Pacific Northwest National Laboratory
Operated by Battelle for the
U.S. Department of Energy

PNNL OS3300 Alpha/Beta Monitoring System Software and Hardware Operations Manual Rev. 0

JM Barnett
CJ Duchsherer

January 2006

DISCLAIMER

PNNL OS3300 Alpha/Beta Monitoring System Software and Hardware Operations Manual

January 2006

Pacific Northwest National Laboratory
Richland, WA 99352

Summary

This Pacific Northwest National Laboratory (PNNL) OS3300 Alpha/Beta Monitoring System Software and Hardware Operations Manual describes how to install and operate the software and hardware on a personal computer in conjunction with the EG&G Berthold LB150D continuous air monitor. Included are operational details for the software functions, how to read and use the drop-down menus, how to understand readings and calculations, and how to access the database tables.

Acknowledgements

The PNNL OS3300 Alpha/Beta Monitoring System and this manual are the result of tremendous commitment from the following staff members who have committed their time and effort to the development, programming, testing, and authoring of the software and/or this manual.

- Brad P. Atencio

- J. Matthew Barnett

- Brad C. Barfuss

- Dorothy M. Carrell

- Greg L. Carter

- David D. Douglas

- Cheryl J. Duchsherer

- Daniel L. Edwards

- Michelle L. Johnson

- Daniel R. Sisk

- Edward Stapleton

Contents

Figures

Tables

1.0   Introduction

The alpha/beta stack monitoring system is controlled by a personal computer (PC) and measures alpha and beta radioactivity in real time. The sampling system consists of a rake-style sample probe located inside the stack, the sample transport line, and an EG&G Berthold LB150D continuous air monitor (CAM) with alpha/beta pseudo-coincidence counting capability. Air is routed from the stack sample probe through the EG&G Berthold LB150D CAM where alpha, beta, and gamma radioactivity are measured with a triple counter tube stack of thin-window, large-area, proportional counters located directly above the sample filter. The system also provides readings on man-made alpha and beta radioactive particulate concentrations. This manual describes how to install and operate the Pacific Northwest National Laboratory (PNNL) OS3300 Alpha/Beta Stack Monitoring System software on a PC when connected to a LB150D CAM.

1.1   Formatting Conventions

Software menus are bolded in this manual. At times, the words "**Menu 1|Menu 2**" are used to tell the user to select **Menu 1** and then, from a drop-down menu, select the option labeled **Menu 2**. Clickable buttons and field names on screens are in italics. Text in message boxes, such as "Enter your name," is surrounded by quotation marks.

1.2   Terms and Definitions

A/B sample flow   The sample alpha/beta air flow through the LB150D CAM where
                     particulates are deposited on an S-class 8-inch glass fiber filter.

alpha spill   The ratio of alpha counts in the beta channel to counts in the alpha channel
                     when an alpha source is present. The alpha spill is expressed as a percent.

artificial activity Whether from beta emitters or alpha emitters, this term refers to any
                     radioactivity that is not naturally occurring, i.e., the radioactivity of real
                     concern. Examples of "artificial" alpha emitters are ^{239}Pu, ^{235}U, and ^{241}Am;
                     some "artificial" beta emitters are ^{60}Co and ^{32}P.

beta spill   The ratio of beta counts in the alpha channel to counts in the beta channel
                     when a beta source is present. The beta spill is expressed as a percent.

concentration   The radionuclide activity per unit volume of air.

integral   Usually used in reference to or as the record of total released or measured
                     radioactivity.

isokinetic sampling A technique for sampling airborne particulates in which the air stream
                     entering the sampling device has a velocity equal to that of the gas stream
                     just ahead of the sampling port/nozzle of the collector resulting in a
                     collection efficiency of unity.

LB150D   A thin-window, large-area, proportional counter (detector), which collects
                     and analyzes radioactivity deposited on an 8-inch-diameter filter paper.

LabMaster^{TM} An ORTEC® multi-function input/output PC card, which includes the counter/timers for collecting data from the LB150D CAM.

natural activity   Whether from beta emitters or alpha emitters, this term refers to any radioactivity that results from natural sources, principally particulate daughters of radon and thoron. This activity interferes with the measurement of artificial activity.

pseudo-coincidence   True coincidence counting occurs when two decays arise from the same nuclear event within a source (i.e., when an atom of radioactive material decays, it emits two radiations at the same time). The two decays are not separated in time. In this application, pseudo-coincidence counting appears to be the term applied to decays emitted by isotopes in transient equilibrium where the radiations are separated by a very short period of time. Glenn Knoll refers to this as delayed coincidence in *Radiation Detection and Measurement* (Knoll 2000).

stack flow   The air flow in the stack.

1.3   Abbreviations, Acronyms, and Initialisms

BNC   Bayonet Neill Concelman—electrical cable connector
Bq   Becquerel
CAM   continuous air monitor
CD   compact disc
cfm   cubic feet per minute
cpm   counts per minute
cps   counts per second
F_a alpha factor
F_b beta factor
ISA   Industry Standard Architecture
I/O   input/output
kscf   kilo-standard cubic feet
M^3 cubic meters
M_a correction factor for alpha activity calculations
M_b correction factor for beta activity calculations
μ   Micro
μCi   micro-curie
μCi/ml   micro-curies per milliliter
μs   Microsecond
PC   personal computer
PNNL   Pacific Northwest National Laboratory
PNNL OS3300   PNNL OS3300 Alpha/Beta Stack Monitoring System
Ps   pseudo-coincidence count rate
Ps_o low pseudo-coincidence
QA   quality assurance
scfm   standard cubic feet per minute

S/N   serial number
V   volt

2.0   Installation

The PNNL OS3300 Alpha/Beta Stack Monitoring System (PNNL OS3300) software runs in the Windows® environment and interacts with the LabMaster™ data acquisition PC card to obtain raw counts from the detectors in the LB150D CAM. The LabMaster™ data acquisition PC card and drivers must be installed before installing the alpha/beta monitoring program. The monitoring program also interacts with Microsoft Access®, and the user should install the Access 2000® or earlier version before installing the monitoring software.

2.1   PNNL OS3300 Software Installation

This section describes the processes for installing and uninstalling the PNNL OS3300 software.

2.1.1   Installing PNNL OS3300 Software

To install the PNNL OS3300 software, follow the steps below.

1. Insert the compact disc (CD) into the CD drive of the computer (typically Drive D).

2. From the *Windows® Start* menu, select *Run*.

3. Click the *Browse* button and change to the CD drive from the dialogue box.

4. Double-click the file named *Setup.EXE*.

5. After returning to the Run dialogue box, click *OK*, and the setup program will begin.

6. The software can be installed on any drive in any directory on the computer. Select the default drive and directory (C:\Program Files\OS3300) when prompted (this directory may need to be created before installation).

7. When complete, the program will indicate if the installation was successful.

The software generates the following data files that are saved to the C:\Program Files\OS3300 directory:
- event files
- source check
- plateau
- background
- efficiency
- pseudo-coincidence.

Note: The computer does not need to be rebooted after installation is complete.

2.1.2   Uninstalling PNNL OS3300 Software

The PNNL OS3300 software can be uninstalled with the "Add/Remove Programs" icon in the Windows® Control Panel. Select the PNNL OS3300 software from the list shown in the Control Panel. The database will not be automatically deleted when removing the software.

2.2   Database Installation

This section describes the processes for installing and uninstalling the PNNL OS3300 software database.

2.2.1   Installing PNNL OS3300 Software Database

After the PNNL OS3300 software is installed, the database for the alpha/beta measurement data needs to be copied from the installation disk to the computer, as follows:

1. Insert the CD into the CD drive of the computer (typically Drive D).

2. From the *Windows*® *Start* menu, select *Programs|Windows Explorer*®.

3. Click on the CD icon for the computer in the left-hand pane of the dialogue box.

4. Click the file named *AlphaBeta97.mdb* in the right-hand pane of the dialogue box.

5. Copy the file from the CD (*Edit|Copy* menu) to the C:\ISEMS\ISEMSDBS directory (this directory may need to be created before installation).

6. Close Windows Explorer®.

The database is typically installed in directory C:\ISEMS\ISEMSDBS, but can also be installed in any directory. If the database is stored in a directory other than C:\ISEMS\ISEMSDBS, the program must be directed to the database location. See the section on Select Database for instructions on how to change the database location if this is warranted.

2.2.2   Uninstalling PNNL OS3300 Software Database

If removal of the database is required, the operator must manually delete it from the computer with Windows Explorer®.

2.3   Hardware Installation

This section describes the processes for installing the LabMaster™ Card and connecting the LabMaster™ and breakout box with cables,

2.3.1   LabMaster^TM Card Installation

Before collecting data, the LabMaster^TM input/output (I/O) card must be installed in the PC. A detailed description of the installation procedure is in the LabMaster^TM manual. To summarize:

1. Open the computer case (consult PC documentation).

2. Locate an available industry standard architecture (ISA) slot. **Note**: The LabMaster^TM is an ISA board, and the PC must have ISA slots to use this card.
3. Remove the screw in the slot and the blanking panel from the PC (if installed).

4. Insert the LabMaster™ firmly in the slot and reinsert the screw to hold the card in place.

2.3.2 LabMaster™ and Breakout Box Cable Connections

Connect the 68-pin ribbon-cable between the LabMaster™ I/O card and the breakout box. This supplies the LabMaster™ with easy-to-connect Bayonet Neill Concelman—electrical cable connector (BNC), screw terminals, and the 9-pin "D" connector for making the hardware connections.

The LabMaster™ breakout box has 24 BNCs on its front panel. For systems that use both the LB150D alpha/beta CAM and the LB110 tritium CAM, use the connection scheme in Table 2.1 for the BNC connectors.

Table 2.1. LabMaster™ BNC Connections

Breakout Box	System	Description
0	LB150D Alpha	Alpha Counter Output from Pseudo-Coincidence Board
1	LB150D Beta	Beta Counter Output from Pseudo-Coincidence Board
2	LB150D Total Coincidence	Total Coincidence Counter Output from Pseudo-Coincidence Board
3	LB150D Random Coincidence	Random Coincidence Counter Output from Pseudo-Coincidence Board
4	LB150D Guard	Guard Counter Output from Pseudo-Coincidence Board
5-7	Empty	
8	LB110 Tritium	Tritium Counter Output from rear of LB110
9	LB110 Channel B	Channel B Counter Output from rear of LB110

3.0   Software Operation

The software for PNNL OS3300 provides several functions controlled through the PC environment. Those functions are:

- Collect data at regular intervals.
- Calculate activities and concentrations from data collected.
- Display data and alarm conditions.
- Run calibration utilities.

Each of these functions is discussed in the following sections.

3.1   General Operations Information

This section describes the process of information flow, including short and long count calculations.

3.1.1   Information Flow

In very general terms, the LB150D CAM collects pulses, and the output of the detected pulses is stored as either an alpha or a beta pulse. The pseudo-coincidence board determines in which bin the counts will be stored. The signals are sent through BNC cables from the detectors to the breakout box and then to the LabMaster™ data acquisition card through a 68-pin cable. The LabMaster™ card contains groups of counters and associated timers. When instructed by the software, a group of counters will collect the number of pulses from the LB150D over a period of time equal to the user-selected short count time.

After each short count period has expired, the PNNL OS3300 software requests the time and number of counts from the LabMaster™ card, increases the count time by one short time interval, and restarts the measurement process. The software uses the counts and time values from the LabMaster™ card to calculate the concentration of radioactive material from the alpha and beta pulses during the count period and adds that to the running total. This process is repeated until a long count time is reached. After each long count time, the software stores the values of concentration and activity to a database along with other relevant information (such as the raw counts from the LabMaster™ card).

During each short count time, the software checks the concentration value against the alarm limit. If the alarm limit is exceeded, the software automatically changes the long count time to the short count time for faster data integration. Upon returning to a non-alarm state, the long count time is returned to the user-defined value. Optionally, during the short count time, the raw and calculated data can be stored in a separate database table for reconstructing each long measurement data set.

3.1.2   Data Collection

In very general terms, the CAM collects count rate data from the detectors for periods of time (set by the user) and then calculates the alpha and beta activity collected on the filter paper for that time period. Two time periods are used; they are referred to as the short count and the long count (Figure 3.1). A long count time consists of an integral multiple of short count periods. See Section 3.3.6.6, Count Times, for a detailed discussion of appropriate time periods for the short count and long count.

Illustration of Short and Long Counts

Long Count

Short Count

1   2   3   4   5   6   7   8

Time Interval

Long Count:
Activity calculated and updated on screen

Activity alarm is checked at the end of each long count.

