAS SAMPLING HEAD (AMS4 OPT8)

The gas sampling head provides the capability for monitoring the general workplace or for monitoring noble gas concentrations either in a stack or duct by drawing air from those spaces. The gas sampling head can be attached to the side of the AMS-4, used stand-alone near the workplace or wall mounted as desired. The brass hose barb which exits at the top rear of the sampling head may be left open to the immediate environment or attached to a sampling tube coming from a stack or duct. The standard AMS-4 integrated pump option (AMS4 OPT1) may be connected to the vacuum side of the gas sampling head or an external pump may be used. A 3/8 inch hose barb fitting is provided for this connection.

The programming in the AMS-4 (Version 2.XX and newer) provides the ability to select either the particulate/iodine sampling head or the gas sampling head. Make sure the correct head type is selected before using any sampling head on the AMS-4. From the AMS-4 select *Instrument Parameters, Sampling Head* and then press the *Edit* key to toggle between the two head types. Note that both the radial entry and inline heads are particulate/iodine heads. From the Windows based PC program select *Edit, Operating Parameters* and click on the radio button for Gas Sampling Head. Also make sure the correct DAC Isotope is selected from the DAC Isotope list. <sup>85</sup>Kr and <sup>133</sup>Xe are included in the table. Additional gas isotopes may replace particulate and iodine isotopes in the 10 element table by using an attached computer and the Windows PC program.

The extension cable and air tubing option (AMS4 OPT6) may be used with the gas sampling head to extend its distance from the AMS-4 main unit.

### I. RF MODEM OPTION (AMS4 OPT9)

The RF Modem Option consists of a bi-directional 500 mW spread spectrum RF data modem and cabling to connect the RF Modem to the AMS-4. The RF Modem is powered by a 9 Vdc 500 mA wall transformer type power supply which must be plugged into 115 Vac at the AMS-4. Since the RF modem operates within the FCC's guidelines for spread spectrum systems, it does not require an FCC site license.

Before using the RF Modems for the first time, the RF modems must be properly configured. Configuration parameters are stored in non-volatile memory so it is not necessary to repeat this procedure. There are only two configurations for RF Modems. One is for the Central Computer (PC) and one is for all the AMS-4s using RF Modems.

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To configure an RF modem, plug the RF modem (using only the cable attached directly to the RF modem) to a serial port on a PC and start a serial communications program configured for 9600 baud, no parity, 8 data bits and 1 stop bit. The Terminal program supplied with Windows 3.1 works well for this task. Plug in the power connector to the RF modem and press the small white button on the end of the RF Modem. The following menu should be present on the PC's screen if the Terminal program is properly configured.

```
RF Modem V2.4
by Proxim Inc., (c) 1990,91

MAIN MENU

Serial #: XXXXX      Radio Channel: 1

D - Display Parameters
R - Reset Parameters to Defaults
C - Change Radio Channel
N - Network Configuration
S - Serial Configuration
A - Advanced Configuration
L - Launch Operating Mode

Enter Selection:
```

Next, select D to display the current settings for the RF modem. Choose one of your RF Modems and configure it to be the Central Computer RF modem. Note the serial number at the top of the parameter settings screen since this serial number will be programmed into all the AMS-4 RF modems later. Edit the Central Computer RF Modem parameters to agree with those listed below by using the Serial and Network Configuration utilities from the Main Menu shown above. When done select Launch Operating Mode from the main menu to save the configuration.

```
PARAMETER SETTINGS
Serial #: XXXXX

Serial Port
-----
Operating Mode: Pass-Through      Delimiters: None
Echo Mode: None                  Max Length: 256
Baud Rate: 19200                 Input Time-Out: 1

XON/XOFF Generation: Disabled    XON/XOFF Recognition: Disabled
CTS Generation: Disabled         DSR Generation: Disabled

Network
-----
Radio Channel: 1                  Radio Speed: 121 KBaud
Subchannel: 5550                 Broadcast Address: 1

Dest. Serial #: Broadcast        Lost Communication: Continue
Serial # Filter: None            Type Filter: None
```

For each RF Modem which will be connected to an AMS-4, connect the RF Modem to the PC and configure the parameters to match the following table. Enter the serial number of your Central Computer RF Modem into the *Dest. Serial #:* and *Serial # Filter:* fields. When done select Launch Operating Mode from the main menu to save the configuration.

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### PARAMETER SETTINGS

Serial #: YYYYY

#### Serial Port

-----

Operating Mode: Pass-Through	Delimiters: None
Echo Mode: None	Max Length: 256
Baud Rate: 19200	Input Time-Out: 1
XON/XOFF Generation: Disabled	XON/XOFF Recognition: Disabled
CTS Generation: Disabled	DSR Generation: Disabled

#### Network

-----

Radio Channel: 1	Radio Speed: 121 KBaud
Subchannel: 5550	Broadcast Address: 1
Dest. Serial #: XXXXX	Lost Communication: Continue
Serial # Filter: XXXXX	Type Filter: Broadcast

To finish the RF Modem configuration for your AMS-4 system, make sure all the AMS-4s are setup for *non-ULAN, 19,200 baud* and make sure each is assigned a unique instrument address from 1.. max number of AMS-4s in the system (Instrument Parameters from AMS-4 menu).

## J. CENTRAL COMPUTER RF MODEM OPTION (AMS4 OPT10)

The Central Computer RF Modem Option consists of a bi-directional 500 mW spread spectrum RF data modem that connects to a personal computer (Central Computer). The RF Modem is powered by a 9 Vdc 500 mA wall transformer type power supply which must be plugged into 115 Vac at the computer. Since the RF modem operates within the FCC's guidelines for spread spectrum systems, it does not require an FCC site license.

Utilizing this option with the RF Modem Option (AMS4 OPT9) and the AMS-4 Monitoring System for Windows program (AMS4 OPT13), allows monitor and control of a network of up to 12 AMS-4 CAMs from an IBM-PC compatible computer.

AMS-4s may be connected via RS-232, telephone modems, RF modems and RS-485. By connecting one RF modem to the central computer and one RF modem to each AMS-4, one can quickly set up a network of CAMs to monitor a job.

Before using the RF Modems for the first time, the RF modems must be properly configured. Configuration parameters are stored in non-volatile memory so it is not necessary to repeat this procedure. Refer to the previous section on RF Modem Option for configuration instructions.

## K. NOBLE GAS CALIBRATION TRANSFER STANDARD (AMS4 OPT11)

Since it is impractical to perform radioactive gas calibrations on the AMS-4 Gas Sampling Head every time calibration is required, Eberline has performed a primary gas calibration with <sup>85</sup>Kr and <sup>133</sup>Xe and transferred the primary calibration to a <sup>99</sup>Tc solid source so that AMS-4s can be easily field calibrated. This primary calibration is documented in Eberline Engineering Document 12000-A67.

AMS4 OPT11 consists of an approximately 400K dpm <sup>99</sup>Tc source plated onto a rod which is mounted in a fixture which guarantees a consistent geometry when inserted through the hose barb at

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the end of the gas chamber. Before using the source make sure that the source index cap is resting against the rear of the chamber.

Determine the detector efficiency with this source in position and then adjust the efficiency to establish the desired noble gas efficiency. For a  $^{85}\text{Kr}$  calibration, multiply the  $^{99}\text{Tc}$  source efficiency by 1.338 and enter the new efficiency manually into the AMS-4. For a  $^{133}\text{Xe}$  calibration, multiply the  $^{99}\text{Tc}$  source efficiency by 0.917 and enter the new efficiency manually into the AMS-4.

