Bladewerx SabreBPM²
Operations Manual

SabreBPM² Operations Manual

Documentation version 2.3

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Getting Started

General Description

The SabreBPM² is a portable beta air monitor designed to function both as a workplace monitor and a Continuous Air Monitor (CAM). Spectral analysis is conducted via a 1024-channel analyzer that feeds data to the embedded processor. Factory configuration provides either beta particulate measurements, special nuclear materials (SNM) measurements or radon progeny measurements of potential alpha energy concentration (PAEC).

Measurements are taken in both fast-responding (acute) and high-sensitivity (chronic) assessments and report in English or SI units.

The instrument stores acquired data in comma-separated-variable (.csv) format. Data may be saved in the instrument's internal memory or written to an SD card for later retrieval.

The SabreBPM² features an integrated LCD and touchscreen that displays information on instrument status and readings during operation. The estimated dose and instrument status is displayed at all times. A window below may be switched from showing historical readings and battery status, or to display the current spectrum.

Unpacking and Repacking

Remove the calibration certificate and place it in a secure location. Remove the instrument and ensure that all of the items listed on the packing list are in the carton. Check individual item serial numbers and insure calibration certificates match between instruments.

To return an instrument for repair and calibration, provide sufficient packing material to prevent damaged during shipment. Every returned instrument must be accompanied by an Instrument Return Authorization Number, or RMA. Call Bladewerx at 505.892.5144 to request one.

Parts of the SabreBPM²

The SabreBPM² consists of a fiberglass NEMA enclosure containing the SabreMCA™ electronics, battery and pump assemblies. A detector head, mounted to the right side of the case, contains the detector, preamp, and a filter holder. A light stack containing an audible alarm and red light is mounted to the top of the case.

On the front, the SabreBPM² contains a 5.5-inch touch-screen display. The display is most easily operated using a stylus. There are three buttons located below the touch-screen display which allow the user to toggle displayed units and isotope/channel, as well as an alarm acknowledge to silence and clear an alarm.

On the right side below the detector head, there is a red power button, mini USB port, charging port and LED charging indicator, along with other ports needed for additional options.

The SabreBPM² includes an annunciator (alarm light/audible alarm) that is used when radiological alarms have been enabled. The annunciator has an adjustable volume setting. To adjust the volume, twist the top of the light stack, mechanically limiting its sound. To make the alarm louder, twist counter-clockwise, allowing more sound from the horn. To make the alarm softer, twist the ring clockwise.

In addition to the SabreBPM² itself, the package it comes in contains an AC Adapter for charging the SabreBPM², a USB sync cable for exchanging data with a PC, a flow calibration aid, and a CD with software, certificates and training videos.

Understanding the Detector Head

The SabreBPM² has an integrated head that houses the detector. Optionally, it can house an additional guard detector for use in gamma background subtraction. Also, an In-Line Sample Head on an umbilical is available as an option.

The detector head has several components that function together to be able to accurately detect the decay of radioactive particulates. The following is a brief summary:

- The **detector** is mounted to the side of the case inside a cavity, covered by a removable filter holder. The detector is delicate and should not be touched.

- The **filter holder** captures a 37mm **filter** with a threaded **ring** and mounts it inside the cavity, opposite the detector face.

- Between the detector face and the filter is a **small gap** of air that creates a flow path by extending circularly around the outside of the Detector Head.

- Air-borne **particulates** are suctioned into the Head via the air flow path, through the radial gap and are captured on the filter.

- The **air flow** continues past the filter, through the side holes, and into the case, where it is pumped out the bottom of the case.

- As particulates on the filter decay, the emitted **alpha and/or beta particles** hit the face of the detector and are recorded by the unit.

Following is a series of diagrams that illustrates the progression of particulates and their decay.
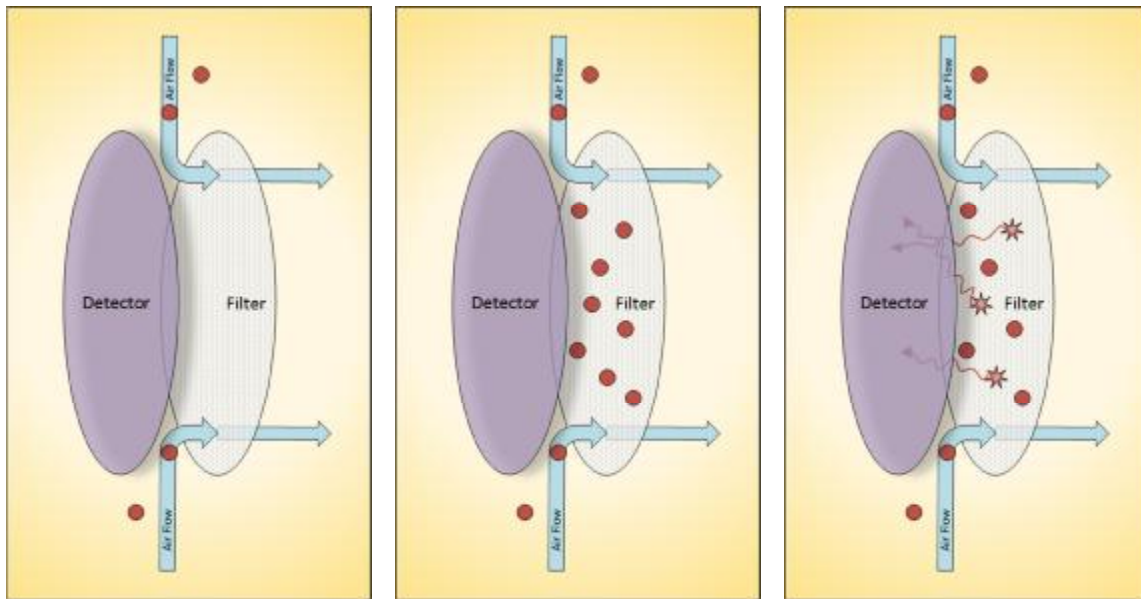
Turning the Unit On

A red switch located on the side of unit below the detector head turns on the power to the SabreBPM². After pressing the switch, the SabreBPM² application will execute automatically. In general, a cold startup takes about 20 seconds. If it does not, the unit needs to be charged.

Charging the Batteries

Upon receiving a new unit, or when preparing a unit that has been shut down for a length of time, the Lithium-Ion battery must be fully charged. The battery can be charged by plugging the AC Adapter into a wall socket (115/220 VAC only) and plugging the power connector into the jack at the lower right side of the case. A Red/Green LED next to the connector indicates the charging state. When the LED is Red, the battery is being charged. When the LED is Green, the battery is charged and the charger may be removed. The charging time is approximately 4 hours.

Complete Battery Discharge

The SabreBPM² has persistent registry settings that are saved in non-volatile flash memory thus keeping your program configuration settings intact if the battery is fully discharged. Also the SabreBPM² application will be stored in non-volatile memory and will be restored once power is returned to the unit. So after the battery is fully discharged, all that is needed is to reconnect the unit to AC power and allow the battery to charge again.

Depending on user settings, measurement records can either be stored on the SD card or in the My Documents folder. The default save location for log data is the My Documents folder, but in the event of a full battery discharge, these files would not be restored. Only files saved on the SD card will be retained if the instrument is turned off or the battery dies.

NOTE: Two charge cycles may be required for completely discharged batteries. Simply unplug and re-plug the power connector to start a new charge cycle.

Power Button Functions

To turn the instrument off, press and hold the power button for 4 seconds; or until the display goes blank and the pump turns off. Be aware that this clears all measurement files in My Documents. In most cases, standby mode will be sufficient for most storage situations, and a charge of at least 50% should last the weekend. Full shutdown should be used for shipping or storage longer than several days.

Starting the Program

Under normal circumstances, the SabreBPM² program will start automatically when the instrument is turned on, and remains in the program when the instrument is shut off. If there is a need to exit the program, it can be restarted from the desktop screen by double tapping the icon labeled 'Bladewerx SabreBPM' using the stylus.

Once the SabreBPM² program is running, you will not be able to perform any other Windows CE operations like setting the clock, running other applications or changing display or network settings. To close the SabreBPM² program tap *File – Close* in the menu.

Response Check

Unless it is disabled on startup, the Response Check dialog is the first screen to be displayed after starting the SabreBPM² program.   The Response Check function will be covered later in this manual. For now, and until the SabreBPM² is fully calibrated, tap the **Skip** button to bypass the Response Check or wait for 60 seconds for it to time out and then automatically continue. The home screen is then displayed.
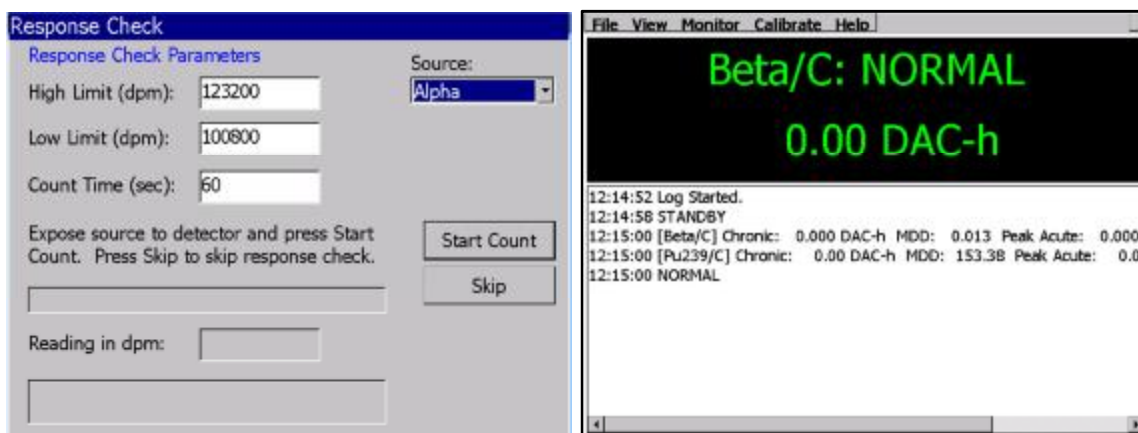
Understanding the Display

The basic display for the SabreBPM² includes a **Menu** bar across the top, a **Meter** in the upper half of the screen and a **Log** entry in the lower half that toggles to view the current **Spectrum**.