The data are written to Raw Data table of the database.

Short Count:
Concentration calculated and updated on screen

Concentration and fail alarms checked at end of each short count

Data written to Raw Data Short Count table of the database

Illustration of Short Count Alarm

Initially, the long count is set at five short count periods.

When concentration alarm occurs after three short count periods, the long count is adjusted to end at the same time as the short count that triggered the alarm.

After abbreviated long counts are complete and there is no longer an alarm, the long count interval reverts to original value (5 short count periods in this example).

Figure 3.1. Illustration of Short and Long Counts

3.1.2.1   Short Count Calculations

At the end of each short count, the PNNL OS3300 software obtains the average and gross (uncorrected) alpha and beta count rates from the LabMaster^{TM} card. The LabMaster^{TM} card is a PC-slotted card that interacts with the LB150D CAM. The background is subtracted from each count rate, and then the estimated counts from radon progeny on the filter are subtracted. The resulting net count rates are used to calculate the total alpha and beta concentrations present on the filter. The total alpha and beta concentrations calculated during the previous short count time are then subtracted. The final result is a net alpha and beta concentration that is accumulated on the filter during the lapsed short count period.

The net alpha and beta activity is divided by the sample flow volume, and the resulting concentration is compared to the concentration alarm set point. If the calculated value exceeds the concentration alarm set point, the associated circular indicator on the computer screen turns yellow, and selected alarm relays are activated. When the concentration alarm set point is exceeded, the CAM will also initiate a shortened long count equal to the same length as the short count (Figure 3.2). This allows the CAM to calculate and compare both concentration and activity to the alarm set points each time interval. If the integrated activity and concentration do not exceed alarm set points, the long count time is restored to its previous value, and the CAM begins counting again with the first short count of the long count cycle.

If the user has selected the option to save data to the short count table in the database, data are written to the database at the end of the short count.

Important: The system adopted at PNNL uses a gleaner program to publish CAM data to a web page. The gleaner program pulls data from the short count table, so for PNNL applications, the user must select the option to save data to the short count table.
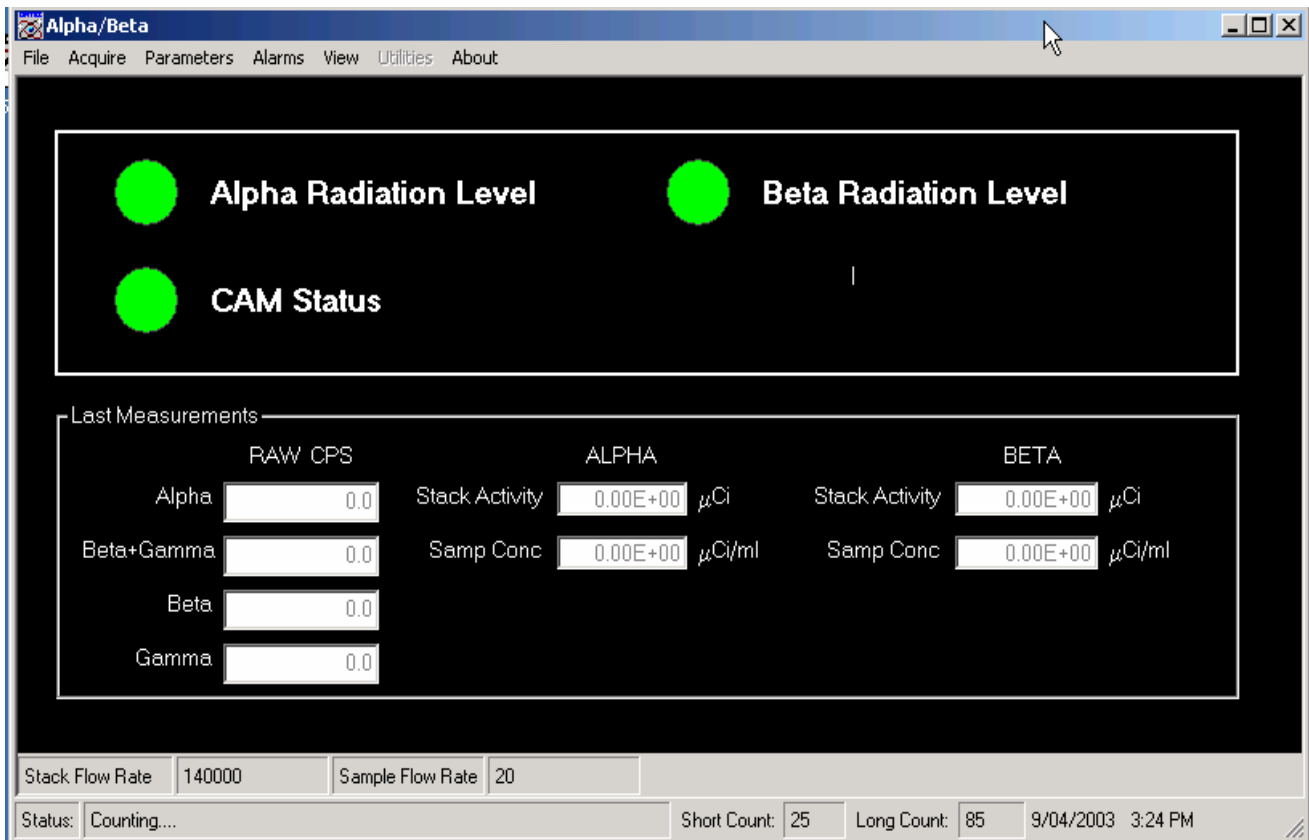
Figure 3.2. Main Screen—Alpha/Beta Monitor Status Screen

3.1.2.2 Long Count Calculations

At the end of each long count, the PNNL OS3300 software sums the net alpha and beta activity calculated during each short count time. The result is the net alpha and beta activity collected on the filter paper during the lapsed long count period. This result is compared to the integral alarm set points. If the calculated activity exceeds the alarm set point, the associated circular alarm indicator on the computer screen turns red (Section 3.2), and the long count time is set to the short count time.

At the end of each long count, the software writes the measured values and calculated results to the database. The user does not have the option to disable storing long count data to the database.

3.2 Alpha/Beta Monitor Status Screen Description

This section describes the alarm indicators, the last measurements, and the status bar.

3.2.1   Alarm Indicators

The status screen has three alarm indicators that provide the status of the system components. The color green indicates normal status (Figure 3.2). Red indicates an alarm condition for the specified component. Alarm indicators for alpha and beta activity have a third state, yellow, which indicates that the concentration during a short measuring period was above the alarm limit. Table 3.1 provides a description for each alarm indicator.

Table 3.1. Alarm Indicator Definitions

Indicator	Alarm Meaning		
	Green	Yellow	Red
Alpha Radiation Level	Normal operating status	The alpha concentration measured at the end of a short count was above the alpha concentration alarm set point.	Either the alpha integral activity or concentration was above its respective alarm set point at the end of a long count.
Beta Radiation Level	Normal operating status	The beta concentration measured at the end of a short count was above the beta concentration alarm set point.	Either the beta integral activity or concentration was above its respective alarm set point at the end of a long count.
CAM Status	Normal operating status	The CAM status indicator only turns red and does not turn yellow under any conditions.	Any combination of the following: 1. Communications lost to the LabMaster^{TM} I/O card. 2. Alpha, beta/gamma, or gamma count rate less than fail threshold setting.

3.2.2   Last Measurements

The main screen also shows indicators for the last readings made by the system for several important parameters. These parameters, listed in Table 3.2, are updated at regular intervals. Units for each of these parameters are shown on the screen as well.

Table 3.2. Last Measurements

Parameter Name	Units	Explanation
Alpha	Raw cps	Alpha channel count rate for the last short count time.
Beta+Gamma	Raw cps	Beta/gamma channel gross count rate for the last short-count time
Beta	Raw cps	Net beta count rate (beta channel count rate minus gamma channel count rate) for the last short count time.
Gamma	Raw cps	Gamma channel count rate for the last short count time.
Alpha Stack Activity	μCi	The calculated net alpha activity collected on the filter during the most recent long count time. This value is compared to the "Integral Alpha Activity" alarm set point. This net activity is updated at the end of each long count time.
Alpha Samp Conc	μCi/ml	Alpha concentration measured in the sampled air over the last short count time. This value is compared to the "High-Alpha Radiation" alarm set point. The concentration measured in the sample should equal the concentration in the stack (assuming isokinetic sampling). The measured concentration is updated at the end of each short count time.
Beta Stack Activity	μCi	The calculated net beta activity collected on the filter during the most recent long count time. This value is compared to the "Integral Beta Activity" alarm set point. This net activity is updated at the end of each long count time.
Beta Samp Conc	μCi/ml	Beta concentration measured in the sampled air over the last short count time. This value is compared to the "High-Beta Radiation" alarm set point. The concentration measured in the sample should equal the concentration in the stack (assuming isokinetic sampling). The measured concentration is updated at the end of each short count time.

3.2.3   Status Bar

The status bar, on the bottom of the main screen, provides 1) the CAM status (e.g., channel failure), 2) countdown timers, in seconds, for the short count and the long count, and 3) the current time and date. Stack flow rates are set in the **Alarm Settings** menu (Section 3.3.4). If the CAM has multiple failure alarms, only the most recent failure alarm is displayed. Just above the status bar, the stack and sample flow rates are displayed in cubic feet per minute (cfm). (This status bar is not displayed when normal counting has been stopped.) Table 3.3 explains the messages that appear in the status bar.

Table 3.3. CAM Status Messages and Definitions

CAM Status Message	Explanation
"Counting"	Normal operating mode
"Alpha Channel Failure #cps" "Beta Channel Failure #cps" "Gamma Channel Failure #cps"	Count rates are lower than fail threshold setting
"Detectors Stopped"	Detectors are not counting
"Counting to acquire operating parameters"	Start-up count running (one minute)

3.3   PNNL OS3300 Main Screen Operations

This section explains the menu functions of the PNNL OS3300 software. It also explains the menu selections starting with the options under the **File** menu and proceeding across the menu bar to the right (Figure 3.3).
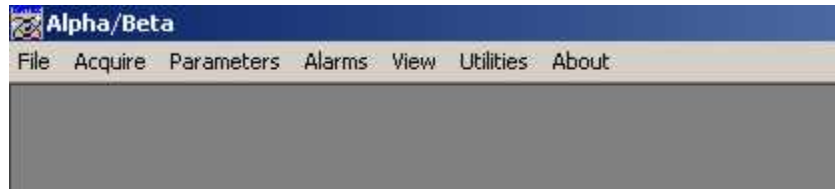

Figure 3.3. Main Screen Drop-Down Menus

3.3.1   File Drop-Down Menu

The following two options are available under the **File** menu:

- **Print Setup** allows you to set up the printer if one is connected to the computer.
- **Exit** closes the alpha/beta monitor program.

3.3.2   Acquire Drop-Down Menu

The options under the **Acquire** menu are used to start and stop the alpha/beta system counters (i.e., data acquisition). When the acquisition is stopped, the **Utilities** menu becomes available. The following options are available under the **Acquire** menu:

- **Start**
- **Stop.**

Only one button is enabled at a time: **Stop** when acquiring data, and **Start** when data acquisition is stopped.

3.3.2.1   Start

The **Start** option starts the routine data collection from the LB150D CAM. The real-time display and data acquisition can be stopped by clicking on **Acquire|Stop**. If data are being actively collected, the software will warn the operator that closing the real-time display will terminate the current counting and offer the option to cancel this operation.

3.3.2.2   Stop

When the **Stop** option is selected, data from the LB150D CAM is retrieved from the LabMaster^{TM} card, activities and concentrations are calculated, and the results are stored to the database. To restart the counting, the operator must select **Start** from the **Acquire** menu. The counting status is provided on the bottom-left corner of the display screen. In the stopped mode, the **Utilities** menu is available, and the count time can be set. To restart data acquisition, select the **Acquire|Start** option.

Note: The stack monitoring system uses a commercial hardware/software monitoring system called Watchdog. The Watchdog program monitors both the PNNL OS3300 and PNNL OS3700 stack monitoring software programs for system lockups by verifying time stamps on the database files produced. If one or the other of the software programs does not successfully provide a new record in a specified amount of time, Watchdog assumes the system has locked up and executes a hard reboot of the system. All necessary programs are maintained in the startup menu so the reboot will restart all necessary stack monitoring programs.