The correction factor for  $^{85}\text{Kr}$  is greater than the  $^{133}\text{Xe}$  correction factor since  $^{85}\text{Kr}$  (250 keV, 100%) is a stronger beta emitter than  $^{133}\text{Xe}$  (Eavg = 100 keV, 100%). The relationship between the solid source efficiency and the gas efficiency has no direct bearing (other than as a transfer standard) since the counting geometries are very dissimilar between the two.

Note that using the transfer standard correction factors provides a calibration referenced to standard temperature (22°C) and pressure (760 mm Hg).

### L. AMS-4 MONITORING PROGRAM FOR WINDOWS (AMS4 OPT13)

The AMS-4 Monitoring System for Windows allows an IBM-PC compatible computer to monitor and control a network of AMS-4 beta continuous air monitors (CAMs). The present software structure allows for the monitoring of 1 to 12 AMS-4s.

AMS-4s may be connected via RS-232, telephone modems, RF modems and RS-485. By connecting one RF modem to the central computer and one RF modem to each AMS-4, one can quickly set up a network of CAMs to monitor a job.

The AMS-4 Monitoring System runs in the multi-tasking Windows operating system allowing the operator to run other applications while simultaneously polling a CAM network. Up to five different windows are simultaneously displayed by the system to provide detailed current and historical information to the operator regarding a specific CAM. All operating parameters, including alarm setpoints, are editable through the system under three level password control; even when the CAMs are on-line monitoring. A simulator mode is built-in to facilitate demonstration and training.

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### SECTION 6. AMS-4 HARDWARE COMPLEMENT SHEET

#### **CUSTOMER STANDARD** **DOCUMENT NO. 17000-A92**

The printed circuit boards (PCBs) which comprise certain Eberline instruments are designed to be as flexible as possible, therefore it is impractical to list all applications in each PCB manual subassembly section. The microcomputer hardware complement sheet provides a means of listing detailed information regarding each PCB configuration for a specific application.

The following is a description of each PCB as it applies to the AMS-4. For additional information, schematics, and spare parts, consult the appropriate manual subassembly section.

Like PCBs may not be directly interchangeable because of different configurations. Replacement boards from the factory, or from other systems, should not be installed until proper configuration is verified by comparing the board to the information contained in the hardware complement sheet.

#### **FRONT PANEL BOARD**

1. Part Number: SP24E (YP11526000)
2. Quantity: One required
3. Special Requirements:
  - A) Front Panel Board must be configured to accept a 64K X 8 EPROM (27C512). Verify the existence of a PCB trace on the component side of the PCB which connects the two pads nearest to the silkscreened number "512" located behind connector P1. If this trace has been cut, install a buss wire jumper which connects the above mentioned pads.
  - B) AMS-4 Front Panel Board Version X.X firmware contained in a 27C512 EPROM installed in socket A4. Consult Eberline for current version.
  - C) Non-volatile RAM/Real Time Clock socket must be installed in A8. Eberline part number: ICXX26. Dallas Semiconductor part number: DS1216C.
  - D) Non-volatile RAM sockets must be installed in A5. Eberline part number: ICXX27. Dallas Semiconductor part number: DS1213C.
  - E) 32K X 8 CMOS RAM ICs must be installed in sockets A5 and A8. Eberline part number: ICCM43C256. NEC part number: D43256AC
  - F) 80C51FA Microprocessor must be installed in A1. Eberline part number: ICCMAC51FA. Intel part number: 80C51FA.

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- G) Empty 16-pin socket must be installed at SW1-8.
- H) A 12 pin connector must be installed on the component side of the PCB in the holes provided for connector P12. Eberline part number: COMR112. Molex part number: 22-23-2121.
- I) **RS-232 Communications Between AMS-4 and Host Computer only (standard):** TTL to RS-232 converter I.C. must be installed in socket A27. Eberline part number: ICXXMAX233. Maxim part number MAX233. RS-485 driver I.C. must be removed from socket A29.
- J) **RS-485 Communications Between AMS-4 and Host Computer only:** RS-485 Driver I.C. must be installed in socket A29. Eberline part number: ICCM485 or ICXXAS3695. Linear Technology part number LTC485 or National part number DS3695. TTL to RS-232 converter I.C. must be removed from socket A27.

### MODULAR DETECTOR BOARD

1. Part Number: SP28C (YP11543000)
2. Quantity: One required
3. Location: Sampling Head, connected to Beta Detector.
4. Special Requirements:
  - A) Must have RG-174 coax cable connecting board to Beta Detector.
  - B) Jumper must be in place at JP1.
  - C) Connection must be made at JP7 and JP8.

### MODULAR DETECTOR BOARD

1. Part Number: SP28D (YP11543000)
2. Quantity: One required
3. Location: Sampling Head, connected to Background Detector.
4. Special Requirements:
  - A) Must have RG-174 coax cable connecting board to Background Detector.
  - B) Jumper must be in place at JP1.
  - C) Connection at JP8 must be removed. Connection must be made at JP7.

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### SECTION 7. AMS-4 FRONT PANEL BOARD

#### A. GENERAL DESCRIPTION

Designed to be a general purpose control panel, this board provides many commonly-used functions required for control of typical instruments. A variety of input, output and communications ports are included, along with memory and computing capabilities. Provision has been made to connect an alphanumeric display to the board.

#### B. CIRCUIT DESCRIPTION

##### 1. Processor

An 80C51, supported by 64K of program storage and 32K of working RAM provides control and computational abilities. One additional 32K bank of RAM is installed to provide a large buffer for history data. By using RAM sockets which contain lithium batteries, backup power may be supplied for data retention during power outages. One of these "smart" sockets also contains a clock-calendar chip to provide date and time information.

##### 2. Serial Ports

Four serial ports are available. The first, which uses the CPU's internal UART, is dedicated to an RS-485 bus for communication with other boards in the system. Three other serial ports are implemented with 82510 communications chips. By installing appropriate interface driver/receiver chips or jumpers, each may be configured for either TTL or RS-232 levels, and supports DSR/DTR handshaking. One of the three may also be configured as a second RS-485 port. Another is intended to support an optical or magnetic badge reader, and includes supply voltages for this device.

##### 3. Alphanumeric Display

An IEE 2-line by 20 character vacuum fluorescent display module may be connected to the Front Panel PCB. Power for this display, along with data and control lines, connect through a socket strip on the back of the board.

##### 4. Keyboard Inputs

A matrix-encoded keypad of up to 20 keys may be connected to the front panel. An extra connector is provided which will connect directly to a 4-key strip mounted directly below the alphanumeric display, instead of the second keyboard.

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### 5. Parallel Ports

Eight switch inputs are provided, each pulled up to +5 volts and protected from external voltage spikes by capacitors and series resistors. Seven additional inputs (with pull-ups, but without protection) are distributed across two parallel I/O connectors and the badge reader interface. Twenty channels of parallel output are available on three connectors. Each is capable of sinking 0.5 Ampere to approximately 1 Volt, however some limits exist as to how much total power the outputs can drive at any one time.

### 6. Voltage Regulators

Three linear regulators produce +5 Volts from an input of 6-12 Volts. The first is used to power the panel itself, and the second for the display module. The third powers the RS-232 and RS-485 interface chips and may also be used to power a badge reader and/or other low-current loads.