Menu

Meter

Log & Spectrum
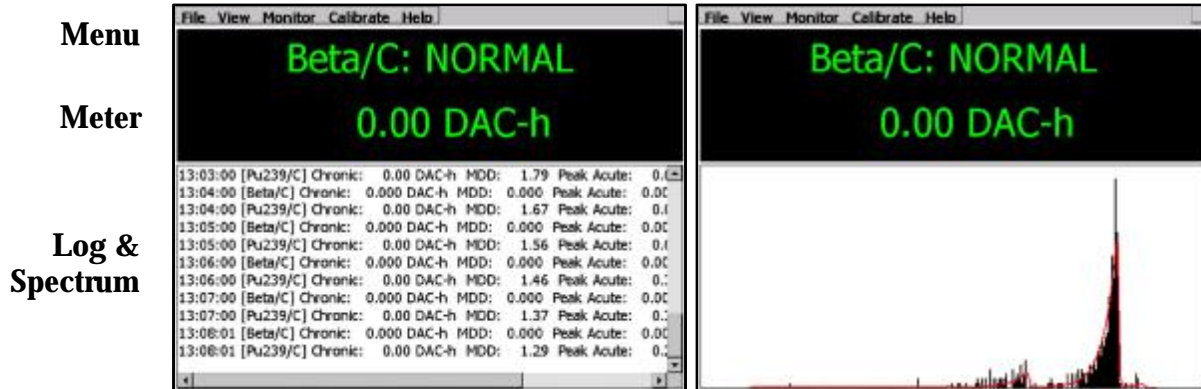
The **Menu** bar across the top of the screen provides access to the various settings and other information. They will appear differently depending on whether the password security feature is enabled. These menu items and their sub-menus will be covered in detail in other sections of the manual.

The **Meter** displays the status and current data of the selected channel. In Beta-Only mode, only the beta and flow channels are displayed. In Alpha-Beta mode, it will display up to two alpha isotopes of interest and the short-lived radon daughters: Po-212, Po-214 and Po-218. The first line indicates the channel name with a suffix character to denote the type of reading, Acute (/A) or Chronic (/C), which is followed by a status, usually normal. The second line reports the current reading with the default unit.

The **Log** entry display in the lower half of the screen shows the readings for the beta channel and alpha channels (optional), logged once a minute. Each standard log entry lists the chronic reading, the minimum detectable dose, the highest acute reading of that minute and the battery charge level. Other log entries are listed as they occur. Possible log entry status conditions are high alarm, low battery, flow rate failure, and other types of failures.

The **Spectrum** can also be viewed in the lower portion of the screen, in addition to the log entry display, by tapping *View—Spectrum…* in the menu. The spectrum is displayed as a bar graph made up of the detected counts. Each count is assigned to one of 256 channels, increasing in energy along the non-visible X-axis. The Y-axis is a non-visible scale of counts that compresses to fit the entire spectrum in view. The red line represents the mathematical peak-fit curve that best matches the actual data. After several hours, three peaks will have formed on the right end of the spectrum and illustrate the counts associated with the three radon daughters.

The meter displays the various isotopes and variables being measured. To toggle the current channel displayed, press the **Channel** button on the front of the unit. Repeated presses of the Channel button will cycle through the channels, switching between acute and chronic info before cycling to the next channel.

Changing the units displayed on the meter is done by hitting the **Units** button. This will toggle through units of activity and concentration (e.g. pCi, cps, DAC-Hr, DAC). Each Channel has its own set of four units, while Flow and Gamma (optional) channels only have one unit each.

How to Change the Filter

After a SabreBPM² has been monitoring for some time, the filter will become laden with dust and need to be replaced. Do this regularly; either by a specific schedule or when the flow rate declines and indicates Lo Flow (see section 3 on configurations).

Replace the filter by removing the Filter Holder from the Detector Head, unscrewing the ring that captures the filter, and discarding or storing the filter appropriately. With the *Back* or *Pump Side* facing up, lay a new filter into the retaining ring and screw it back onto the Filter Holder. It should be snug enough to create a good seal with the O-rings. The back side should not be visible. Insert the Filter Holder back into the Detector Head cavity. From the menu, tap *Monitor — Reset Instrument* to start a new count that does not include data from the old filter. **Always reset the instrument after a filter change**.

Password Security

The SabreBPM² supports password security to prevent unauthorized users from changing the instrument configuration or calibration. By default, password security is turned off and all menus and functions are accessible. Password security may be enabled by checking **Use Password Security** from the *File—Properties…* menu. The Properties dialog is explained fully in Section 3: Configuration. Tap *File—Login…* from the menu to enter a password.

Security Levels and Default Passwords:
- Logged Out User level allows access to the View menu item only
- Configuration level allows access to the View and Monitor menu items- **config**
- Calibration level allows full access to the View, Monitor and Calibrate menu items - **calib**
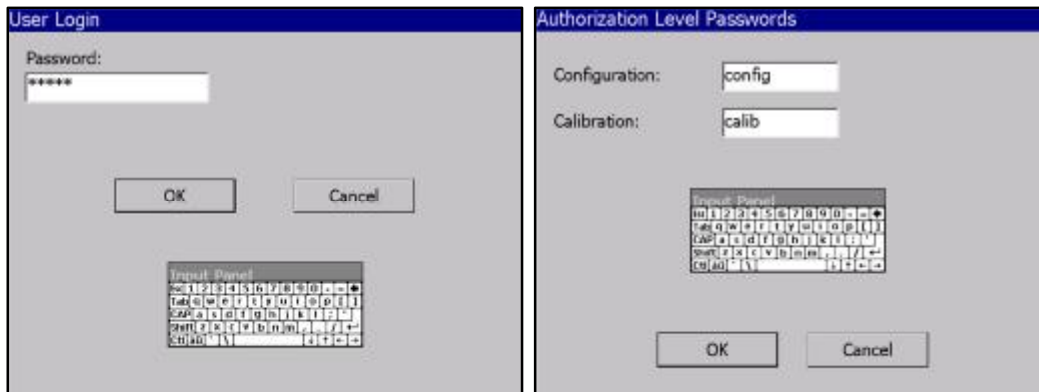
When logged in to the calibration level, the user is able to change the password(s) by tapping *File—Security Options…* to open the **Authorization Level Passwords** dialog. Be sure to record the new passwords in a safe place, as a forgotten password would require factory support to reset.

Setting the Clock

The SabreBPM² is configured with a real-time clock which can be manually set or set automatically when connected via the USB port to a PC. The unit is factory calibrated to the correct customer time-zone before shipment. Whenever the battery and external power are disconnected from the main processor board during maintenance or repair, the clock will be reset to a default date. The SabreBPM² program will sense this condition and allow the operator to manually set the clock during startup. To access the Date/Time properties dialog, double tap the time displayed in the lower right of the desktop.
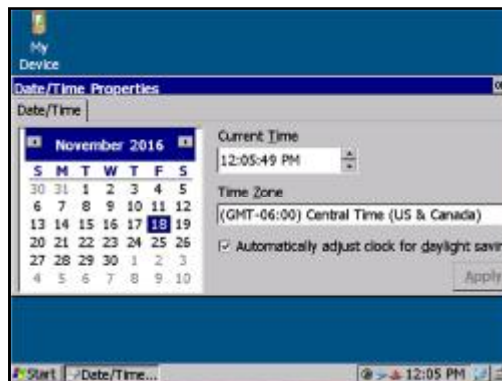
Calibration

To maintain accurate measurements of dose and concentration, the unit must be calibrated periodically. Separate Alpha, Beta, and Flow calibrations are required for complete calibration.

The purpose of alpha calibration is to insure that the peak-fitting algorithm knows where in the spectrum to expect the radon peaks. This ensures that proper radon background subtraction of the beta channel is performed.   If the radon peaks appear too far from the expected locations, the peak-fitting algorithm will fail (POOR FIT status) and the unit will fail to alarm properly.

The purpose of beta calibration is to ensure that the unit is measuring beta counts with the highest possible counting efficiency and low noise. Flow calibration is also important, as it determines if the SabreBPM² is converting the pump current into the measured flow rate correctly.

The calibration functions are accessed from the Calibration item on the main menu. The four calibration functions are Flow, Alpha Energy, Alpha Efficiency and Beta Efficiency. Calibrations should be performed in this order, for both Beta-only and Alpha/Beta configurations: Alpha Energy è Alpha Efficiency è Beta Efficiency. Flow calibration can be performed at any time.

NOTE: Bladewerx instruments are shipped already calibrated at the factory elevation of 5100 feet. Because they are elevation-dependent, for any elevation difference greater than 1000 feet, both the <u>Alpha Energy</u> Calibration and <u>Flow</u> Calibration should be repeated at the customer site before the instrument is put into service.

Calibration Overview

When performing a calibration, the Alpha energy calibration step should always be performed before doing the alpha or beta efficiency calibrations.

Flow Calibration consists of:
- Setting up an apparatus: Flow Calibration Aid, Flowmeter, & flow restriction device
- Defining 3 flow rates and entering the measured flow of each in LPM
- Validating the calibration with a 4th flow rate, which gives an error percentage

Alpha Energy Calibration consists of:
- Roughing in the position of the IoI peak with a source and adjusting the Offset
- Running the unit overnight to accumulate a radon decay product spectrum
- Setting the peak marker positions of the Po-212, Po-214 and Po-218 radon daughter peaks along with the IoI peak marker.

Alpha Efficiency Calibration consists of:
- Determining the counting efficiency to an alpha calibration source.

Beta Efficiency Calibration consists of:
- Adjusting threshold potentiometers on a PCB inside the case for desired beta and guard detector background
- Acquiring a 10 minute background count for background subtraction
- Performing an efficiency calibration using a beta source.

Calibration Expiration

The SabreBPM² program keeps track of the last time the alpha energy calibration was performed and will indicate that the unit is out of service if one of two conditions is met:

- A user-defined number of days since the last calibration have elapsed. *Default is 365 days.* [An option allows calibration expiration on the last day of the month following the specified days.]
- The unit has exceeded the user-defined number of hours of pump run-time since the last calibration. *Default is 8800 hours.*

When the calibration expires, the SabreBPM² display will indicate **OUT OF CAL.**

Source Requirements

When performing any of the alpha and beta calibrations, a calibration source is used. Calibration sources should be electroplated on stainless steel disks no larger than 32 mm (1.26") in diameter, have an active area restricted to the center 25 mm (1") diameter, and have an activity between 10,000 and 150,000 DPM.

NOTE: It is vital that the active surface of the source is the same distance from the detector face as the surface of a filter would be. Poor-fitting source holders and sources that are too large or have a bezel would severely impact calibration.

Calibration source holders may be ordered which fit the SabreBPM² detector head and hold a 32mm source in the proper position for repeatable calibration geometry. It is also very important that the alpha calibration source matches the first isotope-of-interest (IoI 1) and the beta calibration source is similar in energy to the expected beta isotope.