Note: Because the Watchdog program triggers on unsuccessful database entries from the software programs, pause the Watchdog program before stopping the counting process on the PNNL OS3300 software. Once the interface with the PNNL OS3300 software is complete, the Watchdog program will need to be restarted.

Note: Watchdog has an active icon (shaped like a human heart) that will palpitate when the program is running. The icon is located in the bottom right-hand corner of the computer screen in the system tray. By clicking on the icon, an interactive window will appear where the program can be paused and/or resumed.

3.3.3   Parameters Drop-Down Menu

The options under the **Parameters** menu are used to set the operating options and values for the program. The following options are available under the **Parameters** menu:

- **Fail Threshold Settings**
- **Preferences**
- **Select Database**.

3.3.3.1   Fail Threshold Settings

The **Parameters|Fail Threshold Settings** option allows the user to set a minimum count rate for each channel or detector. Count rates below the fail threshold values will cause the CAM to register a fail alarm.

The fail threshold setting is an alarm value that determines whether a particular channel or detector of the measuring system is functioning properly. Fail threshold alarm set points are set for the alpha detector ("Alpha"), the beta/gamma detector ("Beta + Gamma"), and the gamma detector ("Gamma"). The values input into these boxes (Figure 3.4) represent the minimum count rates (in counts per minute [cpm]) that must be obtained by the electronics to show that the detectors are functioning. A failure to meet these levels will result in a CAM status alarm on the status screen. This failure is recorded in the event log. Additional detail on event files is provided in Section 3.3.5.2.
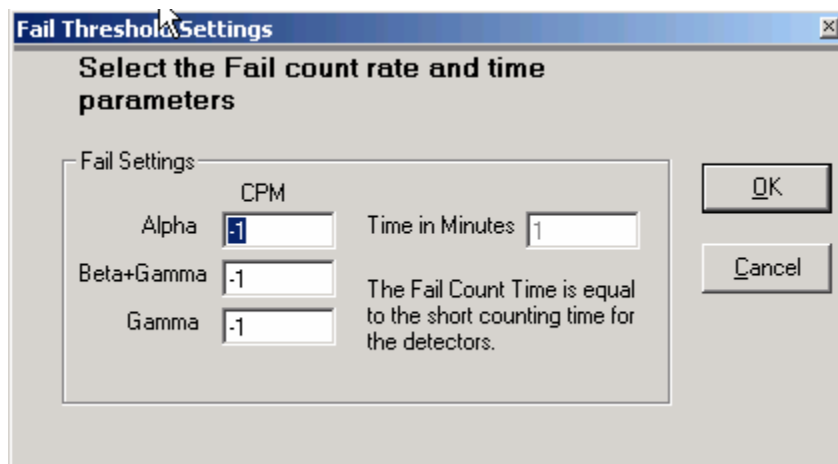
Figure 3.4. Fail Threshold Settings Screen

The factory defaults are 0 cpm for all channels. To set new values, click in the text boxes, enter new values, and click *OK*. (**Note**: Setting these values too high may result in an unacceptably high rate of false fail alarms). The count time displayed is the time period the fail alarm is evaluated. It is equal to the short count time and can not be changed on this form.

The fail alarms can be effectively disabled by setting the alarm set points to negative values.

To exit the **Fail Threshold Settings** form without changing any values, click the *Cancel* button.

3.3.3.2 Preferences

The **Preferences** menu (Figure 3.5) allows the user to change the parameters used by the source check utility, the gamma subtraction function in the CAM algorithm, and select whether to store the results from each short count rate in the database.

Figure 3.5. Preferences/Source Parameters Dialogue Box

A number of parameters used by the source check utility are entered on this form, including the source activities, source check count times and number of cycles, and the criteria (allowable error) for passing a source check. The available selections and settings are described below.

- *Source S/N:* The serial numbers (S/N) of the sources used to perform source checks should be entered in this field. The serial number is written to the source check file along with the results of the source check.

- *Activity (Bq):* The activity of each source, in Becquerel (Bq), at the time the source was certified is entered here. The source activity is used by the source check utility to determine the CAM detection efficiency.

- *Source Cert Date:* The date the source activity was certified is entered in this field. The data must be entered in the form mm/dd/yyyy. The source activity is decay corrected (by the software) from the source certification date to the date the source check is performed.

- *Half-Life (yr)*: The half-life, in years, of the isotope used for each of the check sources is entered in this field. This half-life is used by the CAM software to decay correct the source activity to the date the source check is performed.

- *Count Time (mins):* When the source check utility is run, several counts are completed. The count time for each count is equal to the value entered in this field. The number of counts is set by the parameter *Cycles*. The detection efficiency reported when the source check utility is completed is the average detection efficiency for all cycles.

- *Cycles:* When the source check utility is run, several count cycles are completed. The number of count cycles is determined by the value entered in this field.

- *Allowable Error %:* The allowable error sets the criteria for passing a source check. If the detection efficiency measured during the source check utility is within X% of the detection efficiency measured during calibration, the CAM passes the source check. The value of X is set in this field.

- *Gamma Factor*: The gamma factor is a compensation factor used when the gamma background detector and the beta detector are different sizes or have different sensitivities. The measured count rate in the gamma channel is subtracted from the beta/gamma channel count rate to reduce the effects of gamma background from external sources of gamma radiation (Equation 3.1). The default gamma factor is one, indicating that the two detectors are of equal sensitivity. Experience or testing may produce a slightly different factor. The gross beta count rate is calculated as follows:

$$Beta\ Count\ Rate_{gross} = (Beta + Gamma\ Count\ Rate)_{gross} - (Gamma\ Factor)(Gamma\ Count\ Rate_{gross})$$

(3.1)

- *Disable Gamma Bkg Subtract*. If testing is required for a more accurate factor, a check box is provided to disable the gamma background subtraction. The default state of the check box is unchecked. If the *Disable Gamma Bkg Subtract* box is checked, Equation 3.2 is used to calculate the gross beta count rate.

$$Beta\ Count\ Rate_{net} = (Beta_{gross} + Gamma\ Count\ Rate_{gross})$$ (3.2)

- *Save Short Count Data to Database*. When checked, results calculated at the end of each short count are saved to the database (Section 4.2). The user should be aware that this will grow the size of the database considerably faster.

Clicking the *OK* button will save the parameters to the Windows® registry and implement the changes on the next counting cycle.

To exit the **Parameters** form without changing any values, click the *Cancel* button.

3.3.3.3   Select Database

Upon installation, the database name and path must be entered under **Select Database** so the program knows where to store the data. This option may also be used if the user changes the name of the database.

The software is initially set up to store data in an Access database titled, *AlphaBeta97.mdb*. If the database is renamed, the user must use the **Parameters|Select Database** option to direct the PNNL OS3300 software to the new database file location.

3.3.4   Alarms Drop-Down Menu

The **Alarms** menu allows the user to configure the CAM alarms. The following options are available under the **Alarms** menu:

- **Settings**
- **Relay Setup**.

3.3.4.1   Settings

The **Alarm|Settings** option is used to set alarm levels for the alpha beta control system (Figure 3.6). Although eight alarms are listed, the system uses only four to trigger alarms: *High Alpha Radiation, High Beta Radiation, Integral Alpha Activity,* and *Integral Beta Activity*. The fixed flow rate parameters shown on this form are used to enter sample and stack flow rates into the system. The remaining two parameters (*High Stack Flow Rate* and *High A/B Sampler Flow Rate*) are disabled for the PNNL OS3300 software.

Figure 3.6. Alarm Settings Dialogue Box

To change a setting, click in a text box and enter a new value. When all new values are set, click the *OK* button. To exit without changing any values, click the *Cancel* button.

Once the alarm set points are entered, these values are stored in the software and used to trip the appropriate alarms, for example, a stack monitoring annunciator alarm panel.

The concentration alarms (*High Alpha Radiation* and *High Beta Radiation*) are tripped if the concentration measured during a short count time exceeds the alarm set point. This alarm is non-latching.

After the concentration alarm is tripped and the concentration released during the following short count time is below the concentration alarm set point, the alarm indicator on the status screen will return to green. If the alarm is tripped during the short count time, the alarm indicator on the main screen will turn yellow, and the long count time will be set equal to the short count time. If, at the end of the long count time, the concentration still exceeds the alarm set point or if the integral alarm is tripped, the alarm indicators on the main screen will turn red. Default values for high alpha radiation and high beta radiation alarms are 100 and 200 µCi/ml, respectively. These alarms typically are tripped before the integral activity alarms because integral activity alarms are only checked at the end of the long count time. The user should determine what is appropriate for the particular installation and enter those values here. Avoid entering values that are too restrictive; this can result in numerous false positives.

The integral activity alarms (*Integral Alpha Activity* and *Integral Beta Activity*) are tripped when the net activity released out the stack during the long count time exceeds the alarm set point. If the net activity released during the long count time exceeds the integral activity alarm set point, the radiation level alarm indicator on the status screen will turn red.

The net activity, in µCi, released out the stack is calculated by multiplying the net activity collected on the filter by the ratio of the stack flow rate and the sample flow rate shown in Equation 3.3.

$$Activity_{net,stack} = (Activity_{net,filter})(\frac{Stack\ Flow\ Rate}{Sample\ Flow\ Rate})$$

(3.3)

Like the concentration alarm, the integral activity alarm is non-latching. If the integral activity alarm is tripped (alarm indicator is red), and the net activity released during the following long count time is below the integral activity alarm set point, the alarm indicator on the status screen will return to green.

The *Fixed Stack Flow Rate* and *Fixed Sample Flow Rate* display the fixed flow rates used by the PNNL OS3300 software to calculate flow volumes, concentrations, and net stack activity. These values may be edited by the user. On the PNNL OS3300 system, the stack flow rates will be updated with actual measured flow rate numbers from periodic stack velocity traverses.

Note*:* The user should take care when adjusting the fixed flow rates because these will affect the concentration and net activity calculations of the CAM.

Note: Changing the fixed flow rates on this screen does not change the actual flow rate of the system.

3.3.4.2   Alarm Relay Setup

There are six user-programmable alarm relays for this system, and Figure 3.7 shows the setup screen for these relays. Each relay can be programmed to function as a result of any combination of possible alarms. The alarm options are listed in the left-hand pane of the screen. If more than one option is programmed to a single relay (such as *CAM Function* and *Beta High Rad.* in relay five shown below), the signal uses an either/or logic. If either alarm is tripped, the relay will be energized. Table 3.4 provides alarm relay output descriptions.
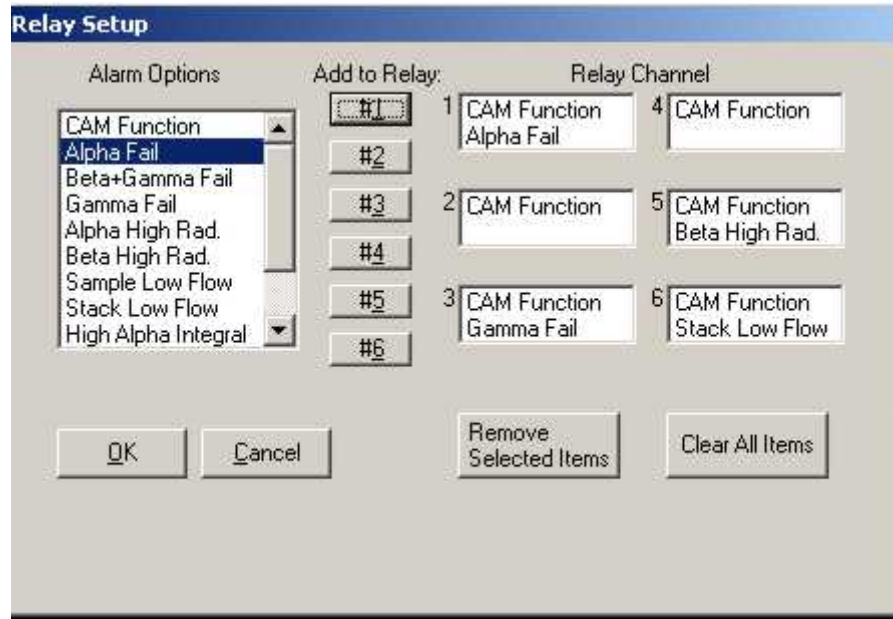
Figure 3.7. Relay Setup Screen

To add an alarm option to a relay, highlight the alarm (by clicking on it) in the A*larm Options* box on the left and then click the appropriate *Add to Relay* numbered button in the middle of the screen to add it to the relay. Each function can be assigned to any number of relays simultaneously. To remove a specific item from a relay, highlight the alarm option in the box on the right (by clicking on the alarm name) and click *Remove Selected Items*. All other alarm options will remain unchanged. To delete all the alarm options for all the relays, click *Clear All Items*. When the relay channels are set as desired, click *OK*. Once *OK* is clicked, the new relay settings are applied. To exit without changing the relay channels, click the *Cancel* button.