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### AMS-4 FRONT PANEL BOARD PARTS LIST

The following table lists the electronic items incorporated in the Front Panel Board and should contain any part necessary for normal electronic repair. Unless otherwise specified, call outs of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value and Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

<b>AMS-4 FRONT PANEL BOARD, YP11526000</b>				
<b>Ref. Desig.</b>	<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
A1	IC	Microprocessor	Intel P80C51FA	ICCMAC51FA
A2	IC	Triple 3-Input NOR	Any 74C27	ICHCA7427
A3,9,10,12,30	IC	3-to-8 Line Decoder	Any 74HC138	ICCMABC138
A4	IC	64K x 8 CMOS EPROM	Consult Eberline	Consult Eberline
A5,6*,7*,8	IC	32K x 8 Static CMOS RAM	NEC D43256AC-10L	ICCM43C256
A11,13,31	IC	Voltage Reg., +5 Low Drop	SGS-Thompson L4941BV	ICAVL4941
A14,29*	IC	RS-485 Transceiver	Linear Tech. LTC485CN8	ICCM485
A15-17	IC	CMOS UART	Intel P82510	ICCM82510
A18,23-25	IC	Octal Buffer	Any 74HC373	ICHCA74373
A19-22	IC	Octal Latch	Any 74HC374	ICHCA74374
A26,27*,28	IC	CMOS to RS-232 Interface	Maxim MAX233CPP	ICXXMAX233
A32*,33*,34*	IC	7-Channel Power Buffer	Sprague ULN2003A	ICXX30
C1	Capacitor	22 pF,	Kemet CK05BX220K	CPCE220P3R
C2	Capacitor	33 pF,	Erie CK12BX330K	CPCE330P3P
C3-5,7-	Capacitor	0.1 $\mu$ F,	Centralab CW20C104K	CPCE104P3N

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AMS-4 FRONT PANEL BOARD, YP11526000				
Ref. Desig.	Part	Description	Manufacturer and Part Number	Eberline Part Number
9,10,12-15,17-28,38-41				
C6	Capacitor	10 $\mu$ F,	Sprague 199D106X0016CA1	CPTA100M4X
C11,16,37,42	Capacitor	22 $\mu$ F,	Sprague 196D226X0016DA1	CPTA220M4H
C29-36	Capacitor	0.01 $\mu$ F,	AVX SR155C103KAA	CPCE103P3N
DS1	LED	Internal Resister, Green, 5-Volt	Hewlett Packard HLMP- 3680	OPLP25
HSA13	Heatsink	High Power, TO-220	IERC 7-340-4PP-BA	MEHS22
HSA11,31	Heatsink	Med. Power, TO-220	Thermalloy 6279B	MEHS20
P1	Connector	7 x 0.100" Header	Molex 22-23-2071	COMR107
P2-4	Connector	DB-9 Female, R/A PCB	AMP 205866-2	COMR1209
P5-7,12*	Connector	12 x 0.100", Header	Molex 22-23-2121	COMR112
P8,9	Connector	6 x 0.100", Header	Molex 22-23-2061	COMR706
P10,11	Connector	9 x 0.100", Header	Molex 22-23-2091	COMR809
P12*	Connector	12 x 0.100", Socket Strip	Samtec BCS-112-LSTE	SOIC212
P13	Connector	5 x 0.100", R/A Header	Molex 22-05-3051	COMR1205
R1-3	Resistor	8.2K, 1/4W, 5%		RECC822B22
RP1-5	Resistor	4 x 1K SIP Network	A-B 708B102	REAR102B21
RP3,6	Resistor	9 x 10K SIP, Network	CTS 750-101-R10K	REAR103B21
S1-8	DIP Switch	8-Position	Grayhill 76SB08	SWMI5
S9	Push Button Switch	PC Mount R/A	Alco TPA11CG-RA0	SWPB27
X1	Crystal	11.0592 Mhz	M-Tron MP-1 11.0592	CYOS18
XXA5,6*,7*	Socket	28-Pin "Smart" with battery	Dallas Semiconductor DS1213C	ICXX27
XXA8	Socket	28-Pin "Smart" with battery and clock	Dallas Semiconductor DS1213C	ICXX26

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\*Denotes items which are specific to various board configurations.





















## AMS-4

### SECTION 8. MODULAR DETECTOR BOARD

#### A. GENERAL DESCRIPTION

Each of the two detectors in the AMS-4 are served by an independent circuit board which combines the functions of high voltage power supply, signal amplifier, pulse height discriminator, and dual channel counter.

All functions of the Modular Detector Board are controlled by a single-chip microprocessor. In addition to the control logic, this device contains program ROM and working random access memory. The processor, an Intel 83C51FA, is capable of outputting pulse-width modulated signals which are filtered to provide DC levels which control the high voltage supply and determine alpha and beta pulse height thresholds. Communications with the Front Panel Board are implemented through the processor's internal serial port.

#### B. EXTERNAL CONNECTIONS

The Modular Detector Board is connected to its detectors by RG-174 coax cable.

Low voltage power and serial data enter through a twelve pin header, J1, at the front edge of the detector board. Pins 1, 2 and 12 of this header are DC ground; a supply of 8-15 volts DC at approximately 50mA is required on pin 2. As configured for use in the AMS-4, pins 4 and 5 are bi-directional serial data at RS-485 levels, buffered to and from the processor chip by IC A5. The remaining pins of J1 are jumpered to ground as necessary to define the network address of each board. This eliminates the need to manually set address switches when replacing a board, since that information is wired into the chassis harness connector.

#### C. HIGH VOLTAGE SUPPLY

Accelerating potential for the detector is produced by an inverter and voltage-multiplying ladder circuit. The output voltage is divided by a 1000:1 resistor network and compared to a reference voltage generated by filtering a pulse-width modulated output from the microprocessor. This feedback loop controls the frequency of the inverter oscillator. Two additional comparators are used which interrupt the processor chip if the high voltage output goes out of tolerance.

High voltage is adjustable in 255 steps of slightly less than 10 volts per step. An adjustment potentiometer is provided for more precise calibration of the (nominally) 1000:1 voltage divider.

#### D. AMPLIFIER AND DISCRIMINATOR CIRCUITS

Pulses from the detector are coupled into a low-impedance amplifier through a DC-blocking capacitor. Two stages of amplification are used; the first stage inverts negative-going detector pulses

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and feeds the alpha pulse threshold comparator. The second stage, which is non-inverting, provides sufficient gain for detection of beta pulses.

Each amplifier output is AC-coupled into its respective threshold comparator. The threshold voltages are obtained by filtering two pulse-width modulated outputs from the microprocessor. One-shot multivibrators condition the comparator outputs into logic-level signals with constant pulse widths. Anti-coincidence logic may be enabled under software control to prevent alpha pulses from also being included in the beta count, or disabled for test purposes.

### CAUTION

THE HIGH VOLTAGE SECTION OF THIS BOARD PRODUCES POTENTIALS OF UP TO 2500 VOLTS, WHICH MAY REMAIN PRESENT FOR SEVERAL MINUTES AFTER POWER IS REMOVED! EXERCISE CARE WHEN WORKING ON THIS MODULE! DISCHARGE THE INPUT JACK TO CHASSIS GROUND WITH AN INSULATED SCREWDRIVER BEFORE REMOVING THE CIRCUIT BOARD FROM ITS HOUSING!