Alpha Energy Calibration

To begin the alpha energy calibration, tap *Calibrate—Alpha Energy…* on the menu. The Alpha Energy Calibration dialog will be displayed showing the alpha energy calibration settings and a window of the spectrum, if it has been collected.
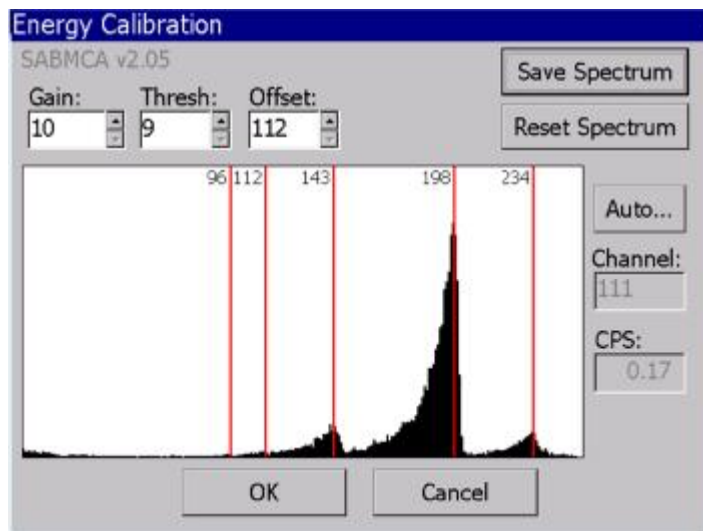
The horizontal axis represents the possible energies, assigned to channels 0 to 255. The vertical scale accumulates counts in each channel and adjusts automatically to display the highest peak.

Several vertical red lines are scattered along the alpha spectrum. The number of lines depends on the operating configuration of the SabreBPM². These lines indicate the position of the alpha peaks, and can be adjusted by dragging to match up with the peak location. The numbers at the top of each red line correspond to the channel number of the peak location.

There are either zero, one or two alpha isotopes-of-interest, plus the Po-218, Po-214 and Po-212 radon-progeny peaks. In radon mode, a peak marker for Po-210 may also appear. If

operating in Alpha-Beta mode, the lower reference line(s) on the spectrum coincide with the isotope(s)-of-interest. In Beta-only mode, only the 3 markers for the radon peaks and one marker for the alpha source are used.

Configuration Settings

The three fields on the top of the Alpha Energy dialog each correspond to one of the three configuration settings. The parameters for Gain, Threshold, and Offset determine the view of the alpha spectrum on the display. These configuration settings affect the location, width, spacing and offset of alpha peaks on the spectrum. The threshold and gain should not have to be adjusted from factory settings, so **only the offset may need to be changed based on the elevation of the instrument's location.**

The instrument is initially calibrated at 5100 feet. Alpha calibration is altitude dependent, so it is important that this is taken note of. The values for these four settings are stored permanently on the SabreMCA board, and changing any of them will save the new values over the old values. The user can read the following descriptions of the four parameters to get a better understanding of how the Alpha spectrum is displayed:

Gain—(Range 1 to 31) This value controls the amplitude of pulses coming from the detector. Increasing the gain broadens isotope peaks, shifts them to the right, and spreads individual peaks further apart. As the Gain is increased, the peak(s) can be shifted completely off the right end of the spectrum display. Also, as Gain is increased, the noise amplitude will increase proportionally, requiring a compensating increase in Threshold level. *Gain should not normally be changed from the factory setting.*

Threshold—(Range 1 to 31) This value controls the amplitude threshold that pulses must exceed to be measured. It should be set just above the level where the amplifier noise is first observed. *Default Threshold is 9. Less than 9 disables the threshold.*

Offset—(Range 0 to 255, in 8 channel increments) Increases in this value shift the 256-channel spectrum the defined number of channels to the left. The Offset is elevation-dependent and may need to be adjusted by the user in increments of 8.

Default Offset is set at factory calibration.

Performing the Calibration

Alpha energy calibration consists of aligning the peak markers with the corresponding isotope peaks in the spectrum. This is most efficient when a mid-energy (e.g. 5 MeV) source is verified to appear near channel 120, then resetting the spectrum and accumulating a radon spectrum overnight. Once the spectrum is positioned, the peak markers may be aligned. Observe the following steps for more detail.

Consideration for Radon Mode

The SabreBPM² can be configured to operate in "Radon Mode" by selecting PAEC as the primary IoI (Iso1) where the radon/thoron progeny are used to determine the PAEC (potential alpha energy concentration) exposure to the worker in milli-working levels (mWL). There will be no marker for the PAEC channel. The PAEC reading will replace the first

isotope-of-interest, but a second IoI can be enabled, usually a Mixed Uranium region-of-interest, which will have a marker. In radon mode, a peak marker may also appear for Po210. The energy of the Po210 peak is at 5.3 MeV, left of the Po218 peak.

Roughing in the Source Peak

Place a mid-energy alpha source such as Am-241 in the sampling head and verify that the peak appears just below mid spectrum (near channel 120) and that the peak tail narrows to near zero at the left end of the spectrum. Adjust the Offset if needed, tapping **reset spectrum** after each adjustment. This insures that the three radon progeny peaks should be visible after the overnight run.
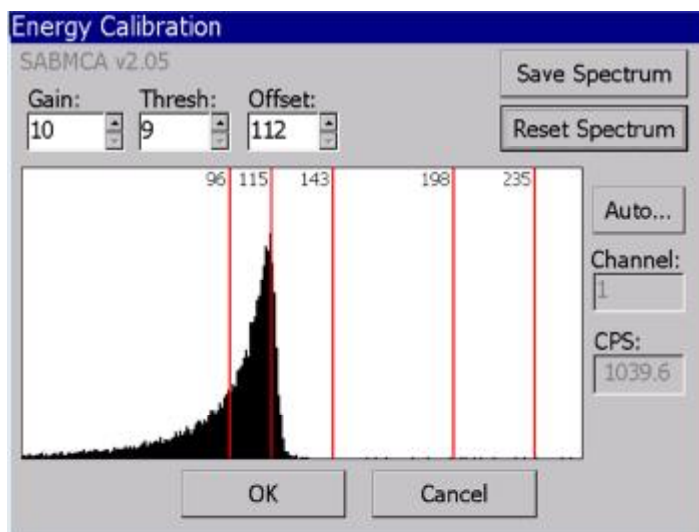

Collecting an Alpha Radon Spectrum

Reset the spectrum, and then make sure a clean filter has been inserted into the detector head and leave the Alpha Energy Calibration window open on the screen before leaving the SabreBPM² to collect the radon spectrum. Leave the SabreBPM² operating in a high radon area for 8-24 hours so that a well-defined radon spectrum can be accumulated.

NOTE: The furthest peak to the right is Po-212 with a 10-hour half-life. If, after a several hours, the 3 peaks (including at least a small Po-212 peak) are not all visible, the Offset should to be increased by 8, 16, or 24 channels to shift the peaks further left. Click **Reset Spectrum** and run the unit again for several hours to **accumulate another spectrum**.

Lining Up the Radon Daughter Peaks

After all three peaks of the Alpha radon spectrum are clearly visible on the screen; the radon daughter peaks can be calibrated. An **Auto…** button allows the software to identify the peaks and set the markers for you. Click it and a message box will appear showing the peaks identified. Click **Yes** to have the markers automatically aligned on the peaks.
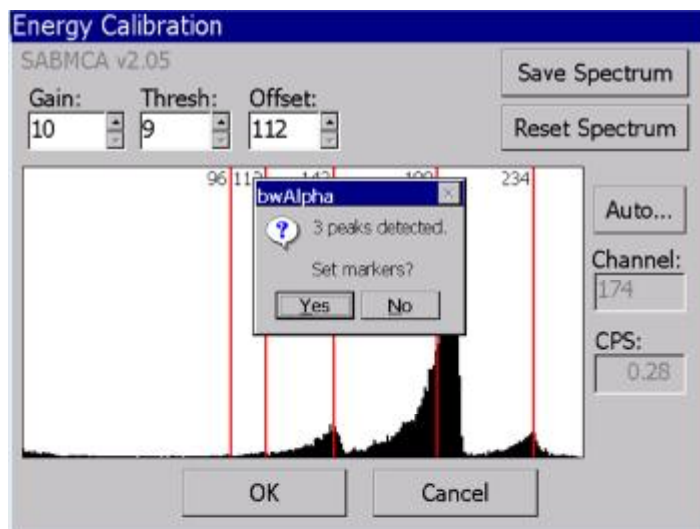
You can always manually set the markers by lining up each of the red lines with their respective peak location. Tap on a line and drag it across the screen until they line up with the center of the peak.

Another number will appear while the line is being dragged that indicates the number of counts per channel. Release the line on the channel with the highest counts.
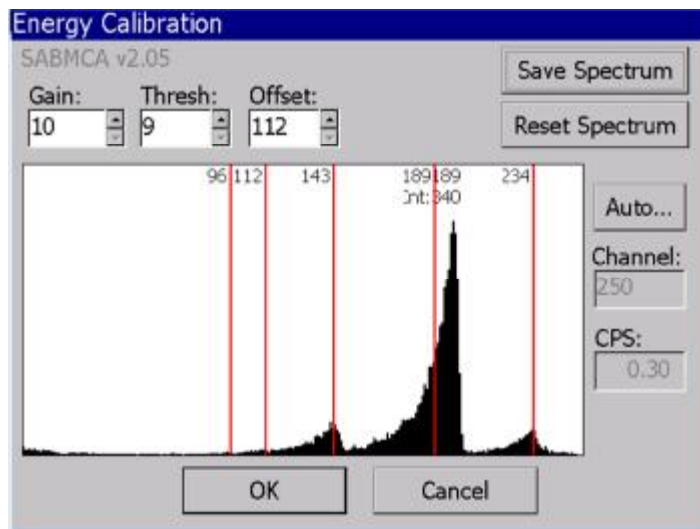
Calibrating the Isotope-of-Interest (Optional)

The isotope(s)-of-interest or source peak also needs to be energy calibrated at this point. Remove the filter and leave the detector exposed.

Using an appropriate source holder, to provide repeatable geometry, place the desired isotope-of-interest calibration source in the detector recess so that the *source face is the same distance from the detector as a filter would be*. Leave it there as a well-defined peak becomes visible on the screen. Remove the source before the peak becomes too large.

Then, click the **Auto…** button or drag the remaining red line and align it with the peak location. Repeat this procedure if necessary with a second source corresponding to the alternate isotope-of-interest.