Table 3.4. Relay Output Descriptions

Function Name	Description
CAM Function	One or more detector count rates were at or below the failure threshold or the software was not able to communicate with the data acquisition hardware.
Alpha Fail	The detector count rate was at or below the failure threshold.
Beta+Gamma Fail	The detector count rate was at or below the failure threshold.
Gamma Fail	The detector count rate was at or below the failure threshold.
Alpha High Rad.	The net alpha activity is above the integral alpha activity threshold or concentration is above concentration threshold.
Beta High Rad.	The net beta activity is above the integral beta activity threshold or concentration is above concentration threshold.
Sample Low Flow	Sample flow rate (scfm) is below the minimum acceptable flow rate.
Stack Low Flow	Stack flow rate (scfm) is below the minimum acceptable flow rate.
High Alpha Integral	The net alpha activity is above the integral alpha activity threshold.
High Beta Integral	The net beta activity is above the integral beta activity threshold.
Sample High Flow	Sample flow rate (scfm) has exceeded the maximum acceptable flow rate.
Stack High Flow	Stack flow rate (scfm) has exceeded the maximum acceptable flow rate.

3.3.5 View Drop-Down Menu

The following options are available under the **View** menu:

- **Filter Log**
- **Event Files**.

3.3.5.1 Filter Log

The **Filter Log** menu option provides a means for viewing the start and end dates for each filter and for saving to disk the detailed emissions data associated with each filter.

The filter log (Figure 3.8) is a table in the database (Section 4.2) that keeps track of information produced when a filter is changed. Each filter used by the CAM is assigned a unique number (listed as *FilterNum* in the filter log). The date and time the filter is installed are logged as the *StartDate*, and the date and time the filter are removed are logged as the *EndDate*. The start and end dates are used to identify specific entries in the CAM database that correspond to the time a specific filter was used.

Figure 3.8. Filter Data Log Screen

From the filter data log screen (Figure 3.8), the operator can save all long count data and calculations associated with a single filter to a file for archival purposes. The *Save Data* button will prompt the user for a filter number (Figure 3.9). The filter numbers are in the left-hand column labeled *FilterNum*. The user is then prompted to provide a name and location for the text file. Data collected after each long count during that filter's run time are copied from the database to the text file.

Figure 3.9. Select Dialogue Box

Table 3.5 summarizes the data saved to the text file in the order they appear.

Table 3.5. Filter Log File Parameter Title

Parameter Title in Filter Log File	Explanation
Date	The date the values were logged into the database
A-stk-Act	The alpha activity released to the stack during the long count time (µCi)
B-stk-Act	The beta activity released to the stack during the long count time (µCi)
Stk-Flo-Rate	The stack flow rate during the long count time (standard cubic feet per minute [scfm])
Stk-Flo-Tot	The total flow through the stack since the last filter change (kilo-standard cubic feet [kscf])
AB-Flo-Rate	The flow rate through the alpha/beta sampler (cfm)
Sample-Total	The total volume of air sampled by the alpha/beta sampler since the last filter change (m^3)
Raw-Time	The time the values were logged into the database

3.3.5.2 Event Files

The **Event Files** menu provides a means for viewing and printing the event log file(s) generated by the PNNL OS3300 software. The event log is a daily file containing information about alarms that occur, user changes to the parameters, and the system status. This log is meant to maintain status reports on the system as a whole. For every software transaction a user makes, a brief description of each event, including the time, date, and action taken, is provided.

The filename format is YYMMDD.log where

- YY are the last two digits of the year the file was created
- MM is the number corresponding to the month the data was created
- DD is the day the data were created.

After selecting the file to be opened and clicking *Open*, Windows Notepad® will open the selected file. From here, the user can review the data and save them to other locations if necessary. The following list provides an example of an event log table.

09/30/2003   11:28:29 a.m.
Description: Alpha/Beta monitor successfully started.

09/30/2003   11:28:29 a.m.
Description: Alpha/Beta Real Time Screen successfully loaded.

09/30/2003   11:29:30 a.m.
Description: Started the Alpha/Beta Monitor counting.

09/30/2003   11:36:38 a.m.
Description: Alpha Channel Failure: 0 cps.

09/30/2003   11:36:38 a.m.

Description: Beta Channel Failure: 0 cps.

09/30/2003   11:36:38 a.m.
Description: Gamma Channel Failure: 0 cps.

09/30/2003   11:39:02 a.m.
Description: Stopped the Alpha/Beta Monitor counting.

09/30/2003   11:39:46 a.m.
Description: Stored new count times.

09/30/2003   11:39:55 a.m.
Description: Changed filter.

09/30/2003   11:40:05 a.m.
Description: Alpha/Beta Real Time Screen successfully loaded.

09/30/2003   11:41:06 a.m.
Description: Started the Alpha/Beta Monitor counting.

09/30/2003   11:41:33 a.m.
Description: Stopped the Alpha/Beta Monitor counting.

09/30/2003   11:41:43 a.m.
Description: Stored new count times.

09/30/2003   11:41:49 a.m.
Description: Changed filter.

09/30/2003   11:41:51 a.m.
Description: Alpha/Beta Real Time Screen successfully loaded.

09/30/2003   11:42:52 a.m.
Description: Started the Alpha/Beta Monitor counting.

3.3.6   Utilities Drop-Down Menu

The utility mode, available only when data acquisition is stopped, is used to activate the following functions:

- Source Check
- Voltage Plateau
- Background
- Efficiency
- Pseudo-coincidence
- Count Times
- Change Filter.

Note: The PNNL OS3300 software has two modes: a utility mode and a count mode.

3.3.6.1 Source Check

The **Source Check** utility is used to verify that the CAM detectors are operating within specifications established at calibration. Essentially, the source check function repeats the efficiency measurements performed at calibration and compares the newly measured efficiency values with the efficiency values established at calibration. The calibration efficiency for both alpha and beta are compared to the efficiency obtained during the source check with the same radiological sources. Pass or fail is determined by the *Allowable Error* set in the Preferences/Source Parameters Dialogue Box (Figure 3.5). If the new efficiencies are within the percent tolerance of the calibration efficiencies, the system passes the source check.

Note: A typical value of the allowed percent variation is 10%.

When the Source Check utility is started, the user is prompted to enter his name (Figure 3.10). Any alphanumeric string may be entered. Entering a blank or clicking *Cancel* cancels the Source Check utility, and the program returns to the main screen.
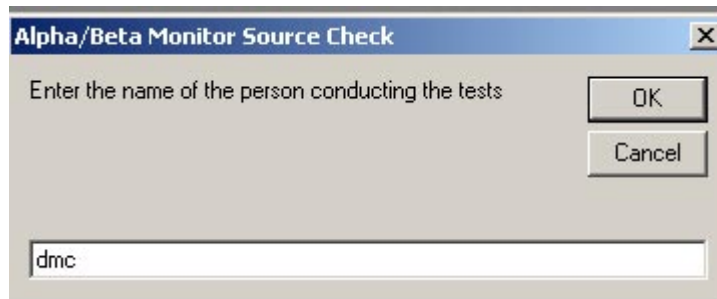
Figure 3.10. Source Check Dialogue Box

After entering your name, click *OK*.

A message box will appear asking the user to confirm the source serial number and the source certified activities (the program will decay the source activities to the date the source check was performed). If correct, click *OK*. If incorrect, click *Cancel* and go to **Parameters|Preferences** to change the source activities, certification dates, and serial numbers.

The user is prompted to start the source check function by selecting *Start*. A dialogue box will prompt the user to place an alpha standard source in the chamber. After placing the source in the detector chamber, click *OK*. The system will count the source for the number of cycles indicated in the **Parameters|Preferences** window.

At the end of each cycle, the calculated alpha and beta efficiency (Equations 3.4 and 3.5) and calculated alpha and beta spill are displayed. The alpha spill and beta spill are expressed as a percent.

$$Alpha\ Eff. = \frac{Alpha\,(cps) - AvgAlphaBkg\,(cpm)/60}{decay\ corrected\ Alpha\ Source\ Activity\,(dps)} \tag{3.4}$$

where Alpha Source Activity is the source activity entered in the preferences form, and AvgAlphaBkg is the average alpha background measured in the background utility.

$$Beta\ Eff. = \frac{[Beta\,(cps) - Beta + Gamma\,(cps)] - AvgBetaBkg\,(cpm)/60}{decay\ corrected\ Beta\ Source\ Activity\,(dps)} \tag{3.5}$$

where Beta Source Activity is the source activity entered in the preferences form, and AvgBetaBkg is the average beta background measured in the background utility.

The count time for each cycle and the total remaining time for the source check are displayed on the main screen's status bar as the short count time and the long count time, respectively. At the end of all count cycles, the average detection efficiency is calculated (Figure 3.11).
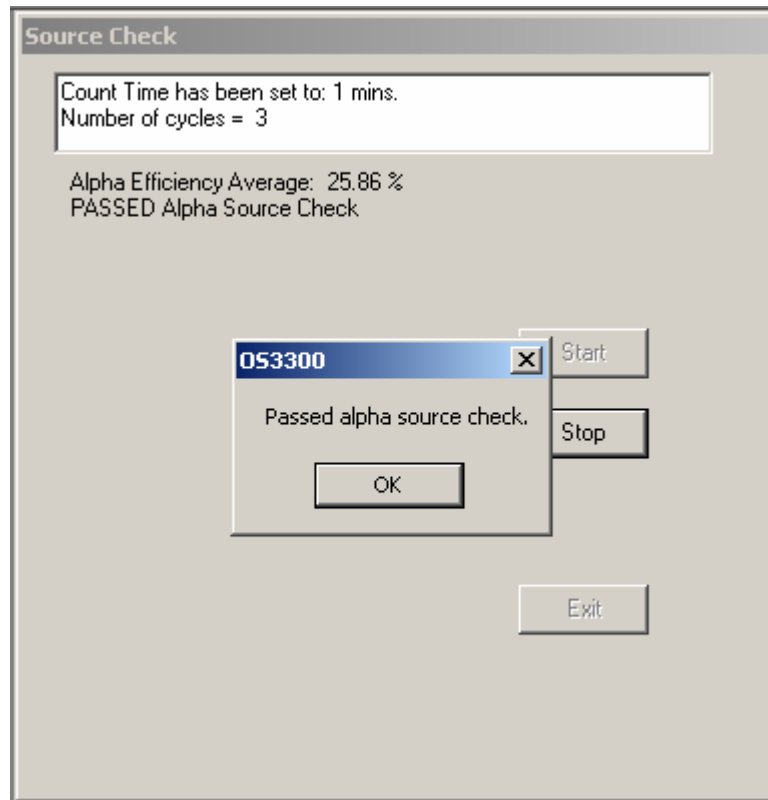
Figure 3.11. Source Check Status Box

If the average measured detection efficiency is not within the limits (i.e., the Allowable Limits % in the Preferences/Source Parameters dialogue box) established in the **Parameters|Preferences** window, the software will indicate that the CAM has failed the source check. If the CAM fails the alpha source check, the dialogue box will state that the alpha source check has failed and will present the user with the options to *Retry* or *Cancel*. *Retry* will take the user back to the beginning of the alpha source routine. *Cancel*

will cancel the alpha source check, and the dialogue box will be displayed asking the user if he wants to run the beta source check. The box includes the option to *OK* or *Cancel*. *Cancel* completely exits the source check routine.

Upon exiting the source check form, the source check results (including failures) are written to the file "C:\Program Files\OS3300\Source Check mm-dd-yyyy.txt" where mm-dd-yyyy is the month, day, and year the source check was performed. If multiple source checks are performed on the same day, the results are appended to the end of the file like the following example.

```
    Alpha Source Check performed on: 9/26/02 By: kk
       Cycle    Alpha Eff. Spillover
       -----    ------------------
        1       .24      100.00
       -----    ------------------
       Average: 0.2428    1.

PASSED!
    Beta Source Check performed on: 9/26/02 By: kk

       Cycle    Beta Eff.
       -----    ----------
        1       0.2007
       -----    ----------
       Average: 0.2007
Calibration Efficiency ≡ 0.445, FAILED!
```

3.3.6.2   Voltage Plateau

Caution: Changing the high-voltage setting voids instrument calibration. The high-voltage plateau should not be run unless the instrument is being calibrated.