## E. SETUP AND CALIBRATION

A 2-by-6 pin header located directly behind J1 configures the modular detector board for operation or calibration. Placing a shorting jumper in position #1 (the left most pair of pins) instructs the microprocessor to operate as a normal detector board. Removing the jumper entirely selects high voltage calibration mode, and jumpering position #6 disables the high voltage power supply entirely. Positions 2, 3, 4 and 5 should not be jumpered. Jumper settings are read only when power is first applied to the board.

If the board is powered up with no jumper installed, the power supply will be set for 1250 Volts. The actual output may be adjusted to this nominal value by potentiometer R10; this is the only calibration required. Use a high impedance voltage divider probe to measure the output voltage, since the supply has an impedance of one megohm.

Operation of the two amplifier stages may be monitored at test points 5 and 6, respectively. DC levels at both of these points should be between 0.5 and 1.5 volts. Alpha and beta one-shot outputs are present on pins 2 and 3 of J2. If a pulse generator is connected to the detector input, note that the input impedance of the amplifier is low and may load the generator output significantly. As mentioned above, placing a jumper in position #6 will disable the high voltage supply for operator safety.

## F. THRESHOLD VALUES

Alpha and beta pulse-height discriminator thresholds default to values of 45% and 6%, respectively. These levels may be changed via the detector parameter menu, however this capability should be

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used only after careful evaluation. The Modular Detector Board is intended to be used with several types of radiation detectors; its full adjustment range is not intended for any one type.

Increasing the beta threshold will rapidly reduce detector response to low-energy (beta and gamma) particles, both from contamination sources and background. This will result in decreased beta/gamma detection efficiency, however background count rates may actually decrease faster than those from contamination.

The default alpha threshold was selected to almost eliminate alpha counts due to beta particles. Lowering this value will increase alpha particle detection efficiency, however false alpha-channel alarms may be caused by large beta-emitting sources. Raising the alpha threshold will slightly reduce the number of beta particles incorrectly counted as alphas, however the opposite error (counting alphas as betas) will increase rapidly.

Before changing these thresholds, it is strongly recommended that a thorough study be made of the effects. Ideally, samples of the actual isotopes to be detected should be used to measure the changes in response to both contamination sources and background. If thresholds are changed, detector efficiencies should also be re-checked.

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### MODULAR DETECTOR BOARD PARTS LIST

The following table lists the electronic items incorporated in the Modular Detector Board and should contain any part necessary for normal repair. Unless otherwise specified, call outs of manufacturers or manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designator, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when one called out by the manufacturers' part number is not available.

<b>MODULAR DETECTOR BOARD, YP11543000</b>				
<b>Ref. Desig.</b>	<b>Part Name</b>	<b>Part Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
(None)	Circuit Board	Modular Detector	Eberline	ZP11543002
A1	Microprocessor	83C51 Mask ROM	Eberline	Consult Factory
A2	I.C.	Quad NOR gate	(Any) 74HC02	ICHCA00002
A3	I.C.	+5 V Regulator	(Any) 7805 TO-0220	ICAV7805
A4	I.C.	+5 V Regulator	National LP2950CZ	ICAVA2950C
A5	I.C.	RS-485 Transceiver	Linear Tech LT485	ICCMA485
A7	Hybrid	Custom Hybrid	Eberline	VEBD14
C1,5-7	Capacitor	10 $\mu$ F, 16V	Sprague 199D106X001CA1	CPTA100M4X
C2,C3	Capacitor	33 pF, Ceramic	Erie CK12BX330K	CPCE330P3P
C4,8-11	Capacitor	0.1 $\mu$ F, 50V	Centralab CW20C104K	CPCE104P3N
C12,16,20	Capacitor	0.01 $\mu$ F, 3000V	Sprague	CPCE103P4Y
C13	Capacitor	0.047 $\mu$ F, 4000V	ASC X675HV.0474000V	CPPF503PXY
C14	Capacitor	220 pF, 3000V	Centralab DD30-221	CPCE221P3Y
C15	Capacitor	0.001 $\mu$ F, 3000V	Centralab DD30-102	CPCE102P3Y
C17	Capacitor	0.01 $\mu$ F, 80V	Sprague 192P1039R8	CPPF103P3O
C18	Capacitor	0.27 $\mu$ F, 50V	Centralab CW30C274M	CPCE274P4N



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<b>MODULAR DETECTOR BOARD, YP11543000</b>				
<b>Ref. Desig.</b>	<b>Part Name</b>	<b>Part Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
C19	Capacitor	33 $\mu$ F, 10V	(Any) Carbon film	CPXX12
CR1	LED, T-1	Red superbright	Stanley BR3668S	OPLP57
CR2-4	Rectifier	High Voltage	Elect. Dev. HX25PD	CRSIVA0025
CR5	Diode	Small signal	(Any) 1N4148	CRSI1N4148
J1	Header	12-Pin x 0.156"	AMP 1-640388-2	COMR612
J2	Header	9-Pin x 0.1"	Molex 22-23-2091	COMR809
J3	Header	4-Pin x 0.1"	Molex 22-23-2041	COMR1104
J4	Banana Jack	Uninsulated	HH Smith 101	COMI14
JP1-6	Header	2x6-Pin x 0.1"	Samtec TSW-106-14TD	COMR1312
Q1,3	Transistor	N-Channel FET	Motorola 2N7000	TRMN2N7000
Q2	Transistor	PNP medium pwr.	(Any) 2N4234	TRSP2N4234
R1-5	Resistor	10K Ohm 1/4W 5%	(Any) Carbon film	RECC103B22
R6	Resistor	220 Ohm 1/4W 5%	(Any) Carbon film	RECC221B22
R7	Resistor	10M Ohm 1/4W 5%	(Any) Carbon film	RECC106B22
R8,R11	Resistor	1M Ohm 1/4W 5%	(Any) Carbon film	RECC105B22
R9	Resistor	270 Ohm 1/4W 5%	(Any) Carbon film	RECC271B22
R10	Potentiometer	200K Ohm trim	Spectrol 64X-204K	PTCE204B33
T1	Transformer	High Voltage	Microtran M8149	TFHV5
X1	Crystal	7.3738 MHz	M-Tron MP1	CYOS12
XA1	I.C. Socket	40-Pin DIP	(Any)	SOIC140
XA2	I.C. Socket	14-Pin DIP	(Any)	SOIC114
XA5	I.C. Socket	08-Pin DIP	(Any)	SOIC308
XJP1	Jumper	2-Pin x 0.1"	Molex 15-29-1024	COHD121

















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### SECTION 9. AMS-4 ANALOG BOARD

#### A. GENERAL

The Analog Board is used as a multi-function board. It provides signal conditioning circuitry for the Bar Graph Display Board and the 0-5 Volt analog output. It also provides circuitry for RS-485 noise suppression and relay outputs if these options are installed.

#### B. THEORY OF OPERATION

Signals which drive the front panel bar graph display and the 0-5 Volt analog outputs are brought onto the board from the AMS-4 Front Panel Board through connector J2. These signals are then damped by capacitors C1-4 and resistors R1-4, 8, and 11. Resistors R9,10,12, and 13 in conjunction with the LM358 op-amp (A1) amplify the signal to the proper level. The output pins of A1 then drive their respective outputs.

If the AMS-4 is equipped with the RS-485 Serial Communications Option components CR1-4, GT1-2, J3-4, J7, R5-6, and R7 are installed. The Front Panel Board is protected from voltage transients by two spark gaps GT1-2 and surge suppressors CR1-4. High voltage on either of the RS-485 communication lines initially are clamped by CR1 to CR4 and current limited by R5 & R6. GT1 and GT2 provide protection after voltage breakdown has occurred.