Alternatively, use the Isotope of Interest Channel Calculator (found on the CD) to determine the peak location, without a source.
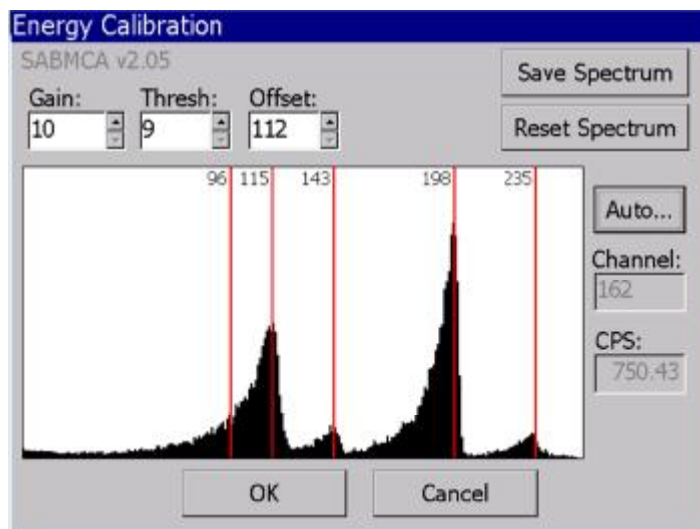
Finalizing the Energy Calibration

Once all of the peaks have been successfully lined up, replace the filter and close up the detector head. Tap the **Reset** button on the screen to clear the spectrum, then tap the **OK** button, then tap **Yes** when prompted to save the settings and update the calibration date.

Alpha Efficiency Calibration

Performing the Alpha Efficiency Calibration is used to determine the detector counting efficiency to the alpha source. This efficiency is used to produce accurate exposure and concentrations in units of measure meaningful to the user (e.g. DAC-h and mWL). It also makes sure that the SabreBPM² is counting at an acceptable rate.

To begin the Alpha Efficiency Calibration, select *Calibrate—Alpha Efficiency…* from the menu. Indicate the source activity in DPM, which should be written on the source, its container or certification sheet.

Remove the filter holder and insert the calibration source holder in the detector recess. In addition, be aware that the detector must only be exposed to 25mm of active area either by using a 25mm source (or by masking the additional area and compensating the source activity for the reduced area).

Once the source activity has been entered and the source inserted, tap **Start Calibration**. The calibration will run until it has reached 10,000 counts.

After the calibration has completed, it will report the efficiency. The Alpha 4-Pi Efficiency should be around 30 percent. Typical efficiencies are 25-31% for Am-241. If the efficiency falls outside these parameters, either **Repeat Calibration** or call a Bladewerx Technician for assistance.

If the efficiency is acceptable, remove the source from the detector, place the filter back, and close up the detector head. Tap **OK** to close the dialog and save the new efficiency setting.
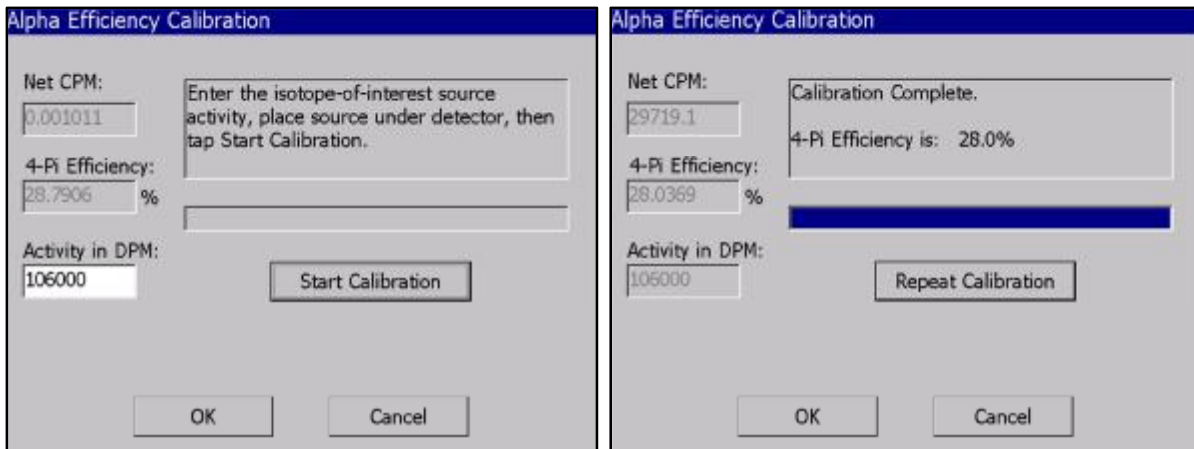
Beta Efficiency Calibration

Performing the Beta Efficiency Calibration is necessary to determine the detector counting efficiency to the beta particulates on the filter. This efficiency is used to produce accurate exposure and concentrations in meaningful units (e.g. DAC-h and pCi). It also makes sure that the SabreBPM² is subtracting beta background counts at an acceptable rate.

This calibration procedure is characterized by manually adjusting several potentiometers (variable resistors) mounted to the Beta PCB within the unit in order to calibrate the lower beta and guard detector discriminator thresholds.

Summary

The following section will describe the steps necessary for setting the beta background by adjusting manual potentiometers. Each time a 'pot' is adjusted, reset the count and wait for at least a minute to get an accurate count. Longer count times improve the statistical accuracy of the background reading as the displayed value is an average since the Reset button was pressed.

You will repeat the following process of adjusting the pots and checking the Gross CPM until the desired count rate is reached. Then the next steps will be a 10 minute background count to confirm the settings. Last, the actual beta efficiency calibration will be performed.

Reset the Background Count

Go to the menu at the top of the screen and tap on *Calibrate—Beta Efficiency...* First, remove the filter and return the filter holder to the radial head, so that the SabreBPM² is operating under normal flow conditions but without a filter. Tap the Beta **Reset** button so the display reads zero for a brief period, then begins its cumulative average. In this dialog, you will watch for changes to the beta **Gross CPM**, as adjustments to the potentiometers are made.

> **Note:** Most SabreBPM² units are shipped with a gamma guard detector installed. Units with a guard detector will display the guard readings in the reading row below the beta readings. The guard detector and beta backgrounds should be matched as closely as possible to each other so that their sensitivities are equal.

The acceptable target background for optimum sensitivity is between 5 and 15 CPM. If after a few minutes, the Gross CPM readings are within that tolerance, skip the threshold adjustment steps and proceed to Verifying the Background Count.

Understanding the 2-Channel Board Adjustments

The SabreBPM² has four settings that control the 2-Channel board beta detection sensitivity; they are controlled by four manually adjustable potentiometers inside the unit.

- **R18** controls the VBIAS voltage used to bias the beta-sensitive **detector**. It allows the bias voltage to be adjusted between zero and 90 volts DC. *Default is 70 V.*

- **R15** controls the **lower beta** threshold. This setting defines the threshold below which, pulses will not be counted. It should be set above the electrical noise baseline so as to maximize the beta signal-to-noise ratio. It is typically adjusted to 0.420 V measured on the test point and lowered until an acceptable background between 5 – 15 CPM is achieved.

- **R11** controls the **upper beta** cutoff for the **alpha** channel. Any pulse exceeding this threshold *will not* be counted as a beta pulse. It is typically adjusted to its maximum of about 1.2 V.

- **R32** controls the **lower gamma** threshold. It should be set to produce equal beta and guard detector responses to a gamma source. For example, it should be set to produce approximately the same count rate in both the beta and guard detector channels when exposed to a gamma field.

Threshold Test Points

VBIAS Test Point
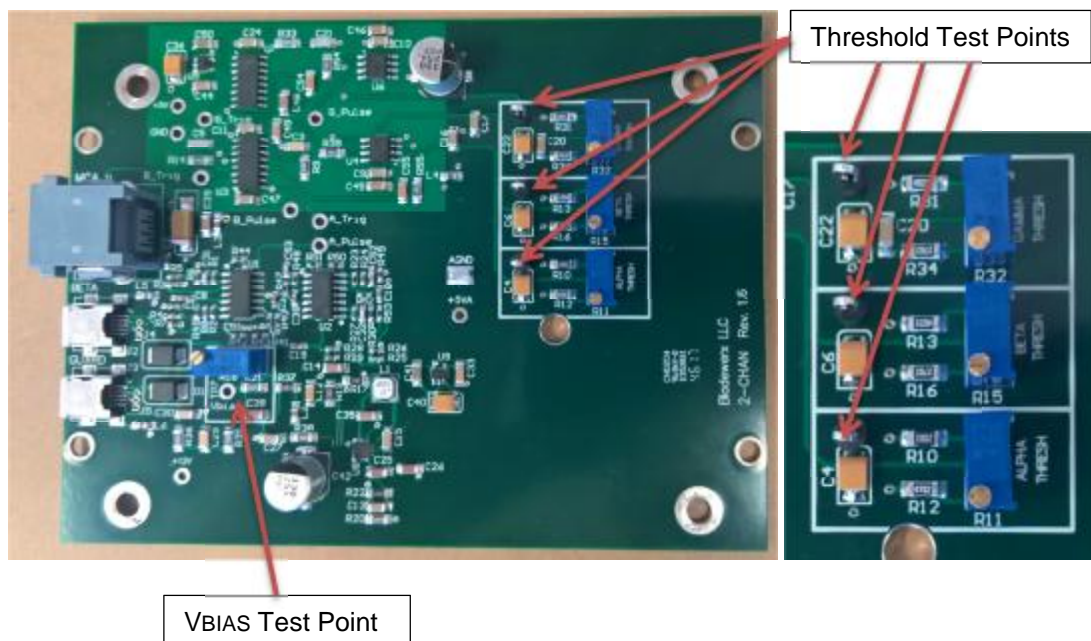
Adjusting the Beta Background Threshold

NOTE: Please use appropriate ESD precautions to protect the unit from electrostatic discharge while the case is open during this process. Only trained personnel should perform this particular step of calibration.

To get to the potentiometers, first unscrew the large plastic screws that secure the SabreBPM² lid to the base and open up the case. The 2-Channel board is located in the top half of the SabreBPM² base, with the potentiometers mounted on blue casings.

Test points on the board allow measuring the threshold voltages with a multi-meter. Turning the potentiometers counterclockwise lowers the threshold and increases the counts per minute, while turning it clockwise raises the threshold and lowers the counts per minute.

1. Starting at about 0.43 volts on the test point, adjust the beta threshold (R15) downward so that the beta background count is 5 – 10 CPM.

2. To observe the effects of adjusting the potentiometers, check the Beta Gross CPM in the dialog box. Remember to press the **Reset** button and wait at least one minute each time after adjusting. Leave the lid closed, but not screwed shut, during these measurements.

3. If behavior is erratic, check that the upper beta (alpha) threshold (R11) is at max thresh: clockwise.

4. If necessary, check that the detector bias (R18) is set to 70 V. A detector bias of 50 to 90V is necessary for beta and gamma pulses to be produced by the detector.

Adjusting the Gamma Background Threshold

If the SabreBPM² does not include the guard detector, then the count rate in the guard field will be disabled and zero counts per minute. This step may be skipped.