This utility runs a high-voltage plateau to aid the selection of an appropriate high-voltage for each detector: alpha and beta. The gamma plateau is not performed because the same voltage setting is used for both gamma and beta because the gamma detector is located directly behind the beta detector. Because of the gamma detector's location, both the beta and gamma detectors measure the same gamma field. The same voltage bias that is across the beta detector is also applied to the gamma detector. This is ideal because it will help eliminate differences between the two detectors and reduce the need for a gamma subtraction factor other than one, or unity. A high-voltage plateau establishes the relationship between the detectors' operating high voltage and its detection efficiency. During calibration, the optimum voltage is found because it is important to know the detectors' counting rates and efficiencies as a function of the voltage supplied. Once the operating voltage has been selected, the manufacturer recommends conducting annual voltage plateaus to verify detector stability.

First, the user must select **Acquire|Stop**. Under **Utilities,** select **Voltage Plateau** and then either the **Alpha** or **Beta** option from the drop-down menu. A dialogue box will appear after the user makes a selection (e.g., see Figure 3.12, which depicts the alpha plateau measurement window).

Figure 3.12. Alpha Plateau Measurement Window

Before a high-voltage plateau can be started, the user must enter several parameters, beginning with the count time for each measurement. Select *Count Time* and enter the time in seconds for each voltage measurement. Then the user must select *Voltage* to edit the start and ending voltages for the plateau. The alpha and beta plateaus can be run with different count times and with different high-voltage ranges. Typical values of the start and end voltages are as follows:

Alpha — 900 to 1500 V
 Beta — 1500 to 2300 V.

The user will then be prompted to place the appropriate standard (calibration source) in the sample chamber.

The software adjusts the high-voltage settings and takes 30 measurements across the voltage range selected. When the measurements are complete, the *Show Graph* button is displayed (Figure 3.13). To select a high-voltage operating point on the graph, click on the *Show Graph* button. The user selects the voltage with the correct plateau response to maximize count efficiency. A voltage that corresponds with a measurement just after the start of the high-voltage plateau shown on the graph should be selected (Figure 3.13).
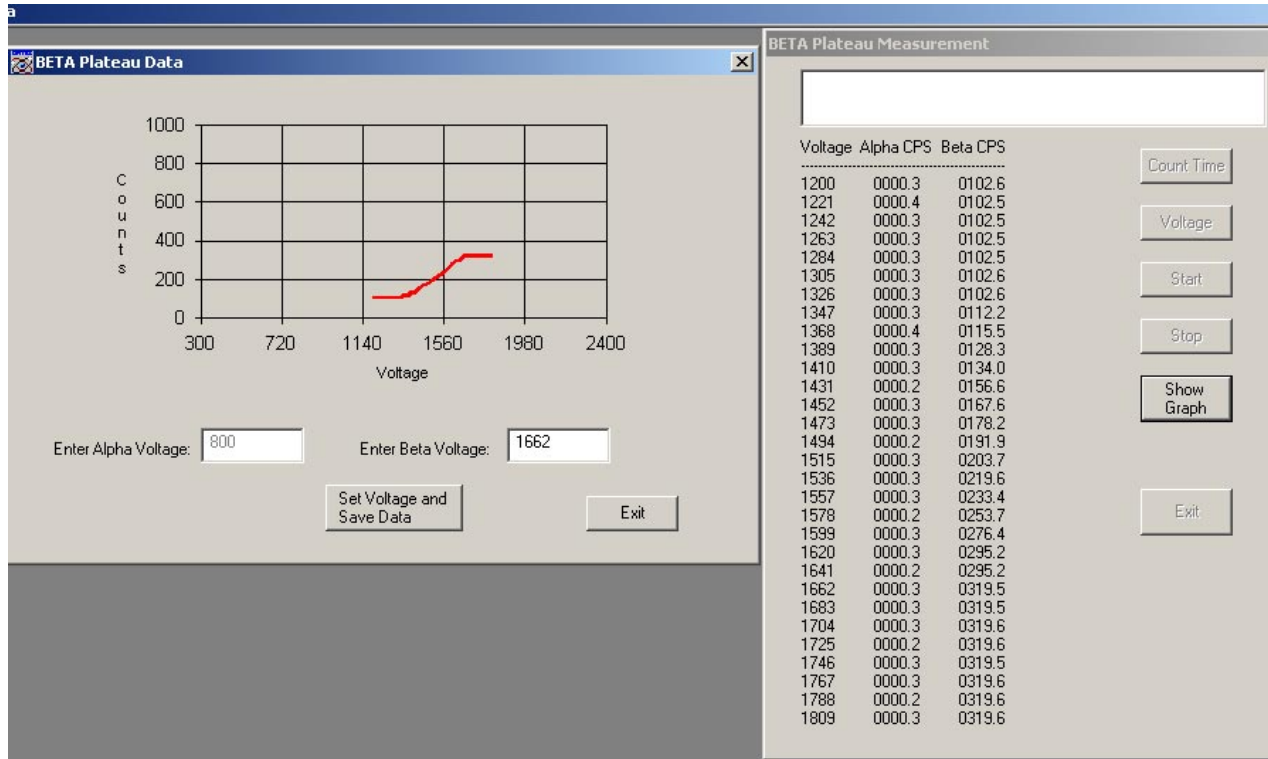
Figure 3.13. Beta Plateau Complete Window and Graph

Typical values of the alpha-high-voltage are between 1100 and 1300 volts. Typical settings for beta are between 1650 and 1850 volts, which will minimize the beta-to-alpha channel spillover.

Caution: Storing these values voids the instrument calibration.

Pressing the *Set Voltage and Save Data* button will store the settings in the file "C:\Program Files\OS3300\Plateau mm-dd-yyyy" where mm-dd-yyyy is the date the plateau was performed.

To stop the plateau run, click on the *Stop* button. To exit the plateau measurement dialogue box, click on the *Exit* button.

3.3.6.3   Background

This utility runs a background measurement to determine the background of the alpha, beta, and gamma channels.

From the **Utility** drop-down menu, select **Background** (Figure 3.14).
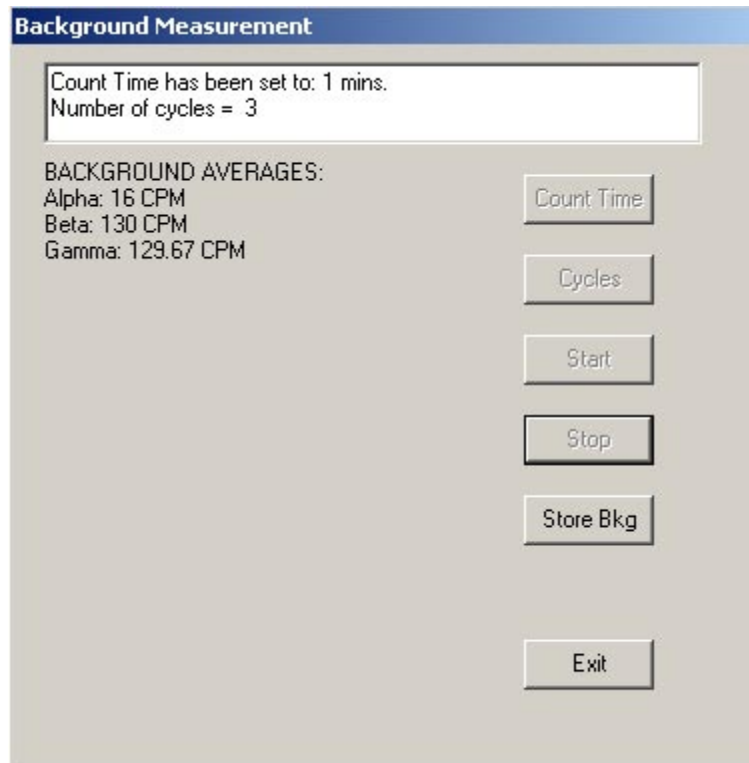
Figure 3.14. Completed Background Measurements

Press the *Count Time* button and enter the desired count time, in minutes, for the background count. The value entered must be between 1 minute and 1,440 minutes. Then click *OK*.

Press the *Cycles* button and enter the desired number of count cycles. Each count cycle will count for the time period entered under count times. Acceptable values for the number of count cycles are 1 to 100.

Press *Start* to begin the background measurement. At the end of each count cycle, the total counts measured by the alpha, beta, and gamma detectors will be indicated. The time remaining in the count cycle is indicated on the status bar.

Caution: Storing these values voids the instrument calibration.

After all count cycles are complete, the average alpha, beta, and gamma background count rates, in cpm, will be displayed. To store these values in the software to be used for calculations, click the *Store* button.

To stop the background count, click the *Stop* button. To exit the background count box, click the *Exit* button.

3.3.6.4 Efficiency

This utility calculates the detection efficiency of the alpha and beta detectors and should be run only as part of the instrument calibration.

Caution: Storing these values voids the instrument calibration.

From the **Utility** drop-down menu, select **Efficiency** and either **Alpha** (Figure 3.15) or **Beta**. Click the *Count Time* button. Enter the desired count time, in minutes, for the efficiency count. The value entered must be between 1 minute and 1,440 minutes. Then click *OK*.

Next, click the *Cycles* button. Enter the desired number of times the count will cycle. Each cycle will count for the time period under Count Time. Acceptable values for the number of count cycles are from 1 to 100.

Press *Start* to begin the detection efficiency measurement. A message box appears confirming the source serial number and activity. If information is correct, click *OK;* if incorrect, click cancel and update the source information by selecting **Parameters|Preferences** (enter correct source parameters in the dialogue box and click *OK*). Click *OK* on the second message box once the source is placed in the chamber. The status box will indicate when each efficiency measurement is completed and provide an average efficiency at the end of the counting.

To save the efficiency, click the *Store Eff.* Button. A dialogue box will appear requesting confirmation of storing the values.

To stop the efficiency detection count, click the *Stop* button. To exit the Efficiency Count box, click the *Exit* button.

Alpha efficiency is calculated by subtracting the average alpha background stored in the registry after running the background utility from the alpha channel raw counts and dividing that result by the source activity. Beta efficiency is calculated by subtracting the average beta background stored in the registry from the beta channel raw counts and dividing that result by the source activity. Gamma background (signal from gamma detector) is subtracted from the beta signal when doing the beta efficiency.
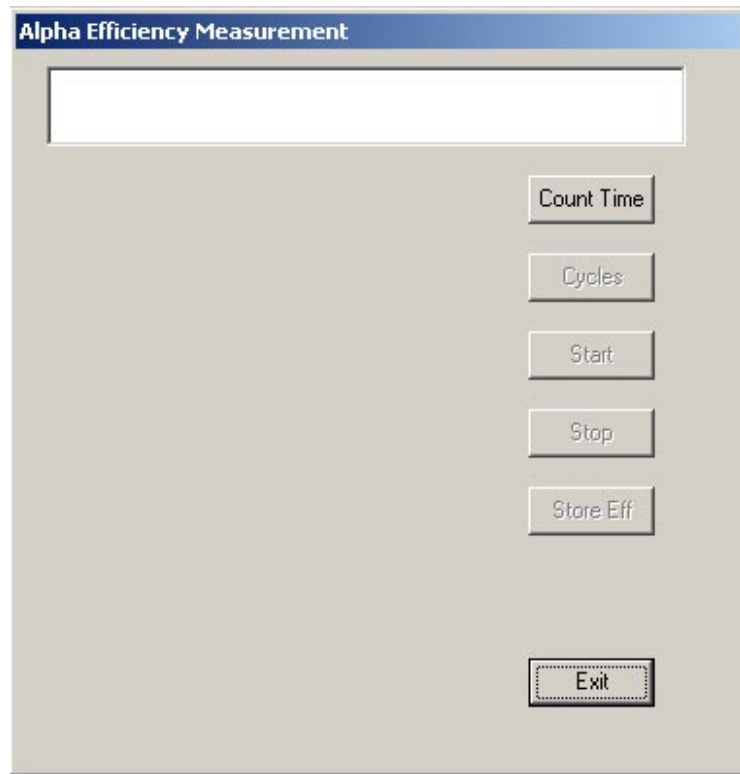
Figure 3.15. Alpha Efficiency Measurement Window

3.3.6.5   Pseudo-Coincidence

The **Pseudo-Coincidence** utility should be run only as part of the instrument calibration. It establishes the factors for the linear equation that estimate the activity on the filter from radon progeny. The utility establishes values for five factors:

F_a = alpha factor
F_b = beta factor
M_a = correction factor for alpha activity calculations
M_b = correction factor for beta activity calculations
Ps_o = low pseudo-coincidence rate.