If the AMS-4 is equipped with the Output Relay Option components CR5-6, K1-2, and TB1 are installed. This option provides the user with two relay outputs. Each of the relay outputs have a normally open (NO), normally closed (NC), and common (C) terminal. The relays are controlled by the AMS-4 Front Panel Board. The Alarm Relay will operate when a Slow Alarm condition is present. The Fail Relay will operate during a Malfunction condition. One side of each relay is connected to the +12 volt supply. A relay is energized when the appropriate output on the AMS-4 Front Panel Board switches low, sinking current. Diodes CR1-2 act to clip voltage transients caused by the relays de-energizing.

#### C. MAINTENANCE

This board requires no scheduled maintenance or initial adjustments.

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### AMS-4 ANALOG BOARD PARTS LIST

The following table lists the electronic items incorporated in the Analog Board and should contain any part necessary for normal electronic repair. Unless otherwise specified, call outs of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value and Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

<b>AMS-4 ANALOG BOARD, YP11552000</b>				
<b>Ref. Desig.</b>	<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
A1	I.C.	Dual Op Amp	National LM358N	ICAOA00358
C1,2,3,4	Capacitor	0.27 $\mu$ F, 50V, 20%	Centralab CW30C274M	CPCE274P4N
C5,6	Capacitor	0.1 $\mu$ F, 50V, 10%	Centralab CW20C104K	CPCE104P3N
<sup>1</sup> CR1,2,3,4	Transient Suppressor		General Semiconductor LCE6.5 or LCE7.0	CRXXLCE65
<sup>2</sup> CR5,6	Diode	General Purpose	General Instrument 1N4001	CRSI1N4001
<sup>1</sup> GT1,2	Surge Arrestor	Spark Gap	Clare CG90L	VETU2
J1	Connector	6 Pin Male, 0.156"	Molex 09-60-1061	COMR406
<sup>1</sup> J3,4	Connector	7 Pin Male, 0.100"	Molex 22-23-2071	COMR107
J5	Connector	5 Pin Male, 0.100"	Molex 22-11-2052	COMR1005
J6	Connector	3 Pin Male, 0.156"	Molex 26-48-1033	COMR803
<sup>1</sup> J7	Connector	2 Pin Male, 0.156"	Molex 09-60-1021	COMR802
<sup>2</sup> K1,2	Relay	13A General Purpose, DPDT	P&B K10P-11D15-12	RLGP32
R1,2,3,4, 8,11	Resistor	1M, 1/4W, 1%		RECE105B12
<sup>1</sup> R5,6	Resistor	4 $\Omega$ , 3W, 5%		REWW040B16
<sup>1</sup> R7	Resistor	100 $\Omega$ , 3W, 5%		REWW101B16

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<b>AMS-4 ANALOG BOARD, YP11552000</b>				
<b>Ref. Desig.</b>	<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
R9,10,12,13	Resistor	10K, 1/4W, 1%		RECE103B12
<sup>2</sup> TB1	Terminal Block	6 Position, PCB Mount	Phoenix 1759059	COTB68
<sup>2</sup> XK1,2	Socket	8 Pin Relay Socket	P&B 27E489	RLSO13
<sup>2</sup> XXK1,2	Clip	Relay Retaining Clip	P&B 20C217	RLHD1

<sup>1</sup> Installed only if the AMS-4 is equipped with the RS-485 Communications Option.

<sup>2</sup> Installed only if the AMS-4 is equipped with the Output Relay Option.













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### SECTION 10. BAR GRAPH DISPLAY BOARD

#### A. GENERAL

The Bar Graph Display Board has two functions, to provide a bank of LED segments which represent the Percentage of Alarm value in comparison to the alarm setpoint and provides the Ready and Malfunction front panel lights.

#### B. THEORY OF OPERATION

The Bar Graph portion of this board contains four banks of 10-segment LEDs (DS1-4), four LM3914 Bar Display Drivers (A2-5) and four resistors (R1-4) which set the operating current of the LED segments. Each of the Bar Display Drivers are cascaded together and have pre-scaled threshold points at which successive LEDs light as the analog input voltage level from the controlling board increases. All LED segments are on when the analog input voltage is 5 volts. The number of LED segments illuminated is in proportion to the input voltage applied to pins 5 of A2-5. The Bar Graph Display has a resolution of 0.125 volts at the input per LED light segment.

The AMS-4 front panel Ready light is provided by LED bars DS5 and DS6. The anode end of the LED bars are pulled up to +12 volts. The LED bars are illuminated when pin 4 of connector J1 is pulled low by the controlling board. Current flow is limited by resistors R7-10.

The front panel Malfunction light is provided by LED bars DS7 and DS8. The anode end of the LED bars are pulled up to +12 volts. The LED bars are illuminated when pin 5 of connector J1 is pulled low by the controlling board. Current flow is limited by resistors R11-14.

The LM317 Voltage Regulator (A1) provides a 3.5 volt supply for the Bar Graph LED segments.

#### C. MAINTENANCE

This board requires no scheduled maintenance or initial adjustments.

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**BAR GRAPH DISPLAY BOARD PARTS LIST**

The following table lists the electronic items incorporated in the Bar Graph Display Board and should contain any part necessary for normal electronic repair. Unless otherwise specified, call outs of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value and Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

<b>BAR GRAPH DISPLAY BOARD, YP11553000</b>				
<b>Ref. Desig.</b>	<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
A1	I.C.	Adjustable Voltage Regulator	National LM317T	ICAVA0317T
A2-5	I.C.	Dot/Bar Display Driver	National LM3914	ICXXLM3914
C1	Capacitor	2.2 $\mu$ F, 16V, 10%	Sprague 199D225X9016AA1	CPTA225P3H
C2,3	Capacitor	22 $\mu$ F, 15V, 20%	Sprague 199D226X0016DA1	CPTA220M4H
DS1-4	Display	10-Segment LED Display, Green	Lite-On LTA-1000G	OPDS27
DS5-8	LED Bar	6x29mm, Green	Stanley MU07-4101	OPLP56
J1	Connector	5 Pin Male, 0.10"	Molex 22-11-2052	COMR1005
R1	Resistor	1.30K, 1/4W, 1%	RN55D	RECE132B12
R2	Resistor	2.55K, 1/4W, 1%	RN55D	RECE252B12
R3	Resistor	3.32K, 1/4W, 1%	RN55D	RECE332B12
R4	Resistor	5.11K, 1/4W, 1%	RN55D	RECE512B12
R5	Resistor	511 $\Omega$ , 1/4W, 1%	RN55D	RECE511B12
R6	Resistor	909 $\Omega$ , 1/4W, 1%	RN55D	RECE911B12
R7,9,11,13	Resistor	220 $\Omega$ , 1/4W, 5%		RECC221B22
R8,10,12,14	Resistor	150 $\Omega$ , 1/4W, 5%		RECC151B22
XA1	Heat Sink	T0-220 High Power	IERC 7-340-4PP-BA	MEHS22









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### SECTION 11. MASS FLOW SENSOR BOARD

#### A. GENERAL

The Mass Flow Board is used to measure the total mass of air passed through the sensing element (A2). The amount of air flow is then translated to an analog voltage and the voltage is then converted to a frequency by the integrated circuit A1.