If the guard detector was included with your SabreBPM², then the guard background threshold must also be set. Setting the guard threshold follows a similar procedure to setting the beta threshold. The count rate for the guard detector is displayed below the beta information. The emphasis in setting the Guard Threshold is so that both guard and beta detectors have the same energy response.

5. **Once the beta and guard detector backgrounds are approximately equal**.

6. Place the BPM on its back over a gamma source well with the source **equidistant** from both detectors.

7. Verify that the Guard count rate reads approximately the same as the Beta rate. Press the **Reset** button and wait 1 minute each time it is adjusted. If the count rates do not match closely, you can record the ratio of BetaCPM::GuardCPM and adjust the **Guard**

Subtraction Factor on the Beta tab under Instrument Options to compensate for the difference.
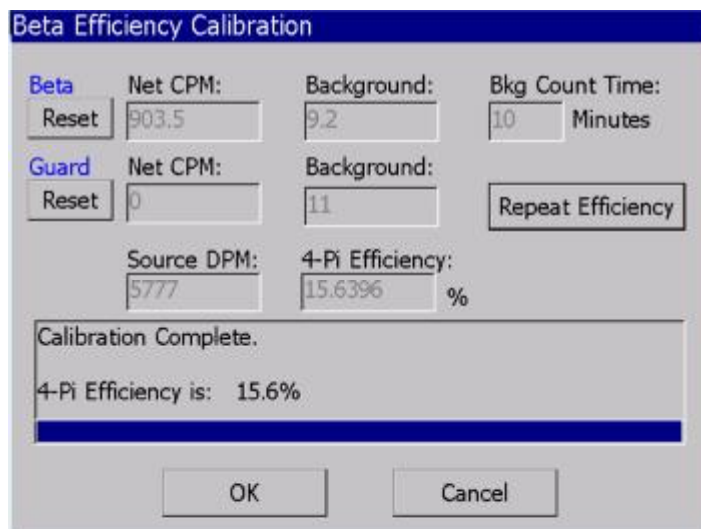
Verifying the Background Count

After achieving the desired background count rate(s), close up the SabreBPM². Set the desired **Bkg Count Time** and tap **Start Calibration**, and the background check will begin. Once the background check is complete, it should produce a gross count rate within the 5 - 15 CPM range (if it does not, reopen the case and adjust the threshold as before). If a guard detector is installed, the guard background will also be determined and should also be approximately equal and in the 5 - 15 CPM range.

Beta Efficiency Calibration

After the background check is complete, begin the Beta Efficiency calibration by removing the filter holder from the radial head. Insert the calibration source into the detector recess. A beta source with a 25 mm (1") active area and at least 10,000 DPM should be used for the calibration. Enter the DPM source activity in the in the **Source DPM** field. If the source activity is reported in **CPM, double the activity** to account for beta backscatter, and enter that amount. Then tap **Start Efficiency**. The calibration will run for two minutes or until it has reached 10,000 counts, whichever is longer.
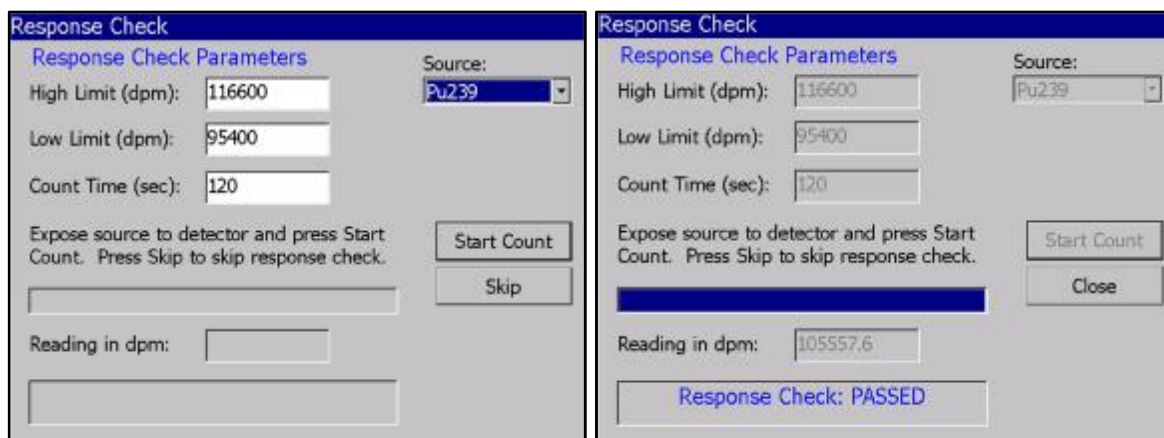
After the beta source count is complete, the SabreBPM² will display the 4-Pi beta efficiency. The efficiency should be in the range of 12-18%. For a low energy beta source like Tc-99, an efficiency of 6-10% is typical. An efficiency result outside of this range could be the result of an improperly set Beta or Guard threshold or an activity calculation error. If the efficiency falls outside these parameters, either **Repeat Calibration** or call a Bladewerx Technician for assistance.

If the efficiency is acceptable, remove the source from the detector, place the filter back, and close up the detector head. Tap **OK** to close the dialog and save the new efficiency setting.

Response Check

After either an Alpha or Beta Calibration has been performed, it is good to double check the calibration by running a Response Check. The response check can also be done at any time if the user wants to verify the unit is still in calibration. Follow the detailed instruction is Section 4 of this manual.

Flow Calibration

The SabreBPM² sample flow rate is estimated by monitoring the internal pump's electrical current. Flow calibration is necessary to insure that the SabreBPM² program is correctly monitoring and converting the pump current into a flow. This relationship is *not* linear. As a result, a three-point flow calibration is used, with validation at a fourth flow rate.

Flow Calibration is also an elevation-dependent function, and thus is *required* before putting the unit into service.

Setting up the Apparatus

To begin the flow calibration, first gather the appropriate equipment for the procedure:

- Volumetric Digital Flowmeter (a Rotameter will work as well)
- Tygon tubing (1/4" inner diameter)
- Flow restriction device (a clamp or needle valve)
- Flow Calibration Aid (included with SabreBPM², 1 per order)

Create the testing apparatus by attaching the flow restriction device to the Tygon tubing between the digital flowmeter the flow calibration aid. Place the Flow Calibration Aid into the detector head as pictured.

NOTE: Ensure that the variable flow restriction does not completely cut off the airflow to the pump. *The pump is not designed to pull a high vacuum* and low flow rates can damage the pump diaphragm. Do not allow the pump to run below 5LPM for 7 LPM pumps (or 4 LPM for 6 LPM pumps) for more than a few minutes.

Performing the Calibration

To begin, make sure the pump is ON (*Monitor–Pump–On…* in the menu). Then, open up the flow calibration dialogue under *Calibrate–Flow…* The flow calibration is a three-point calibration, meaning it takes measurements at three different flow rates (low, medium, and wide open), and the program then uses those measurements to create an equation for a curve. It can then use the curve to calculate the pump's flow later on. A fourth flow rate is used to validate this curve, and reports the measured difference in an error percentage. The flow calibration dialog instructs the user throughout the process.

NOTE: Any flow rate will work as long as the measured flow *entered* is the same as what is *reported* by the flowmeter. So if the Flowmeter reports <u>4.11</u> then the Measured Flow is entered at <u>4.11</u> even if the instructions ask for 4.0 LPM.

The first step in the flow calibration is to reduce the flow rate by adjusting the flow restriction device to a low flow rate, at about **2 LPM below** the unrestricted rate. Enter the actual value from the flowmeter in the dialogue under *Measured Flow.* Then hit **Start Calibration.** Each step in the process will take about 30 seconds as indicated by the progress bar. Repeat this process at about **1 LPM below** the unrestricted rate.

In the third step, adjust the flow restriction device until it is completely open, providing maximum flow. Again, input the LPM indicated on the flowmeter into the *Measured Flow* box on the screen. Continue with the same process as before.

The last step is to validate the calibration. Adjust the flow restriction device until the flowmeter reads approximately 80% of max flow, or **0.5 LPM below** the unrestricted rate. Input the *Measured Flow*, and then tap **Validate**. The validation step will check to make sure the formula calculated by interpolation is correct, and will produce an error percentage, which should be less than 5 percent.

The flow calibration is now completed and this example shows 0.4% error, which is acceptable. Tap Close and save the calibration settings. Remove the flow calibration aid from the detector head, which may be difficult because of the suction created. It is recommended that the pump is turned off temporarily for better leverage. Lastly, replace the filter and close up the detector head.

Configuration

The SabreBPM² program provides several dialogs to allow configuration of the instrument operation. These dialogs are accessed through the *File* and *Monitor* menus. Each dialog and its settings are described below.

Instrument Properties

This dialog controls the operation of the of the user interface aspects of the program. Tap the *File – Properties…* menu item to access the Instrument Properties dialog.

User Options

Use password security—this option provides a method of disabling certain calibration and configuration functions unless the user has entered an acceptable password. Two

password levels are supported: calibration and configuration. The calibration level allows access to all menus and features, while the configuration level provides access only to alarm settings and other non-calibration-related functions. ***Default passwords are:*** **calib** *for calibration, and* **config** *for configuration.*

Alarm Silence by menu only—this check box, when checked, required that alarms are acknowledged from the *Monitor – Acknowledge Alarm* menu selection. When unchecked, alarms may be silenced either from the menu, or by pressing the **Alarm Ack** button on the face of the SabreBPM². When paired with the **Use Password Security** option, the user must have at least a config-level password in order to acknowledge and silence the alarm. ***Default is unchecked.***

Disable buttons when logged out—this setting prevents the use of all three front panel buttons by unauthorized users (not just Alarm Ack). It is only available when Use Password Security is checked. ***Default is unchecked.***

Hide radon progeny channels—this setting disables the display of the Po-218, (Pb-214,) Po-214, and Po-212 acute and chronic data when scrolling through the display channels using the **Channel** button.

Skip Response Check on startup—this option allows startup and use of the unit without performing a response check. When this setting is active, the Response Check is only performed from a menu command. When unchecked, after a startup, the user is prompted to perform a Response Check. ***Default is unchecked.***

Use SI Units—this option selects the use of American (i.e. DAC) or System International (i.e. Sv) units systems for display and logging.

Backlight—this incremental scroll bar controls the level of backlight provided to the LCD screen. To achieve the 8-hr battery runtime, the unit should be set to the lowest setting.

Instrument Options

The Instrument Options dialog controls the functional behavior of the SabreBPM². Access the dialog from the menu by tapping *Monitor – Instrument Options…* The dialog consists of at least four tabs of settings and information: General, Logging, Beta, Flow, and optionally Isotope 1 and 2, RadNet or ASCII.