The function of these factors is described in greater detail in Section 4.0.

The pseudo-coincidence utility collects count rates from the total and random pseudo-coincidence channels that represent typical radon levels in the area where the CAM is installed. Because radon levels fluctuate over the course of a day, total and random pseudo-coincidence count rates must be collected over an extended period of time.

Before running this utility, a clean filter should be installed, the system vacuum supply turned on, and clean air sampled for at least 2.5 hours.

From the **Utility** drop-down menu, select **Pseudo-Coincidence**. Press the *Count Time* button. Enter the desired count time, in minutes, for each count. The value entered must be between 60 minutes and 300 minutes. Then click *OK*.

Press the *Cycles* button. Enter the desired number of count cycles. Each count cycle will count for the time period entered under count times. The range of values for the number of count cycles is 10 to 100.

Press *Start* to begin the pseudo-coincidence measurement. The time remaining in the count cycle is indicated on the status bar. After each count cycle finishes, the cycle number and count rates for the alpha, beta, and pseudo-coincidence are displayed on the screen (Figure 3.16).

Caution: Storing the pseudo-coincidence results voids the instrument calibration.

After all count cycles are finished, the screen below is displayed. To store these values in the registry, press *Store Ps-Coin*.

To stop the pseudo-coincidence count, click the *Stop* button. To exit the pseudo-coincidence count box, click the *Exit* button (Figure 3.16).
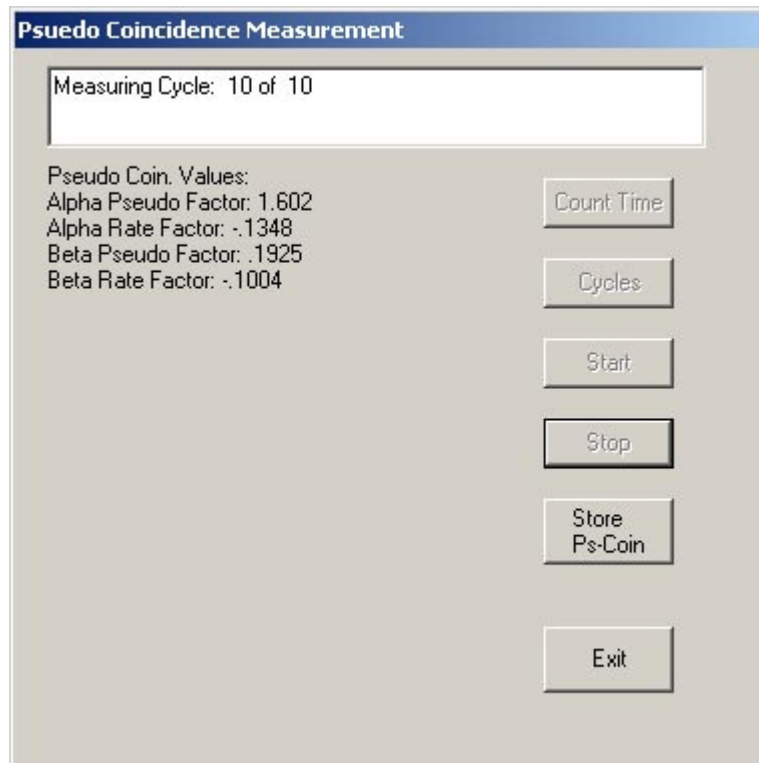
Figure 3.16. Completed Pseudo-Coincidence Count Window

3.3.6.6   Count Times

The second mode for PNNL OS3300 software is a count mode. The main count time used in data acquisition is set in the **Utility** menu. Click on **Count Times** to enter the desired time, in minutes. For convenience, if only the short count time is entered and the user then clicks *OK*, the long count time will automatically be set to six times the short count time. Otherwise, the user will need to enter the short count time and then enter an integer multiple of the short count time for the long count time prior to clicking *OK*. The short count and long count times do not have to be integer values, but this is not recommended; only the multiple between the short count time and the long count time must be an integer. For example, if the short count is set at 3 minutes, the long count needs to be set at 6, 9, 12, or any multiple of 3. After the desired minutes have been entered correctly, clicking *OK* will result in a message that states the count times you have entered will take effect after acquisition is restarted; otherwise, a message to re-enter appropriate values results. Clicking on *Cancel* will exit the *Count Times* window without making any changes (Figure 3.17).

Figure 3.17. Count Time Window

3.3.6.7   Change Filter

The **Change Filter** function must be performed when an operator needs to change the 8-inch-diameter filter in the CAM. Performing this function accomplishes two goals: it resets the counter for the data acquisition and makes an entry in the filter log.

When it is time to change a filter, the user needs to click on **Acquire|Stop** and select the **Utilities|Change Filter**. The operator will be prompted to verify because this will reset the current activity integration (Figure 3.18). By clicking *Yes*, another dialogue box will appear instructing the user to bypass the flow through the detector and change the filter in the LB150D drawer. After doing so, click *OK* to finish the procedure. New information is automatically recorded to the filter log.

Confirm Change Filter ✕

This will reset the current activity integration. Are you sure you want to change the filter?

[Yes]   [No]

OS3300 ✕

Bypass flow through detector,
Then change filter in LB 150-DR drawer.
Press the OK button to reset the measurements.

[OK]

OS3300 ✕

Restore flow through detector.
After pressing ok,
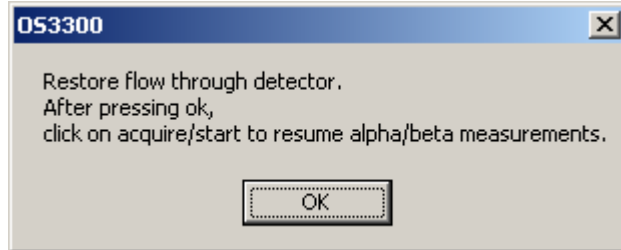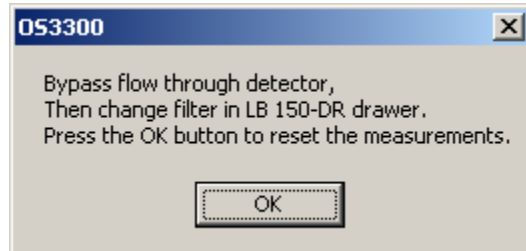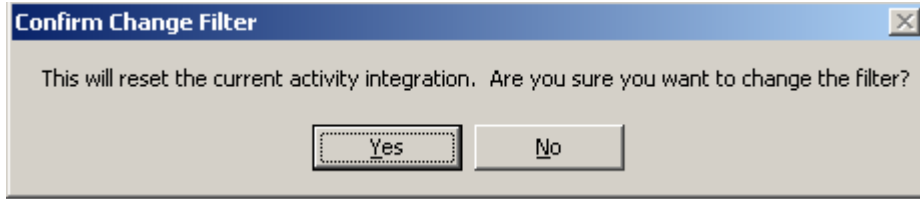click on acquire/start to resume alpha/beta measurements.

[OK]

Figure 3.18. Change Filter Windows in Order of Operation

3.3.7   About Drop-Down Menu

Selecting **About** provides the user information on the PNNL OS3300 software.

4.0   Parameters and Calculations

The software performs a number of calculations. This section provides the algorithms used in the software code to display the results of the monitoring system.

4.1   Parameters

This section describes raw alpha, raw beta + gamma, raw beta, and raw gamma parameters. The alpha and beta stack activity and the alpha and beta sample concentration are also described.

4.1.1   Raw Alpha

The parameter "RAW CPS-Alpha" displayed on the main screen is the count rate measured from the alpha detector (in cps) during the last short count time (Figure 3.2).

4.1.2   Raw Beta + Gamma

The parameter "RAW CPS-Beta+Gamma" displayed on the main screen is the count rate (in cps) measured from the beta detector during the last short count time. The measured count rate includes interference from gamma radiation (Figure 3.2).

4.1.3   Raw Beta

The parameter "RAW CPS-Beta" displayed on the main screen is the calculated net count rate (in cps) of the beta detector for the last short count time. The displayed value is the difference between the "Beta+Gamma" value and the "Gamma" value (Figure 3.2).

4.1.4   Raw Gamma

The parameter "RAW CPS-Gamma" displayed on the main screen is the count rate (in cps) measured from the gamma detector during the last short count time. The gamma detector is located directly behind the beta detector, so it measures, essentially, the same gamma field as the beta detector. The signal from the gamma detector is subtracted from the signal of the beta detector when "Gamma Bkg Subtract" is enabled (Figure 3.2).

4.1.5   Alpha and Beta Stack Activity

The parameter "Alpha-Stack Activity" (μCi) is the net activity released through the stack during the last long count time (Figure 3.2). This value is compared to the *Integral Alpha Activity* alarm set point.

The value is calculated by summing the net alpha activity measured over each short count time and then scaling the result to obtain the activity released from the stack (Equation 4.1).

$$AlphaActStack_{net} = \frac{\left[\int_{0}^{num\ short\ counts} AlphaActivity(i)\right] * StackVolume}{SampleVolume} \qquad (4.1)$$

The parameter "Beta-Stack Activity" (μCi) is the net beta activity released during the last long count time (Figure 3.2). This value is compared to the *Integral Beta Activity* alarm set point.

The value is calculated by summing the net beta activity measured over each short count time and then scaling the result to obtain the activity released from the stack (Equation 4.2).

$$BetaActStack_{net} = \frac{\left[\int_0^{num\ short\ counts} BetaActivity(i)\right] * StackVolume}{SampleVolume}$$
(4.2)

4.1.6 Alpha and Beta Sample Concentration

The concentration of alpha activity in the sample is calculated by dividing the net alpha activity measured during the most recent short count time by the sample volume. Assuming isokinetic sampling, the concentration in the sample should equal the concentration in the stack. The concentration is measured in real time, meaning the measurement is calculated to show the delta change in counts by subtracting the previous counts from the current total to arrive at the most recent short count's concentration.

"Alpha Samp Conc" (μCi/ml) is the alpha concentration measured over the last short count time (Figure 3.2). This value is compared to the *High-Alpha Radiation* alarm set point.

"Beta Samp Conc" (μCi/ml) is the beta concentration measured over the last short count time (Figure 3.2). This value is compared to the *High-Beta Radiation* alarm set point.

4.2 Data Storage

The database has four tables:
- FilterData
- Quality Assurance (QA) Table
- RawData
- RawDataShortCount.

Other data storage includes:
- Calibration Data
- Pseudo-Coincidence Calculation

4.2.1 Filter Data Table

The filter data table contains the start and end dates for each filter. This database table contains the same information as the filter log, which can be viewed from the normal operation window. Table 4.1 provides filter data descriptions.

Table 4.1. Filter Data Table

Filter Data	Description
FilterNum	Sequential number assigned to each filter by the database
StartDate	Date and time the filter was installed in the CAM
EndDate	Date and time the filter was removed from the CAM

4.2.2   Quality Assurance Table

The quality assurance (QA) table provides a duplicate record of the parameter values stored in the registry and used by the PNNL OS3300 software during calculations (Table 4.2). These values are stored in the QA table for the user's convenience.

When values for various parameters are measured or calculated, they are written to both the QA table and the registry. When the PNNL OS3300 software is started, the values used by the program are read only from the registry (not from the QA table). Editing the QA table will not affect CAM operation because these values are not read from the QA table.

Table 4.2. Quality Assurance Table

QA Identifications	
QAID	Sequential number assigned to each filter by the database
AlphaEff	Alpha efficiency (cps/Bq)
BetaEff	Beta efficiency (cps/Bq)
AlphaBKG	Alpha background (cps)
BetaBKG	Beta background (cps)
AlphaVolt	High-voltage setting for alpha detector (V)
BetaVolt	High-voltage setting for beta detector (V)
F_a	Alpha factor
F_b	Beta factor
M_a	Correction factor for alpha activity calculations
M_b	Correction factor for beta activity calculations
Ps_o	Lowest pseudo-coincidence count rate (cps)
EffDate	Date the last efficiency measurement was performed
BetaPlatDate	Date the beta plateau was performed
AlphaPlatDate	Date the alpha plateau was performed
BKGDate	Date the background measurements were performed
PCDate	Date the pseudo-coincidence factors were set
Spillover	Alpha spill measured by the efficiency utility. Spillover is the ratio of beta channel counts to alpha channel counts with only an alpha source present. Spillover is expressed as a fraction
GammaBKG	Background measured on the gamma detector (cps)

4.2.3 Raw Data Long Count

The RawData table stores the results of each long count time (Table 4.3).