#### B. THEORY OF OPERATION

The Micro Switch AWM3300V mass flow sensor (A2) operates on the theory that air flow directed across the surface of a sensing element causes heat transfer. The output voltage of the device will vary between 1 and 5 volts in proportion to the mass of the air flowing through the sensor's inlet and outlet ports.

The output voltage from the flow sensor is then converted to a pulse train by the LM331 (A1). The frequency of this pulse train is proportional to the output voltage of the flow sensor.

Potentiometer R6 provides a frequency output adjustment. The output frequency of A1 at zero flow rate is 2,000 Hz. The output frequency at maximum flow rate (1000 SCCM) is 10,000 Hz.

Resistors R7-9 provide a +5V logic pull-up.

The LM317 voltage regulator (A3) provides the nominal supply voltage of +10V for A1 and A2. Potentiometer R11 is used for fine tuning the +10V output.

#### C. CIRCUIT SETUP

This circuit board requires some set-up by the user to ensure that the board functions correctly.

1. Connect pins 3 (+) and 4 of connector J1 to a 12-18 VDC supply.
2. Adjust potentiometer R11 until the output voltage of regulator A3 is 10 Vdc  $\pm$  0.02 Vdc. This accuracy is required for output precision.
3. Using a frequency counter or an oscilloscope adjust R6 until the output of A1 (pin 1 of J1) is 2000  $\pm$  5 Hz with no air flow through the sensor.

#### D. MAINTENANCE

This board requires no scheduled maintenance or adjustment after the initial set up. However, air flowing through the sensor should be free of condensing moisture and particulate contaminants.

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Using a filter upstream from the sensing unit at all times should substantially reduce the risk of damage to the sensor due to contaminants.

### MASS FLOW SENSOR BOARD PARTS LIST

The following table lists the electronic items incorporated in the Mass Flow Sensor Board and should contain any part necessary for normal electronic repair. Unless otherwise specified, call outs of manufacturers and manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value and Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

<b>MASS FLOW SENSOR BOARD, YP11551000</b>				
<b>Ref. Desig.</b>	<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
A1	IC	Voltage to Frequency Converter	National LM331N	ICXXALM331
A2	Sensor	Mass Air Flow, 0-1000 sccm	Micro Switch AWM3300V	MTFM34
A3	IC	Adjustable Voltage Regulator	National LM317T	ICAVA0317T
C1,3	Capacitor	0.1 $\mu$ F, 50V, 10%	Centralab CW20C104K	CPCE104P3N
C2,5	Capacitor	0.18 $\mu$ F, 80V, 10%	Sprague 192P1849R8	CPPF184P3O
C4	Capacitor	0.01 $\mu$ F, 80V, 10%	Sprague 192P1039R8	CPPF103P3O
C6,7	Capacitor	22 $\mu$ F, 15V, 20%	Sprague 199D226X0016DA1	CPTA220M4H
J1	Connector	4 Pin Male, 0.1"	Molex 22-23-2041	COMR1104
R1,3	Resistor	100K, 1/4W, 1%	RN55D	RECE104B12
R2	Resistor	3.48K, 1/4W, 1%	RN55D	RECE342B12
R4	Resistor	47 $\Omega$ , 1/4W, 5%		RECC470B22
R5	Resistor	12.1K, 1/8W, 1%	RN55D	RECE123B11
R6	Potentiometer	5K, 1/2W, 5%	Bourns 3299W-1-502	PTCE502B33



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<b>MASS FLOW SENSOR BOARD, YP11551000</b>				
<b>Ref. Desig.</b>	<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
R7,8,9	Resistor	10K, 1/4W, 5%		RECC103B22
R10	Resistor	249Ω, 1/4W, 1%	RN55D	RECE251B12
R11	Potentiometer	2K, 1/2W, 5%	Bourns 3299W-1-202	PTCE202B33











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#### SECTION 12. MISCELLANEOUS AND OPTIONS, PARTS LIST

The following table lists the items used in the AMS-4 which are not specified in the subassembly sections. Unless otherwise specified, call outs of manufacturers' part numbers are to be considered typical examples only. There are no restrictions against using equivalent parts with the same operating characteristics. When ordering parts from the Eberline Instrument Corporation, specify model, serial numbers, reference designation, value and Eberline Part No. (EIC), or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

<b>AMS-4 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
AC Power Cord	3 conductor, 18 awg	Belden 17506	WRAC18
AC Power Entry Module	AC Entry/Fuse Holder	Corcom 16ESC1C1	COPR13
AC Line Fuse	1 A, 3AG, 250 V, Slo-Blo	Littlefuse 313001	FUSB12
Display	Vacuum Fluorescent	IEE 3601-95B-040	OPDS26
Filter Paper	47 mm	Hollingsworth & Vose LB5211	FIFP10
Fuse Holder	AC Power Fuse Drawer	Corcom SC1N	COHD73
Graphic Overlay	Front Panel Graphic Overlay		ZP11562019
Handle	Base Unit Handle		ZP11562018
Horn	Solid State	Mallory SC-628F	ADSS1
Key Pad	20 Key Matrix	Grayhill 89JB2-B	SWMI43
P.C.B.	AMS-4 Front Panel Board		SP24E
P.C.B.	Analog Board Standard: Relay Option Only: RS-485 Option Only: Relay and RS-485 Option Only:		SP29A SP29B SP29C SP29D
P.C.B.	Bar Graph Display Board		YP11553000

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<b>AMS-4 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Power Supply	AC input, 12 Vdc output	Kepeco FAW12-4.2K	MEVE118



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<b>AMS-4 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Power Supply Enclosure	Perforated sheet metal	Kepco CA-26	MEVE119
Rubber Feet	Rubber Feet, Base	Rubber Craft 9102-R	MMRU36
Sampling Head	Radial Entry Head (Standard)		YP11562043
Strobe Light	Red, 12 Vdc	Tescor Technology 20012	LPAS32
Switch	AC Power and Pump Switch, SPST	Carlingswitch RA911-VB-B-9-V	SWMI58

<b>AMS-4 RADIAL ENTRY SAMPLING HEAD MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Bulkhead Adapter	Communications Cable Adapter	Heyco 9450	WRS24
Detector	Sealed Gas Proportional	LND 49710	TUPR3
Fitting	1/8-inch MPT x 1/8-inch Hose.	Cajon 8-2-HC-1-2	FGBR53
Fitting	1/8-inch MPT x 1/8-inch FPT	Imperial 116-B02	FGBR19
Fitting	10-32 x 1/8-inch Hose, Brass	Clippard 11752-1	FGBR57
Fitting, Plastic Elbow	1/4-inch MPT x 3/8-inch Hose	Midland 33-041-B	FGPL22
Guide	Plastic, Radial Head Attach bracket	Scanbe 11633-2	HDMI94
Horn	Solid State	Mallory SC-628	ADSS1
Lamp Holder	Red Pilot Lamp, Alarm Indicator	Dialco 101-5030-0971-201	LPAS4
Lamp Bulb	14 V, 0.08 A	SPC ML/330	LPBU6

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<b>AMS-4 RADIAL ENTRY SAMPLING HEAD MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Needle Valve	1/8" x 10-32, Flow Sensor Adjustment	Clippard MNV-1P	FGBR56
P.C.B.	Modular Detector Board, Beta/Alpha Detector		SP28C
P.C.B.	Modular Detector Board, Gamma Background Detector		SP28D
P.C.B.	Flow Sensor Board		YP11551000
Porous Support	Porous Filter Paper Support, 1.62"		ZP11562094
Rubber Feet	Rubber Feet, Base	Rubber Craft 9102-R	MMRU36
Screen	Porous Support Backing Screen		ZP11479063
Switch	Alarm Acknowledge and Door Position, Momentary		ZP11479037
Switch Boot	For Alarm Acknowledge and Door Position Switch	APM-Hexseal N5040	MMRU2
Tubing	1/8-inch i.d. x 1/4-inch o.d., Excelon Clear PVC Tubing	Thermoplastics Size No. 2	MMTU1