General Tab

Serial No—This is a *non-editable* field that identifies the factory-defined serial number of the SabreBPM². *Default: Factory set*

Window Settings

Acute Window—This setting defines the count time (from 5 to 600 seconds) used to determine the Acute Dose, NetCps and Activity. It should be set to provide the fastest response to high concentration spikes of a pre-determined level. Shorter times mean higher minimum-detectable levels but do not necessarily mean faster response times. Some experimentation may be required to achieve a desired alarm level and response time. *Default is 120 Seconds.*

Chronic Window—This setting defines the count time (from 5 to 600 minutes) used to determine the Chronic Dose, Concentration, NetCps and Activity. Longer times provide better sensitivity and lengthen the dose integration time. *Default is 240 Minutes.*

Calibration Expiration Settings

Calibration expires—This non-editable item displays the latest date on which the SabreBPM² calibration will expire. The expiration could occur sooner if the maximum runtime hours are exceeded.

End of Month—this checkbox allows expirations to be posted on the last day of the month following the actual expiration date.

Calibrations are valid for XXX days—This field sets the maximum number of days between calibrations. *Default is 365 days.*

But not more than YYY runtime hours—This field sets the maximum number of hours of SabreBPM² runtime between calibrations. *Default is 8800 hours.*

Logging Tab

The *Logging Interval* settings control the data logging behavior of the SabreBPM². Several types of log files are created on the SabreBPM² during operation. See Section 6: Retrieving and Analyzing the Data, for more information on the log files.
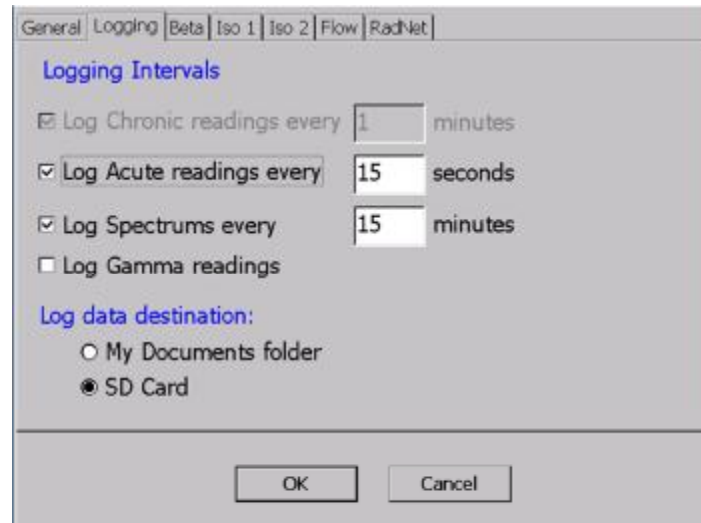
Log Acute readings every—This setting controls the frequency in seconds that Acute readings are written to a log file (Pu239_AcuteYYYYMMDD.txt). Each filename created has the format *NameYYYYMMDD.txt*, where *YYYY* represents the year, *MM* represents the month, and DD represents the creation day. *Default is 15 Seconds.*

Log Spectrums—This setting controls whether spectrum snapshots are written to a log file (SpectrumYYYYMMDD.txt). If the setting is checked, the Log Spectrums frequency field will be enabled. *Default is Spectrum Logging is ON.*

Log Spectrums every—This setting defines the frequency in minutes that spectrums are time stamped and logged. *Default is 10 Minutes.*

Log Gamma readings—this setting causes Acute and Chronic logging of the gamma guard detector net count rate.

Log data destination

This selection defines the location where SabreBPM² data will be saved.

My Documents folder—This setting saves log files in the My Documents folder. ***This is a volatile folder that will be erased in the event of a complete battery discharge or loss of battery power.***

SD Card—this setting causes log data to be saved to the non-volatile SD memory card in the SabreBPM. *Default is the SD Card.*

Beta Tab

This page defines the parameters concerning the measurement of and alarming on the net beta reading. It supports both a fixed beta background, and the use of a guard detector for real-time subtraction of gamma interference.

DAC Constant—This setting defines the conversion constant to convert from Pico-Curies per liter to DAC, defined by 10CFR835. Note that the constant uses units of Pico-Curies per liter to avoid the need for scientific notation. *Default is 1 DAC = 100 pCi/liter*

Alarm Configuration

Enable Alarms—This checkbox controls the checking for and annunciation of alarms for this isotope of interest. **Left unchecked, all alarming will be disabled and no alarm checking will be performed!** *Default is checked, Alarming performed.*

Latch Alarms— This checkbox configures whether alarms are latching or non-latching. Non-latching alarms (un-checked) will clear automatically once the reading drops below the alarm set point. Latching alarms (checked) must be acknowledged by the user before the alarm status will be cleared. Alarms must be cleared manually through the *Monitor - Acknowledge Alarm* menu item, or with the Alarm Ack button. *Default is unchecked, Non-latching*

Alarm Settings…—This button calls up the alarm settings dialog to configure the alarm set points for beta. See the dialog description under Alarm Settings below.

Background Subtraction

Radon subtraction—This setting controls whether counts due to beta-emitting radon progeny are subtracted from the beta reading. When set, the alpha activities of the radon/thoron progeny, determined by alpha spectroscopy, are used to estimate the beta

activities of the progeny. Counts proportional to the estimated beta activity are then subtracted from the gross beta rate to determine the net beta rate. ***Default is selected.***

Subtraction factor—This parameter is multiplied by the calculated radon/thoron beta activity to produce the value subtracted from the gross beta rate. Because the beta counting efficiency is dependent on the beta energy, the radon/thoron betas will have a higher or lower efficiency than the beta calibration efficiency. ***Default is 1.0.***

Guard Detector Present—This checkbox is selected if the SabreBPM² is factory–configured with a guard detector. It is not user-editable.

Fixed Subtraction Factor— [Displayed if Guard detector not installed] This setting controls what portion of the fixed beta background count rate is subtracted from the gross beta count rate. The fixed background rate is determined during the beta efficiency calibration. ***Default is 1.0.***

Gamma Subtraction factor— [Displayed if Guard detector installed] This parameter is multiplied by the Net Gamma activity to produce the value subtracted from the gross beta rate. It can be used to adjust for slight differences to Beta and Guard detector count rates in a fixed gamma field to produce proper energy response. ***Default is 1.0.***

Alarm Settings

This dialog allows configuration of the acute and chronic alarm set points for dose and concentration alarms. Separate Alarm Settings dialogs are applied for Beta and each Isotope.

Chronic Alarms

Chronic Dose—This setting determines the alarm set point for a chronic dose alarm. ***Default is 20 DAC-h.***

Chronic Concen.—This setting determines the alarm set point for a chronic concentration alarm. *Default is 1000 DAC.*

Acute Alarms

Dose (DAC-h)—This setting determines the alarm set point for an acute dose alarm. *Default is 80 DAC-h.*

Acceptable False Alarm Rate

This setting defines the acceptable number of false alarms per year. The limit has an effect on the calculated minimum-detectable dose and concentration limits. Therefore, it has an effect on the dose and concentration sensitivities. The setting is used to determine the Chronic and Acute *sigma factors*, shown to the right, which are multiplied by the standard deviation of the calculated dose and concentration to yield the minimum-detectable level. Allowing more false alarms will provide better alarm sensitivity at the expense of more frequent false alarms. *Default is 10 false alarms per year.*

Isotope Tabs (with Alpha option)

The Iso 1 and 2 tabs define the parameters concerning the primary and secondary isotope-of-interest measurements. By default, the first isotope of interest is Pu-239, however, this isotope may be changed to support the measurement of other alpha-emitting isotopes.

Note: The radon daughters (Po-218, Po-214 and Po-212) are always monitored, even in Beta-only configurations. They are used in the background subtraction algorithm and reported on the meter.

Isotope—This pull-down list provides for the selection of other isotopes of interest from the user-editable **Isotopes Database**. This selection affects only the isotope of interest and not the measurement of radon daughters, which are always monitored. *Default is Pu-239.*

NOTE: The Isotope field can also be used to select the PAEC (or Potential Alpha Energy Concentration) mode for monitoring radon Working Levels.

NOTE: This field can also be used to select a Region-of-Interest (ROI_1) mode.

Peak Channel—this field identifies the channel where the peak of the selected isotope-of-interest is expected by the peak-fit algorithm. Although it is not editable from this dialog page, it is set during the calibration procedure using the peak markers.

DAC Constant—this setting defines the conversion constant to convert from Pico-Curies per liter to DAC, defined by 10CFR835. Note that the constant uses units of Pico-Curies per liter to avoid the need for scientific notation. *Default is 1 DAC = 0.005 pCi/liter*

Regions of Interest

Beginning with software Version 4, energy Regions of Interest (ROIs) can be selected instead, or in combination with, a known radionuclide. Under the Isotope drop down list for Iso 1, you will find the entry **ROI_1**. Likewise under the Iso 2 tab Isotope drop down list, you will find **ROI_2**. Selecting a Region of Interest from the drop down list will enable the energy region fields to be displayed and edited.

Enter the lower and upper energy bounds in the fields to define the region. The software will then log and display net region counts, dose, and concentration for the Iso channel.

NOTE: Energy regions must not overlap each other. In addition, they may not completely overlap the peak of an Isotope-of-Interest. The peak fit algorithm requires at least 100 keV of low energy tail above a ROI bound to function properly.

Alarm Configuration

> **Enable Alarms**—this checkbox controls the checking for and annunciation of alarms for this isotope of interest. **Left unchecked, all alarming will be disabled and no alarm checking will be performed!** *Default is checked, Alarming performed.*
>
> **Latch Alarms**— this checkbox configures whether alarms are latching or non-latching. Non-latching alarms (un-checked) will clear automatically once the reading drops below the alarm set point. Latching alarms (checked) must be acknowledged by the user before the alarm status will be cleared. *Default is unchecked, Non-latching.*
>
> **Alarm Settings…**—this button calls up the alarm settings dialog to configure the set points for the isotope-of-interest. See the dialog description under Alarm Settings above.
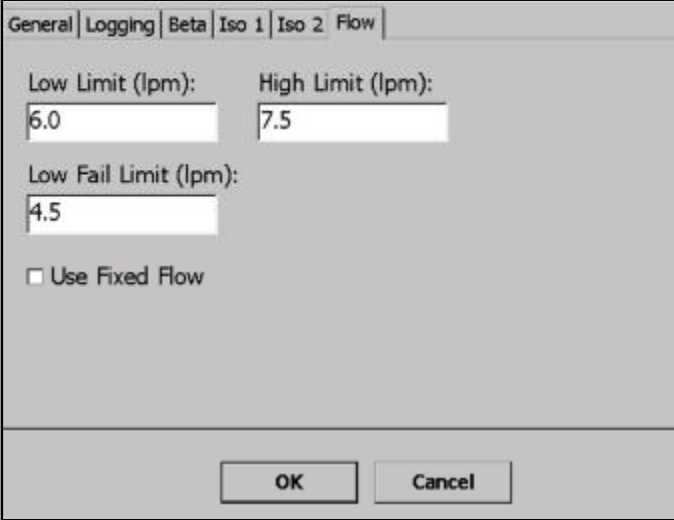
Iso 2 Tab

This page defines the parameters concerning the second isotope-of-interest measurements. By default, the isotope of interest is *None*, however, this isotope may be changed to support the measurement of other alpha-emitting isotopes or a second Region-of-Interest (ROI_2).