Table 4.3. RawData

Parameter Name	Units	Description
RawIndex	Unitless	Unique identifier assigned by the database
AlphaStackAct	μCi	The alpha activity measured during the last long count time
BetaStackAct	μCi	The beta activity measured during the last long count time
CAMStatus	Unitless	Reserved
StackFlowRate	cfm	Flow rate through the stack. This value is set by the user on the **Alarm|Settings** screen. The CAM does not measure the actual flow rate.
StackFlowTotal	kscf	Total volume of air through the stack since the last filter change
SampFlowRate	cfm	Flow rate of air sampled from the stack and passed through the alpha/beta CAM. This value is set by the user on the **Alarm|Settings** SCREEN. The CAM does not measure the actual flow rate
SampleFlowTotal	m^3	Total volume of air sampled by the alpha/beta CAM during the last long count time
RawDate	mm/dd/yyy	Date information was written to the database
RawTime	hr:min:sec	Time information was written to the database
QAID	Unitless	The identification number of QA data in use at the time this record was written. Obtained from the QA Table
AlphaRAW	Counts	Total counts of the alpha channel during the last long count time
BetaRAW	Counts	Total counts of the beta channel during the last long count time
PCTotRAW	Counts	Total counts of the pseudo-coincidence channel during the last long count time
PCRandomRAW	Counts	Total counts of the random pseudo-coincidence channel during the last long count time
CountTime	Seconds	Long count time in seconds
GammaRAW	Counts	Total counts of the gamma channel during the last long count time (referred to in some places as the guard channel)

4.2.4 Raw Data Short Count

The RawData Short Count table stores the results of each short count time (Table 4.4).

Table 4.4. Raw Data Short Count

Parameter Name	Units	Description
RawIndex	Unitless	Unique identifier
AlphaSampConc	µCi/ml	The alpha concentration measured during the last short count time
BetaSampConc	µCi/ml	The beta concentration measured during the last short count time
StackFlowRate	cfm	Flow rate through the stack. This value is set by the user on the **Alarm|Settings** screen. The CAM does not measure the actual flow rate.
StackFlowTotal	kscf	Total volume of air through the stack during short count time.
SampFlowRate	cfm	Flow rate of air sampled from the stack and passed through the alpha/beta CAM. This value is set by the user on the **Alarm|Settings** screen. The CAM does not measure the actual flow rate.
SampleFlowTotal	m^3	Total volume of air sampled by the alpha/beta CAM during the last short count
RawDate	mm/dd/yyyy	Date information was written to the database
RawTime	hr:min:sec	Time information was written to the database
QAID	Unitless	The identification number of the QA data in use at the time this record was written (see QA Table)
AlphaRAW	Counts	Total alpha counts for last short count time
BetaRAW	Counts	Total beta counts for last short count time
PCTotRAW	Counts	Total pseudo-coincidence channel counts for last short count time
PCRandomRAW	Counts	Total random pseudo-coincidence channel counts for last short count time
CountTime	Seconds	Time elapsed since last long count time (short count time multiplied by the number of short count times elapsed since last long count time)
GammaRAW	Counts	Total gamma counts for last short count time

4.2.5 Calibration Data

Parameters generated during calibration and during CAM operation are stored in the Windows® registry (C:\OS3300) and/or the database QA table. Upon running the PNNL OS3300 software, the program will retrieve parameter values from the registry (not from the database). A printed copy of the post calibration registry entries should be maintained to recover from system crashes and/or corrupt files. If the user suspects the calibration data have become corrupt, he should contact the calibration technicians to determine if the calibration is still valid.

4.2.6 The Pseudo-Coincidence Calculation

At the end of the pseudo-coincidence utility, the low pseudo-coincidence factor (Ps_o) is set equal to the lowest measured pseudo-coincidence count rate (Ps) (Equation 4.3).

$$Ps = Ps_{total} - Ps_{random} \tag{4.3}$$

where Ps is the net pseudo-coincidence count rate, Ps_{total} is the count rate of the total pseudo-coincidence count rate channel, and Ps_{random} is the count rate of the random pseudo-coincidence count rate channel.

During the pseudo-coincidence utility, the filter factor (F_k) can be assumed to be equal to one if the filter has been installed, and the CAM has operated for at least 2.5 hours before running the pseudo-coincidence utility.

Radioactivity on the filter from non-natural sources is calculated with Equation 4.4.

$$A_{art} = \frac{(C_{tot} - \dfrac{C_{bkg}}{60}) - Ps * F * F_K * \left(1 + M * \dfrac{Ps - Ps_o}{Ps_o}\right)}{Eff * 37000} \tag{4.4}$$

where
$\quad A_{art}$ = Non-natural activity (alpha or beta) accumulated on the air filter, µCi
$\quad C_{tot}$ = Total counts from radioactivity on the filter, cps
$\quad C_{bkg}$ = Background counts, cpm
$\quad Ps$ = Pseudo-coincidence rate corrected for random events (determined during each short measuring time), cps
$\quad Ps_o$ = Smallest (or lowest) pseudo-coincidence rate, cps
$\quad F_k$ = Correction factor for filter change, unitless
$\quad M$ = Rate factor (M_a and M_b), unitless
$\quad F$ = Pseudo-coincidence factor (F_a and F_b), unitless
$\quad Eff$ = Detection efficiency (set during calibration), cps/Bq
$\quad 37000$ = Conversion factor for correcting Bq to µCi (37000 Bq/µCi).

When the pseudo-coincidence utility is run, radon is the only expected radioactivity that accumulates on the filter. Consequently, the calculated result for A_{art} should be zero. Also, the filter is installed for at least 2.5 hours before the pseudo-coincidence utility is run, so F_k equals one. Substituting 0 for A_{art} and 1 for F_k reduces the equation to Equation 4.5.

$$C_{tot} - \frac{C_{bkg}}{60} = Ps * F * \left(1 + M * \frac{Ps - Ps_o}{Ps_o}\right) \tag{4.5}$$

Results are stored in the Windows® registry (C:\OS3300) instead of a database, and the program retrieves necessary information from the registry (not from the database). A printed copy of the post pseudo-coincidence registry entries should be maintained to recover from system crashes and/or corrupt files. If the user suspects the calibration data have become corrupt, he should contact the calibration technicians to determine if the calibration is still valid.

4.3   Setting Background Count Times

To have a 1% error with background measurements, the background count time needs to be set so that 10,000 counts will be measured in the set time. For example, if the background count time is 1 minute and 100 counts are measured in that time, then 100 cycles with each cycle being 1 minute are needed to measure a total of 10,000 counts.

4.4   General Statistics Discussion for Calculating Total Counts for Specific Error

Radioactive decay and other nuclear reactions are randomly occurring events and must therefore be described quantitatively in statistical terms. Not only is there constant change in the activity of a specific sample because of the half-life of the nuclide(s), but there is also a fluctuation in the decay rate of a particular sample from one instant to the next because of the random nature of radioactive decay. However, if the number of atoms that decay during a particular time period is plotted against the number of times each result was obtained, a bell curve with a normal distribution centered on the average number of events per time period would be obtained (Figure 4.1).
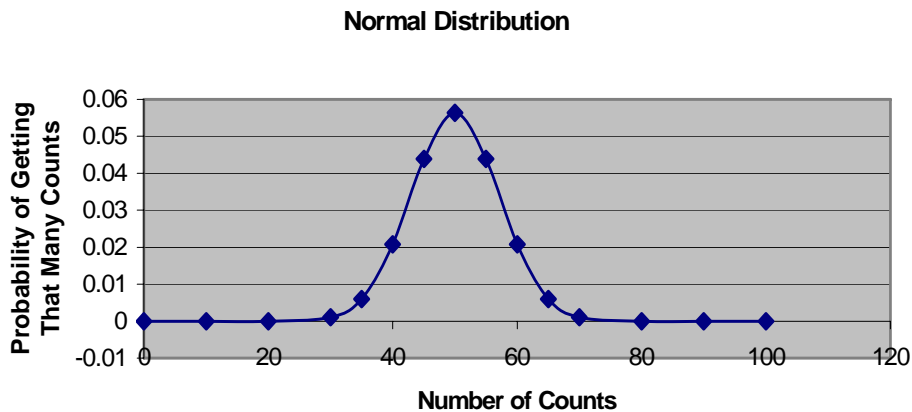

Figure 4.1. Counts Distribution Example

The total area under the curve represents all measurements. Limits may be placed symmetrically above and below the mean value so that the majority of data (area) lie in between. This banded area represents the chance or possibility that a single new observation would have a value lying between the upper and lower limits. These limits are referred to as the "standard deviation about the mean." One standard deviation, 1σ, is defined as the area between the upper and lower limits representing 68% of the total area. Therefore, the standard deviation is a measure of the dispersion of randomly occurring events about the mean, and 1σ represents the 68% confidence limit (i.e., there is a 68% confidence level that the measured value will be within the defined range). Similarly, 2σ, two standard deviations, represent the 96% confidence limit.

Often, the standard deviation is approximated by the Poisson distribution and is given in Equation 4.6:

$$\sigma \equiv \sqrt{n} \qquad (4.6)$$

where σ is the standard deviation, and n is the number of counts observed during the time interval.

When n ≥ ~20, the Poisson and normal distributions nearly coincide. Therefore, the relative error can be calculated with Equation 4.7.

$$error \equiv \frac{1}{\sqrt{n}}$$

$$(4.7)$$

where *error* is the relative error of the observation, and *n* is the number of counts observed during the time interval.

The relative error depends on the total number of counts taken and can be made smaller by counting for longer times to obtain more counts (e.g., if n=10,000, the relative error is 1%).

The interested reader is referred to any number of books with a section on radiation statistics, including *Radiation Detection and Measurement* (Knoll 2000) and *Atoms, Radiation, and Radiation Protection* (Turner 1986).

5.0   Theory of Operation

This section provides PNNL equations to calculate alpha and beta activity.

5.1   Alpha Activity

This section develops the equation used by the PNNL OS3300 software to calculate alpha activity from non-natural sources on the stack CAM filter.

The PNNL OS3300 software calculates two values related to the alpha activity: integrated alpha activity out the stack since the filter was last changed and the concentration of alpha activity in the volume of air passed through the sampler.

Alpha activity reported by the PNNL OS3300 software is the alpha activity, accumulated on the filter, from non-natural sources of radioactivity. It is calculated with Equation 5.1.

$$A_{art} = \frac{C_{a-tot} - C_{a-radon}}{Eff * 37000}$$

(5.1)

where A_{art} = Non-natural alpha activity, μCi
   C_{a-tot} = Total count rate in the alpha channel, cps
   $C_{a-radon}$ = Alpha count rate from radon progeny accumulated on the filter, cps
   Eff = Detection efficiency (set during calibration), unitless
   37000 = Conversion factor for correcting Bq to μCi (37000 Bq / μCi).

The count rate from radon progeny collected on the filter ($C_{a-radon}$) is measured with a pseudo-coincidence circuit, which counts the number of beta disintegrations that are accompanied, within a brief time period, by an alpha disintegration.

5.1.1   Pseudo-Coincidence Counting

The radon (^{222}Rn) and thoron (^{220}Rn) decay chains decay by alpha emission to very short half-life isotopes that decay by alpha and beta emissions. In the ^{222}Rn decay chain, the decay of ^{214}Bi (a beta emitter) is followed by the decay of ^{214}Po (an alpha emitter with a half-life of 164 μs). Because the half-life of ^{214}Po is 164 μs and because the definition of half-life states that half the atoms decay within one half-life, there is a 50% probability that any particular ^{214}Bi decay will be accompanied, within 164 μs, by a ^{214}Po decay.

Similarly, in the thoron (^{220}Rn) decay chain, the decay of ^{212}Bi (a beta emitter) is followed the decay of ^{212}Po (an alpha emitter with a 0.3 μs half-life). Using the same argument as in the previous paragraph, 50% of the ^{212}Bi decays are accompanied, within 0.3 μs, by a ^{212}Po decay. Within the 164 μs window while 50% of the ^{214}Po (from the radon decay chain) decays following a ^{214}Bi beta emission, essentially all ^{212}Po atoms from the thoron decay chain will have decayed by alpha emission. Because ^{212}Bi decays to an alpha emitter only 64% of the time, only 64% of the ^{212}Bi decays will be accompanied by an alpha emitter within 164 μs (again, the 164-μs window is from the radon decay scheme).