<b>AMS-4 IN-LINE SAMPLING HEAD, YP11562049 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Air Manifold	Flow Sensor Splitter		ZP11479080
Bracket	Air Manifold Mounting		ZP11562066
Bracket	Flow Board Mounting		ZP11562067
Bracket	Filter Door Limiter		ZP11562070
Bracket	Door Position Switch Mounting		ZP11562073
Bumpers	Filter Door Limit Bracket, Rubber	3M SJ5003	MMRU72
Cap	Detector Side Cap		ZP11562053

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<b>AMS-4 IN-LINE SAMPLING HEAD, YP11562049 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Case	In-Line Head Enclosure		ZP11562063
Connector	5-Pin, Communications Connector	Amphenol 165-36	COMC405
Detector**	1" Dia. Sealed Gas Proportional	LND 49742	TUPR4
Detector Block	Air Flow Chamber		ZP11562051
Door Arm	Filter Paper Door		ZP11562056
Fitting	5/16" i.d. Hose x 1/4" MPT, Brass	Cajon B-5-HC-1-4	FGBR1
Fitting	5/16" i.d. Hose x 1/8" MPT, Brass	Imperial KF05-02PS	FGBR3
Fitting	5/16" i.d. Hose x 1/8" MPT 90°, Brass	Imperial KF05-02PS-90	FGBR4
Fitting	1/4" FPT x 15/16" Long Bulkhead Adapter, Brass	Imperial 129-B-04X15	FGBR40
Fitting	3/8" i.d. Hose x 1/4" MPT, Brass	Imperial KF06-04PS	FGBR43
Fitting	1/8" i.d. Hose x 1/8" MPT, Brass	Cajon B-2-HC-1-2	FGBR53
Fitting	10-32 x 1/8" i.d. Hose Barb, Brass	Clippard 11572-1	FGBR57
Fitting	1-1/4" o.d. Swagelok Connector, Air Inlet		ZP11562052
Gasket	Communications Connector		ZP10567085
Gasket	Sonalert (horn)		ZP11410086
Gasket	Bulkhead Connector		ZP11479092
Gasket	Detector Block Halves Seal		ZP11562095
Gasket	Door Hinge Seal		ZP11479096
Gasket	Grommet Plate		ZP11562103
Grommet	1-1/4" i.d., Rubber	Rubber Craft #71	MMRU44
Ground Contact	Detector Ground (Behind		ZP11562065

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<b>AMS-4 IN-LINE SAMPLING HEAD, YP11562049 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
	Background Detector)		
Ground Disk	Detector Ground (Between Detectors)		ZP11562096
Ground Screw	Detector Ground		ZP11562054
Hinge	Filter Paper Door		ZP11562057
Hinge Spacer	Door Arm Spacer		ZP11479069
Horn	Alarm Horn , Chassis Mount	Mallory SC628	ADSS1
Housing	Filter Support Body		ZP11562058
Lamp	Alarm Light, Sealed Pilot Type, Red	Dialco 101-5030-0971-203	LPAS31
Lamp Bulb	Type 330, 14 Vdc	SPC ML/330	LPBU6
Latch	Filter Paper Holder	Camloc 95L11-1-1BC	HDLA20
O-ring	0.145" i.d. x 0.070" wide, Buna N or Neoprene	Parker 2-007	ORBN2007
O-ring	0.301" i.d. x 0.070" wide, Buna N or Neoprene	Parker 2-011	ORBN2011
O-ring	0.426" i.d. x 0.070" wide, Buna N or Neoprene	Parker 2-013	ORBN2013
O-ring	0.174" i.d. x 0.103" wide, Buna N or Neoprene	Parker 2-106	ORBN2106
O-ring	1.174" i.d. x 0.103" wide, Buna N or Neoprene	Parker 2-123	ORBN2123
O-ring	1.674" i.d. x 0.103" wide, Buna N or Neoprene	Parker 2-131	ORBN2131
O-ring	0.475" i.d. x 0.210" wide, Buna N or Neoprene	Parker 2-310	ORBN2310
O-ring	2.100" i.d. x 0.210" wide, Buna N or Neoprene	Parker 2-330	ORBN2330
O-ring	1.614" i.d. x 0.070" wide,	Parker 2-030	ORSI2030

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<b>AMS-4 IN-LINE SAMPLING HEAD, YP11562049 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
	Silicone		
O-ring	0.549" i.d. x 0.103" wide, Teflon	Parker 2-113	ORTF2113
P.C. Board	Beta/Alpha Detector Board		SP28E
P.C. Board	Background Detector Board		SP28F
P.C. Board	Flow Sensor Board		YP11551000
Plate	Grommet Plate, Swagelok Seal		ZP11562064
Porous Support	1.15" Dia., Filter Paper Support		ZP11479101
Retainer	Door Hinge O-ring		ZP11479011
Retainer	Detector Retainer		ZP11562050
Retainer	Swagelok Connector		ZP11562062
Ring	Filter Paper Holder		ZP11479059
Roll Pin	1/16" Dia. x 1/4" Long, Stainless Steel		HDMI121
Roll Pin	1/16" Dia x 1-1/2" Long, Stainless Steel		HDMI175
Socket	High Voltage (Detector)		ZP11562091
Switch	Lever Switch, Door Position	Cherry E61-50H	SWMI22
Switch	SWPB14 Modifications		ZP11479037
Switch Boot	Waterproof Switch Boot, Alarm Ack. Switch	N5040	MMRU2
Switch Contact	Door Position Switch		ZP11479079
Thumb Screw	#8-32 x 7/16", Stainless Steel	McMaster-Carr 91830A207	SCTS26
Finger Nut	#8-32 x 5/16", Stainless Steel	McMaster-Carr 92741A009	SCTS22
Tubing	1/8" i.d. x 1/4" o.d., PVC	Thermoplastic Size #2	MMTU1
Tubing	5/16" i.d. x 9/16" o.d., PVC	Thermoplastic Size #11	MMTU2

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<b>AMS-4 IN-LINE SAMPLING HEAD, YP11562049 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Valve	1/8" MPT x 10-32, Air Flow Sensor Adjustment, Brass	Clippard MNV-1P	FGBR56

\*\* Early models of the AMS-4 In-Line Head used detectors with the Eberline part number TUPR2 (LND #49730). The TUPR4 detector is a suitable replacement for the TUPR2 detector. The nominal high voltage operating point for the TUPR4 detector is 1550 Vdc. Both detectors in the sampling head must be of the same type.