Flow Tab

This page defines the high, low, and failure limits for air flow measurement in liters per minute. It also offers a Fixed Flow setting for externally plumbed units.

Low Limit—This setting defines the limit in liters per minute below which the SabreBPM² will indicate a LO FLOW status. A low flow status can indicate a loaded or wet filter. *Default is 6.0 LPM*

High Limit—This setting defines the limit in liters per minute above which the SabreBPM² will indicate a HI FLOW status. A high flow status can indicate a missing filter, leaking or disconnected vacuum line. To achieve a 'missing filter limit', remove the filter, replace the filter holder, check the flow rate, and set just below this rate. *Default is 7.5 LPM.*

Low Fail Limit—This setting defines the limit in liters per minute below which the SabreBPM² will indicate a FLOW FAIL status, go out of service, and will not alarm. A flow fail status can indicate a kinked or clogged vacuum line. *Default is 4.5 LPM.*

Use Fixed Flow—When checked, this setting is used for units with external pumps with no flow measurement capabilities. *Default is Unchecked.*

RadNet Tab (with WiFi or Ethernet option)

This page contains the settings for RadNet Protocol broadcasts for SabreBPM² units with the RadNet over WiFi, or RadNet over Ethernet option installed. This page will only appear for wireless- or Ethernet-enabled instruments.

Use WAN IP Address—when checked, a specific WAN IP address can be entered. When unchecked, the unit broadcasts to the entire C-class subnet. *Default is unchecked*

Broadcast Measurements—this checkbox enables or disables the transmission of measurement packets to RadNet clients. *Default is enabled and uneditable.*

> The list describes the options for measurement packet broadcasts. Allowable choices are Chronic and Acute data, Chronic Only, and Acute Only. *Default is Chronic and Acute and is factory set to user specifications*

Broadcast Spectrums—this checkbox enables or disables the transmission of SabreBPM² spectrums to RadNet clients. Check the box to enable spectrum broadcasts.

Spectrum Type List Box—this list describes the options for spectrum packet broadcasts. Allowable choices are Chronic unless Acute Alarm, Chronic Only, and Acute Only. *Default is Chronic unless Acute Alarm and is factory set to user specifications*

Port—this field specifies the UDP Port number which RadNet packets are broadcast on. User editing of the port number is disabled. *Default is 16367.*

Debug mode—checking this setting will insert wireless debug information into the status log. It can be of use by IT personnel when attempting to troubleshoot communications issues. *Default is unchecked*

Output on—this field indicates whether the instrument is broadcasting RadNet data via WiFi or Ethernet.

ASCII Tab (with RS-232, Ethernet, or WiFi option)

This page contains the settings for ASCII Communications Protocol broadcasts for SabreBPM² units with an RS-232, Ethernet, or WiFi Option installed. The RS-232 and Ethernet options offer a RJ-9 or RJ-45 connector on the side panel respectively, while the WiFi option utilizes an internal antenna for broadcasting.

RS-232 Settings

RS-232 Enabled—when checked, this setting transmits measurement packets via RS-232 using the ASCII Protocol. *Default is checked if ordered*

COM—this field specifies the Communications Port number of the PC that the RS-232 cable is connected to. *Default is COM5.*

Baud—this field specifies the bits per second with which ASCII packets are broadcast. *Default is 19200.*

TCP/UDP Settings

Ethernet Enabled—When checked, this setting transmits measurement packets over the wired Ethernet connection using the ASCII Protocol. When unchecked, it transmits using WiFi.

TCP/Port— if the TCP radio button is active, the Port field specifies the TCP Port which ASCII packets are broadcast on. *Default is 7001.*

UDP/Port— if the UDP radio button is active, the Port field specifies the UDP Port which ASCII packets are broadcast on. *Default is 16467.*

Enable Beta Data—when checked, this setting includes beta data in the measurement packets. *Default is checked*

Enable Alpha Data—when checked, this setting includes alpha data in the measurement packets. If unit is Beta-only, this setting is disabled. *Default is checked*

Enable Short ASCII Format—when checked, ASCII broadcasts are stripped of extraneous space characters to improve communications throughput. *Default is checked*

Enable AMS-4 Format—when checked, ASCII broadcasts mimic the Eberline AMS-4 communications messages.. *Default is unchecked*

SECTION

4

Starting a Dose Measurement

Response Check Routine

Before starting a dose measurement, the SabreBPM² should be tested using the Response Check routine to make sure that it is operating properly and in calibration. The purpose of the Response Check is to verify the following:

- A consistent activity is reported from a source of known activity

- The detector and SabreMCA are functioning properly

- For beta response checks, that the noise/background is properly compensated for and the beta efficiency has not changed.

- For alpha response checks, that the source isotope is correctly identified, the peak area properly measured, and that the alpha efficiency has not changed.

Source Requirements

In both alpha and beta source checks, the source used should have an active (plated) diameter of 25mm (1-inch). If the active area is larger, the activity of the 25mm area must be known so that when masked to that size by the opening in the sampling head, the counting efficiency will be calculated properly. The overall diameter of the source can be no larger than 32mm (1.26-inch). The sources also need to match the beta energy and/or the isotope-of-interest the SabreBPM² is configured to measure. The activity for beta sources should take *backscatter* into account. It is suggested that the DPM activity be calculated from 2X the surface emission rate in CPM.

Running the Response Check

After starting the SabreBPM² program, the Response Check dialog is automatically initiated. It may also be initiated from the menu by tapping *Monitor – Response Check….* There are four edit fields in the upper portion of the screen:

Source—This list box selects the Alpha or Beta sources that can be used for the response check..

High Limit (dpm)—this setting specifies an upper fail limit on the measured activity. Any reading above this value at the end of the test will cause the Response Check to fail. The user should set this value to be approximately the source activity in dpm, plus 10%.

Low Limit (dpm)—this setting specifies a lower fail limit on the measured activity. Any reading below this value at the end of the test will cause the Response Check to fail. The user should set this value to be approximately the source activity in dpm, minus 10%.

Count Time (sec)—this setting defines the time window in seconds over which the activity will be averaged. The actual duration of the Response Check will be longer to account for stabilization of the reading.

Set the High/Low Limits to reflect the desired tolerance and set the Count Time to produce a reading that will reliably fall within the limits. The tolerance of ±10% is only a suggested limit and actual tolerances may be varied based on customer procedures or preferences.

Remove the filter holder, exposing the detector head, and place the source in the detector recess. The location and spacing of the source to the detector should be repeatable, and should produce geometry identical to the location and spacing of the filter.

When the source is in position, tap the **Start Count** button to begin the test. A progress bar and *Reading in dpm* field provide visual feedback during the test.

When the test is complete, the final activity reading and results of the test are displayed with a Pass/Fail possibility. In the event of a Response Check: FAILED result, it is up to the

user to determine whether the instrument is still serviceable. As with any statistical test, given a mean and a set of limits, there is a finite probability that the test may fail, even though the instrument is operating normally. A reading slightly out of range may indicate only that the unit should be Response Checked again with a longer count time. A reading significantly out of range is a warning that the instrument is not operational.

Tap the **Close** button, or just wait for the dialog to time out after a minute of inactivity, to exit the Response Check routine. Another dialog will prompt you to remove the source, then install a clean filter, and reinsert the filter holder into the detector head.

Normal Measurement Operation

Once the Response Check is completed, the SabreBPM² enters normal operation and begins monitoring for beta activity and, optionally, for the alpha isotope(s)-of-interest. The instrument will begin measuring dose and concentration immediately and can alarm on a measurable activity.

Minimum-Detectable Levels & Window Times

The minimum-detectable levels of concentration and dose will be elevated until the Acute and Chronic Window times have elapsed, defaulted to 120 sec and 240 min respectively. Until the full window times have elapsed, the SabreBPM² is using incomplete spectrum accumulations to calculate the dose and concentration and has elevated statistical fluctuations of the results.

This means that for the first 120 seconds the Acute MDD will be elevated, and, for the first four hours the Chronic MDD will be elevated. Since the concentration calculations involve two Window times for comparison, the MDC will be high for twice 4 minutes and eight hours respectively. If the user-set Window times are different, then the elevated MDC/MDD times will be accordingly affected.

For the unit to alarm, it is required that the dose or concentration must exceed the **minimum-detectable level** *and* **the alarm set point**. In the beginning, the minimum-detectable levels will likely be above the alarm set points, but will gradually decline and plateau below the alarm set points.

Display: Meter/Spectrum/Log

The SabreBPM² display components, the Meter, Log and Spectrum, were described in greater detail in Section 1. What follows is a brief summary.

The meter displays readings on a continual basis during operation. The default meter display is the Chronic Dose reading for the beta channel. In alpha-beta mode, the Dose, Concentration, activity and net count rate for the isotope(s)-of-interest—as well as the radon daughters, Po-212, Po-214, Po-218—may be displayed as well through the use of the buttons on the front panel of the SabreBPM².

To select between Acute and Chronic readings and the flow channel, press the **Channel** button to cycle through the various readings. Acute readings are denoted by the suffix **/A**, and chronic readings by the suffix **/C**. In alpha-beta mode, alpha channels are similar. For example, the Pu-239 Acute reading is labeled, Pu239/A and the Pu-239 Chronic reading by Pu239/C. Press the **Units** button to cycle through DAC-h, DAC, NetCPS, pCi/l, and other units.