Because it is desirable to have the ratio of beta particles followed by alpha particles within a particular time period equal for both the radon and thoron decay chains, the timing window used for the radon decay chain was increased from 164 μs to 190 μs. By increasing the window from 164 μs to 190 μs, the number of ^{214}Bi beta emissions followed by an alpha emission is increased from 50% to 64%. And, during the same time window, 64% of the ^{212}Bi beta emissions will be followed by an alpha emission.

If a beta decay (by either ^{214}Bi or ^{212}Bi) is used to trigger a timing circuit that registers a count only if an alpha decay is detected within 190 μs, then each count registered by this timing circuit would indicate the decay of a radon daughter product. The counts registered by the timing circuit divided by the count time gives the pseudo-coincidence count rate.

Because there are several other isotopes in the radon and thoron decay schemes that are not counted by the pseudo-coincidence counting circuit, the true number of radon/thoron alpha events counted by the system is only proportional to the pseudo-coincidence count rate. Therefore, a pseudo-coincidence rate factor, F_a, is introduced in the equation to account for the radon/thoron alpha emissions that are not counted by the pseudo-coincidence counting circuit (Equation 5.2).

$$A_{art} = \frac{C_{a-tot} - Ps * F_a}{Eff * 37000} \qquad (5.2)$$

where Ps is the pseudo-coincidence count rate, cps, and F_a is the pseudo-coincidence rate factor (ideally 1/0.64 or 1.56).

F_a is set by running the stack CAM with a clean filter, measuring the average pseudo-coincidence count rate over a long period (Ps_{ave}), measuring the gross alpha count rate (C_{ave}), and determining the value for F_a required to make the following equation true (Equation 5.3).

$$C_{ave} - Ps_{ave} * F_a = 0 \qquad (5.3)$$

Unfortunately, F_a is not constant. As environmental radon levels fluctuate, the ratios of various radon and thoron progeny on the filter paper also fluctuate. As a result, the value of F_a changes as the pseudo-coincidence count rate changes. To account for these fluctuations in F_a, another factor is added to the equation for calculating artificial alpha activity (Equation 5.4).

$$A_{art} = \frac{C_{a-tot} - Ps * F_a * F(Ps)}{Eff * 37000} \qquad (5.4)$$

where $F(Ps) = F$ is a linear function of Ps and accounts for the changes in F_a with the pseudo-coincidence count rate (Equation 5.5).

$$F(Ps) = \left[1 + M_a\left(\frac{Ps - Ps_o}{Ps_o}\right)\right] \qquad (5.5)$$

where $F(Ps) = F$ is a linear function of Ps and accounts for the changes in F_a with the pseudo-coincidence count rate (Equation 5.5), M_a is the alpha rate factor, unitless, and Ps_o is the lowest pseudo-coincidence count rate, cps.

The PNNL OS3300 software calculates M_a and F_a with linear regression. A detailed description of the calculation is described in Section 5.3.

5.1.2 Time Required for Radon Progeny to Reach Equilibrium

Lastly, one more factor must be added to the equation for calculating non-natural alpha activity. When a fresh filter is installed in the CAM, there is essentially no activity present on the filter. As air is drawn through the filter, radon progeny begin to accumulate. However, it takes time for the radon progeny to decay and for the isotopes counted by the pseudo-coincidence counting circuit to reach equilibrium.

The time required for the radon progeny to reach transient equilibrium is accounted for with a filter factor (F_k) that is equal to 1.25 immediately after the filter is changed and decreases linearly to 1.0 over the first 2.5 hours of filter use. After the filter has been installed for 2.5 hours, the filter factor is equal to 1.0 until the filter is changed again.

The final equation for calculating non-natural alpha activity on the filter paper is in Equation 5.6.

$$A_{art} = \frac{C_{a-tot} - Ps * F_a * F_k * \left(1 + M_a * \frac{Ps - Ps_o}{Ps_o}\right)}{Eff * 37000} \tag{5.6}$$

where F_k is the correction factor for filter change, unitless.

Equation 5.6 calculates the total activity collected on the air filter, which is synonymous with the total activity in the volume of air sampled from the stack.

Because there may be an artificial alpha background from materials in the sample chamber, etc., the alpha background measured at the time of calibration is subtracted from the total alpha signal. In this case, the alpha background is not the background from radon or other naturally occurring alpha emitters; it is from alpha emitters that are inherent to the system (e.g., alpha-emitting contaminants in the construction materials) (Equation 5.7).

$$A_{art} = \frac{(C_{a-tot} - \frac{C_{a-bkg}}{60}) - Ps * F_a * F_k * \left(1 + M_a * \frac{Ps - Ps_o}{Ps_o}\right)}{Eff * 37000} \tag{5.7}$$

where C_{a-bkg} is the alpha background measured during calibration, cpm.

The PNNL OS3300 software calculates the beta activity that is released through the stack by multiplying the beta activity on the filter by the ratio of the total volume of air through the stack to the total volume of air through the sampler (Equation 5.12).

$$A_{StackActivity} = A_{art} * \left(\frac{StackVolume}{SampleVolume} \right) \quad [\mu Ci] \qquad (5.8)$$

5.2 Beta Activity

This section provides the equation used to calculate beta activity collected on the filter from non-natural sources. The activity from non-natural sources is calculated with Equation 5.9.

$$B_{art} = \frac{C_{b-tot} - C_{b-radon} - C_{gamma}}{Eff * 37000} \qquad (5.9)$$

where B_{art} = Beta activity from man-made sources, µCi

C_{b-tot} = Total count rate in the beta channel, cps

$C_{b-radon}$ = Count rate in the beta channel from radon progeny collected on the filter, cps

C_{gamma} = Count rate in the beta channel from ambient gamma radiation that contributed to the beta count rate, cps

Eff = Detection efficiency (set during calibration)

37000 = conversion factor for correcting Bq to µCi (37000 Bq / µCi).

The gamma contribution to the count rate of the beta channel is measured in a shielded "guard" detector. Because the sensitivities of the beta detector and shielded gamma detector may be different (i.e., in identical fields, the two detectors may have slightly different responses), a gamma factor is used to make the following equation (Equation 5.10) balance.

$$C_{gamma} = K * G \qquad (5.10)$$

where G is the count rate in the gamma channel, cps, and K is the gamma factor.

Following the example of the alpha activity development, the beta activity is then determined from Equation 5.11.

$$B_{art} = \frac{\left(C_{b-tot} - \dfrac{C_{b-bkg}}{60} \right) - Ps * F_b * F_k * \left(1 + M_b * \dfrac{Ps - Ps_o}{Ps_o} \right) - K * G}{Eff * 37000} \qquad (5.11)$$

where C_{b-bkg} is the Beta background measured during calibration, cpm.

The PNNL OS3300 software calculates the beta activity that is released through the stack by multiplying the beta activity on the filter by the ratio of the total volume of air through the stack to the total volume of air through the sampler (Equation 5.12).

$$B_{StackActivity} = B_{art} * \left(\frac{StackVolume}{SampleVolume} \right) \quad [\mu Ci] \tag{5.12}$$

5.3 Calculation of Rate Factors (M_a and M_b) and Pseudo-Coincidence Factors (F_a and F_b)

This section describes the method used by the PNNL OS3300 software to calculate appropriate values for the alpha and beta rate factors (M_a and M_b), and the alpha and beta pseudo-coincidence factors (F_a and F_b). The use of these variables in the alpha and beta activity calculations is described in Sections 3.1 and 3.2. For clarity, and because the alpha and beta factors are calculated in an identical manner, only the variables M_a and F_a are used in this discussion. However, the calculations are identical for M_b and F_b.

Before the PNNL OS3300 software can calculate M_a and F_a, a clean filter must be installed in the CAM, and the CAM must run for at least 2.5 hours. No artificial activity can be present in the air supply during this utility.

Because no artificial activity is present, the calculated artificial activity should be 0 (Equation 5.13).

$$0 = \frac{C_{a-tot} - Ps * F_a * F_k * \left(1 + M_a * \frac{Ps - Ps_o}{Ps_o} \right)}{Eff * 37000} \tag{5.13}$$

Because the filter is installed for at least 2.5 hours before this calculation is performed, F_k equals one, and the equation can be reduced to the following (Equation 5.14):

$$C_{a-tot} = Ps * F_a * \left(1 + M_a * \frac{Ps - Ps_o}{Ps_o} \right) \tag{5.14}$$

The PNNL OS3300 software calculates M_a and F_a with linear regression in the following manner. First, assuming no artificial activity (because the CAM ran with a clean filter for at least 2.5 hours before this calculation is performed), Equation 5.14 becomes Equation 5.15:

$$0 = C_{a-tot} - Ps * F_a * \left[1 + M_a \left(\frac{Ps - Ps_o}{Ps_o} \right) \right] \tag{5.15}$$

Rearranging the terms results in Equation 5.16:

$$\frac{C_{a-tot}}{Ps} = Ps * \frac{M_a * F_a}{Ps_o} + F_a - M_a * F_a \tag{5.16}$$

Comparing Equation 5.16 to the typical linear relation

$y = m * x + b$,

results in the following associations (Equation 5.17):

$$y = \frac{C_{a-tot}}{Ps}, \quad x = Ps, \quad m = \frac{M_a * F_a}{Ps_o}, \quad b = F_a - M_a * F_a \qquad (5.17)$$

The problem then reduces to measurement of total activity, in the absence of artificial activity, and the associated net pseudo-coincidence count rate with corresponding minimum Ps_o. With these measured values, the desired parameters can be determined from Equations 5.18 and 5.19:

$$F_a = b + m * Ps_o \qquad (5.18)$$

and

$$M_a = \frac{m * Ps_o}{F_a} \qquad (5.19)$$

6.0   Software Maintenance

This section describes the requirements for software development, reloading instructions, and maintenance schedules and procedures.

6.1   Software Development Requirements

The PNNL OS3300 software was developed with Microsoft Visual Basic 6.0 Professional Edition® for 32-bit Development. As a 32-bit development system, the PNNL OS3300 software is designed to run in the Windows 2000® or Windows NT® operating environments.

Questions or requests for modifying the source code for the PNNL OS3300 software should be directed to the following:

Pacific Northwest National Laboratory
P.O. Box 999, Mail Stop J2-25
Richland, WA 99352

6.2   Reloading Instructions

If the operating software for the PNNL OS3300 becomes corrupt, fails to function properly, or otherwise needs to be re-installed, the following procedure may be used to perform the necessary setup:

1. Copy the following files to a floppy diskette:
    - *AlphaBeta97.mdb* (The database with all data stored)
    - C:\OS3300\YYMMDD.LOG (location of log files).
2. Start the Windows® Control Panel.
3. Double-click the *Add/Remove Software* option.
4. Select the *OS3300* option in the dialogue box.
5. Click the *Add/Remove* button to remove the software.
6. Click *Yes* on the confirmation that you want to remove the software.
7. Exit the Control Panel when the software has been removed.
8. Select the **Start|Run** option of the Windows® operating system.
9. Click *Browse*.
10. Change to the D:\ drive or applicable drive for a CD in "My Computer."
11. Double-click the *Setup* icon in this folder.
12. Click *OK* from the Run dialogue box.
13. Accept the defaults of the OS3300 setup screens.
14. Click *OK* when the OS3300 setup has been successfully completed.

15. Optionally, the PNNL OS3300 software can be added to the Windows® Startup group so each time the Operating System starts, the software will automatically start.

6.3   Maintenance Schedules and Procedures

There are six relay outputs controlled by the software. These relays are controlled by a connection to the 25-pin D connector on the LabMaster™ breakout board. These outputs (numbers one through six) are programmable from the software. Two additional digital outputs are present on the 25-pin D connector, but are not currently used by the software. If any of these relays do not operate correctly (i.e., alarms when there is no alarm or fails to alarm when the level is reached), follow the steps in Table 6.1.

If the checklist fails to remedy the problem, contact the factory for further assistance.

Table 6.1 Analog Output Troubleshooting Checklist

Step	Procedure	If there is a problem, take this next step.
1	Check the ribbon cable connections at the LabMaster™ card on the rear of the computer.	Reconnect if loose. Repair damaged connector (e.g., bent or broken pins).
2	Check electrical terminations in the breakout box.	Reconnect loose cables. Repair damaged connector.

7.0 References

Knoll GF. 2000. *Radiation Detection and Measurement,* Third Edition. John Wiley & Sons, New York.

Turner JE. 1986. *Atoms, Radiation, and Radiation Protection,* First Edition. Pergamon Press Inc., New York.