<b>AMS-4 NOBLE GAS HEAD, AMS4 OPT8 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Base	Sampling Chamber Base		ZP11562118
Bracket	Male Attach Bracket (to AMS4)		ZP11562013
Bracket	Detector Boards Bracket		ZP11562012
Bracket	Sampling Chamber Bracket		ZP11562110
Bulkhead Adapter	Communications Cable Adapter	Heyco 9450	WRSR24
Cables	Internal cable set, Gas Head Opt		YP11562128
Case	Noble Gas Head Detector Case		ZP11562113
Chamber	Noble Gas Sampling Chamber		ZP11562109
Connector	4 Pin Audio Cord Plug		COMC304
Cover	Sampling Chamber Cover		ZP11562111
Cover	Sampling Head Rear Cover		ZP11562009
Detector	2" Dia. Sealed Gas Proportional		TUPR3
Fitting	3/8" i.d. Hose x 1/4" MPT, Brass	Imperial KF06-04PS	FGBR43
Fitting	Male Elbow, 1/4 o.d. Tube x 1/8" P, Brass	Weather Head 1069X4	FGBR62
Fitting	3/8" Hose x 1/4" NPT ELB		FGPL22

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<b>AMS-4 NOBLE GAS HEAD, AMS4 OPT8 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Fitting	10-32 x 1/8" i.d. Hose Barb, Brass	Clippard 11572-1	FGBR57
Gasket	Rear Cover Gasket		ZP11562009
Gasket	Sampling Chamber Base Gasket		ZP11562112
Gasket	Chamber Seal		ZP11562117
Gasket	Sonalert (horn)		ZP11410086
Grommet	7/8" i.d. x 1 5/8" o.d.	Rubbercraft #25	MMRU95
Ground Disk	Detector Ground Disk (Between Detectors)		ZP11562127
Guide	Plastic, Noble Gas Head attach bracket	Scanbe 11633-2	HDMI94
Horn	Solid State, Sonalert	Mallory # SC628	ADSS1
Lamp Holder	Red Pilot Lens, Alarm Indicator	Dialco # 101-5030-0971-201	LPAS4
Lamp Bulb	14V, 0.08A, Alarm Indicator	SPC ML/330	LPBU6
Latch Bar	Latch Bar, Chamber Cover		ZP11562115
Manifold	Air Manifold, Noble Gas Head		ZP11562125
Needle Valve	1/8 MPT, 10-32 Slot, Air Flow Adjustment	Clippard MNV-1P	FGBR56
O-ring	Sampling Chamber, Detector	Parker 2-033	ORBN2033
O-ring	Sampling Chamber, Cover/Base	Parker 2-161	ORBN2161
P.C.B.	Flow Sensor Board		YP11551000
P.C.B.	Modular Detector Board, Beta/Alpha Detector, with cable		SP28G
P.C.B.	Modular Detector Board, Gamma Background Det. w/cbl.		SP28H
Philips Screws	Black coated case screws, 4-40 x 3/8, flat head		SCFH0406PB

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<b>AMS-4 NOBLE GAS HEAD, AMS4 OPT8 MISCELLANEOUS PARTS LIST</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Plate	Backing Plate, Chamber Base		ZP11562114
Rubber Feet	Rubber Feet, Base	Rubber Craft 9102-R	MMRU36
Screw	8-32 x 1/2", Socket Head		SCSH0808
Switch Boot	Waterproof, Alarm Ack. Switch	APM Hexseal N5040	MMRU2
Switch	SWP14 Modification		ZP11479037
Tubing	1/8" i.d. x 1/4" o.d., PVC	Thermoplastic #2	MMTU1
Valve	Vacuum Relief Valve		ZP10538031

**MISCELLANEOUS PARTS LIST**

The following are several parts lists which pertain only to specific AMS-4 options and are applicable only to AMS-4s which were purchased with these options.

<b>INTEGRATED PUMP OPTION PARTS LIST, AMS4 OPT1</b>			
<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Fitting	1/8" MPT x 3/8" Hose	Midland 32-011	FGBR86
Rubber Feet	Rubber Feet, Base	Rubber Craft 9102-R	MMRU36
Shock Mount	Pump Anti-Vibration Mounts	Lord Company J-4624-63	PUHD54
Tubing	3/8" i.d. x 5/8" o.d., Excelon Clear PVC Tubing	Thermoplastics Size No. 14	MMTU6
Vacuum Pump	2.1 CFM Rotary Vane, 110 Vac, 60 Hz.	Becker VT3.3	PTVA12

**PORTABLE SERIAL PRINTER OPTION PARTS LIST, AMS4 OPT2**



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<b>Part</b>	<b>Description</b>	<b>Manufacturer and Part Number</b>	<b>Eberline Part Number</b>
Cable	External Communications Cable, 6 ft.		CA-94-72
Paper	Thermal Printer Paper	Seiko TP201-6CL	RCCP11
Printer	Thermal, 20 column, serial interface	Seiko DPU201GS	RCDI17



## AMS-4

### SECTION 13. RECOMMENDED SPARE PARTS FOR ONE YEAR SUPPORT FOR ONE UNIT

The following list is comprised of easily replaceable modules, which will limit the units downtime due to failures. Some failed modules, such as printed circuit boards, can be repaired and returned to stock for future use.

<b>AMS-4 SPARE PARTS LIST</b>		
<b>Quantity</b>	<b>Description</b>	<b>Eberline Part Number</b>
1	Sonalert Horn (Alarm)	ADSS1
1	AC Fuse Drawer, for Power Entry Module	COHD73
1	AC Power Entry/Fuse Holder Assembly	COPR13
100	47mm Filter Paper	FIFP10
5	Fuse 1 Amp, 250 Volt, Type 3AG, Slo-Blo	FUSB12
1	Alarm Strobe	LPAS32
1	Power Supply, 12V, 4.2 A	MEVE118
1	Display Module	OPDS26
1	AMS-4 Front Panel Board	SP24E
1	AMS-4 Analog Board, Standard:	SP29A
	Relay Option Only:	SP29B
	RS-485 Option Only:	SP29C
	Relay and RS-485 Option Only:	SP29D
1	Key Pad	SWMI43
1	Rocker Switch, Power and Pump On/Off	SWMI58
1	AMS-4 Bar Graph Board	YP11553000

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<b>AMS-4 RADIAL ENTRY SAMPLING HEAD SPARE PARTS LIST</b>		
<b>Quantity</b>	<b>Description</b>	<b>Eberline Part Number</b>
1	Sonalert Horn (Alarm)	ADSS1
2	Attachment Bracket Plastic Guides	HDMI94
2	Lamp Socket, (Alarm Indicator)	LPAS4
6	Bulb, 14 V, (Alarm Indicator)	LPBU6
2	Switch Boot (Detector Position and Alarm Acknowledge)	MMRU2
1	Modular Detector Board, Beta/Alpha Detector	SP28C
1	Modular Detector Board, Gamma Background Detector	SP28D
2	Sealed Gas-Proportional Detector	TUPR3
1	Flow Sensor Board	YP11551000
2	Switch (Detector Position and Alarm Acknowledge)	ZP11479037

<b>AMS-4 IN-LINE SAMPLING HEAD SPARE PARTS LIST</b>		
<b>Quantity</b>	<b>Description</b>	<b>Eberline Part Number</b>
1	Sonalert Horn (Alarm)	ADSS1
2	Lamp Socket and Lens, (Alarm Indicator)	LPAS31
6	Bulb, 14 V, (Alarm Indicator)	LPBU6
1	Switch Boot (Detector Position and Alarm Acknowledge)	MMRU2
1	Modular Detector Board, Beta/Alpha Detector	SP28E
1	Modular Detector Board, Gamma Background Detector	SP28F
1	Switch (Filter Door Closed)	SWMI22
2	1" Dia. Sealed Gas-Proportional Detector	TUPR2
1	Flow Sensor Board	YP11551000
1	Switch (Alarm Acknowledge)	ZP11479037