> **Note: The display of the radon progeny channels (i.e. Po-218, Po-214, Po-212) can be prevented by checking the Hide radon progeny channels control on the File—Properties… dialog.**

The SabreBPM² spectrum may be displayed from the menu by tapping *View—Spectrum*. In this view, the 256-channel spectrum is displayed instead of the log entries. Return to the log entry view by tapping *View—Log*
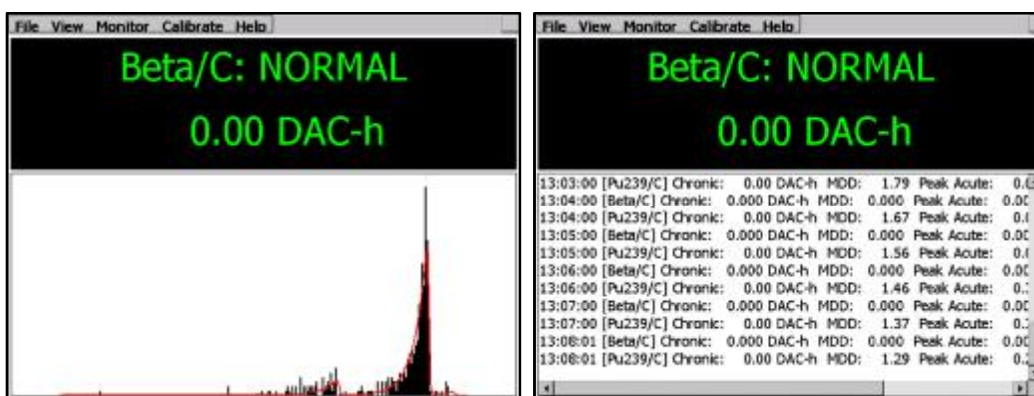
In the event that a dose or concentration reading exceeds alarm limits, the SabreBPM² will alarm visually and audibly, automatically display the channel of the chronic or acute reading that caused the alarm, and the status will be changed to **High Alarm**.

Operational Duration

For lengthy or continuous air monitoring, it is recommended that the unit be run using the AC adapter.

When operating off the battery, the SabreBPM² will run, under normal conditions, for approximately eight hours before the battery level forces a shutdown. A LOW BATT warning status will be displayed when the battery level falls below 25%. The age of the battery, as well as the use of wireless reporting capability, will affect the run time.

NOTE: In order to preserve program and log data, the SabreBPM² will automatically shut down when the battery life reaches 15%.

Measurement Calculations

Acute & Chronic Moving-Windows

In order to calculate a concentration, the counts for each counting channel are saved—along with the flow rate and volume—in a history array, so that the increase in counts over time can be used to determine the net count rate. For each counting channel, two different time intervals are used to determine concentrations and are referred to as the 'Acute' and 'Chronic' window times. These are sometimes referred to as the "fast window" and "slow window".

The counts under the peak—based on the history values over one and two window times— are used to determine the net count rates. For instance, if the window time is 60 seconds, then the net count rates for the last minute and also the minute previous, are calculated. For long-lived isotopes, the increase in net count rates over the two intervals is proportional to the concentration.

The Acute window time offers a very quick response to measurement data, sacrificing some accuracy in the process.

The Chronic window time provides a very accurate dose reading, but must take place over a substantial period of time.

Beta Measurement Calculations

Because the counting efficiency for betas is dependent on the maximum isotope energy, the SabreBPM² must be calibrated for the beta isotope-of-interest in order for the concentration and dose calculations to be accurate. Typically, it is calibrated to SrY-90, Cl-36, or Tc-99.

Beta Concentration Calculations

To determine the net beta count rate, one or two forms of background subtraction are applied: guard detector (or fixed) compensation for gamma interference; and optional radon compensation.

Net beta calculation *with* guard detector:

$$Net = B_{Gross} - B_{Bkg} - F_G(G_{Gross} - G_{Bkg}) - F_R[0.56 \times Po_{212} + 1.35 \times Po_{214}]$$

Net beta calculation *without* guard detector:

$$Net = B_{Gross} - F_G B_{Bkg} - F_R[0.56 \times Po_{212} + 1.35 \times Po_{214}]$$

Where,

B_{Gross}	= Gross beta counts	G_{Bkg}	= Guard background
B_{Bkg}	= Beta background	F_R	= Radon subtraction factor
F_G	= Guard (Fixed) subtraction factor	Po_{212}	= Po_{212} counts
G_{Gross}	= Gross guard counts	Po_{214}	= Po_{214} counts

Acute Net counts are stored in the acute history buffer every second, while Chronic Net counts are stored in the chronic history buffer every minute. The concentration equation used for the acute and chronic beta calculation is:

$$Concentration = \frac{Net_1 - Net_0}{T_{WA} \times Vol_{Sample} \times K_{DAC} \times Cal \times Eff}$$

Where,

T_{WA}	= Actual window time in seconds	Eff	= Beta efficiency (4-Pi)
Net_0	= Net counts: $T - 2T_{WA}$ to $T - T_{WA}$	Vol_{Sample}	= Air volume since filter change
Net_1	= Net counts: $T - T_{WA}$ to T	K_{DAC}	= DAC conversion factor (equals 1 if DAC not used)
Cal	= Calibration constant		

The T_{WA} *actual window time in seconds* may be shorter than the user-defined window time. When a new spectrum is begun, following a spectrum reset or a filter change, a window time equal to the elapsed time, is used so that a "best guess" concentration value can be calculated. This actual window time will increase until it is equal to the user-defined time. This occurs when the user-defined window time has elapsed since the filter change or spectrum reset. After this point, the user-defined time is used.

Beta Dose Calculation

The SabreBPM² program calculates dose according to the activity collected on the filter. Because the SabreBPM² is typically used to continuously monitor the air in a facility, the concept of "worker dose" is dependent upon the portion of time the worker spends in the facility in comparison to the time the SabreBPM² filter has been accumulating activity. For instance, if a unit has been sampling air at 1 CFM for 40 hours, and the activity of SrY-90 is 150 dpm, the worker dose is dependent on how many of the 40 hours the worker spent inside the room being monitored.

Therefore, the determination of worker dose must be accomplished administratively by noting the dose readings when the worker enters and leaves the area and **calculating** the increase in dose.

$$Dose = \frac{Net_1}{\left(T_{WA} \times K_{DAC} \times Cal \times Eff \times Flow_{Sample} \times 60\right)}$$

Where,

T_{WA}	= Actual window time in seconds	Eff	= Beta efficiency (4-Pi)
Net_1	= Net counts from $T - T_{WA}$ to T	$Flow_{Sample}$	= Flow rate
Cal	= Calibration constant	K_{DAC}	= DAC conversion factor (equals one if DAC not used)

Alpha Measurement Calculations

For alpha-beta mode configurations, the curve fit function produces coefficients for each isotope that correspond to the counts under the peak. Like the beta channel behavior, alpha channels use a history array, so that the increase in counts over time can be used to determine the net count rate. The peak counts—based on the history values over one and two window times—are used to determine the net count rates. For long-lived isotopes, the difference in net count rates over the two intervals is proportional to the concentration. Once the change in net count rate is known, the calibration constant and flow volume are used to derive the concentration in the specified measurement units.

An additional term is included in the concentration calculation to account for the expected count rate losses due to activity that has decayed off during the last interval. For longer half-lived isotopes the term $Net_0 \lambda$ goes to zero. However, this term is very important for the proper treatment of the short-lived radon daughters.

It should be noted that in situations where the counts under a peak are changing very slowly or not at all, slight variations may occur in the determination of the net count rate, which can result in small negative concentrations. These effects are minimized by the use of the two different evaluation intervals, with a longer interval providing greater precision in low-level measurements.

Alpha Concentration Calculation

The concentration equation used for the acute and chronic alpha calculation is:

$$Concentration = \left((Net_1 - Net_0)/T_{WA} + Net_0 \lambda \right) \times \frac{Yield}{Vol_{Sample} \times K_{DAC} \times Cal \times Eff}$$

Where,

T_{WA}	= Actual window time in seconds	$Yield$	= Isotope Alpha yield
Net_0	= Net counts: $T - 2T_{WA}$ to $T - T_{WA}$	Vol_{Sample}	= Air volume since filter change
Net_1	= Net counts: $T - T_{WA}$ to T	K_{DAC}	= DAC conversion factor (equals one if DAC not used)
Cal	= Calibration constant		
Eff	= Detector efficiency (4-Pi)	$Lambda$	= decay constant, $\lambda = \dfrac{\ln(2)}{T_{\frac{1}{2}}}$
			where, $T_{\frac{1}{2}}$ = isotope half-life

The flow measurement is used to accurately determine the volume of air collected on the filter paper during the count time.

Alpha Dose Calculation

Like beta worker dose, the determination of alpha worker dose must be accomplished administratively by noting the dose readings when the worker enters and leaves the area and **calculating** the increase in dose.

$$Activity = \frac{Net_1 \times Yield}{T_{WA} \times Cal \times Eff}$$

$$Dose = \frac{Activity}{\left(K_{DAC} \times Flow_{Sample} \times 60\right)}$$

Where,

T_{WA}	= Actual window time in seconds	$Yield$	= Isotope Alpha yield
Net_1	= Net counts from $T - T_{WA}$ to T	$Flow_{Sample}$	= Flow rate
Cal	= Calibration constant	K_{DAC}	= DAC conversion factor (equals one if DAC not used)
Eff	= Alpha efficiency		

Minimum Detectable Measurement Calculations

Uncertainties in Peak Counts

In most ROI-based Alpha-CAM's, the minimum detectible concentration is based on the statistical uncertainty of the background counts that fall within the region, in combination with the uncertainty of any counts in excess of the background. In the SabreBPM², the minimum detectible concentration (MDC) is not directly related to the spectrum counts, but to the uncertainty in the peak fit.

An examination of the peak area variances confirms that when the counts due to an interfering isotope greatly outnumber the counts due to the isotope of interest, the variance of the isotope of interest increases. Likewise, when there are very few interfering counts from other isotopes, the variance begins to approach a value equal to the peak area counts.

When spectrum counts are zero, there is still a minimum variance of the peak areas. This minimum variance affects the minimum detectable levels of dose, concentration and activity. At the start of operation, the program calculates and saves the minimum variance for the Isotope of Interest for use later in the calculation of the minimum detectable levels.

Uncertainties in Flow Rate

The measurement of the flow rate and volume has a statistical variance that contributes to the MDC and MDD. This statistical variance is calculated by the program and applied in the MDC and MDD calculations.

Calculation of the Variance of Peak Counts

The variances returned from the curve fit routine represent the uncertainties on the peak counts for each isotope during the last peak-fitting. The limit of detectability variance used is a combination of the fit variance with the previously saved 'zero-counts' variance.

$$Var_{LD} = \left[K \sqrt{VarZero} + 1.645 \sqrt{Variance_0} \right]^2$$

Where, **K** is the Sigma Factor—a multiplier based on the False Alarm setting and the number of alarm determinations per year.

Calculation of the Minimum Detectable Activity - MDA

$$MDA = \frac{Var_{LD}}{T_{WA} \times Cal \times Eff}$$

Calculation of the Minimum Detectable Concentration - MDC

$$MDC = \sqrt{\left[\frac{\frac{\sqrt{Var_{LD} + Variance_0}}{T_{WA}} + 1 \times \sqrt{Variance_0}}{\frac{(Net_1 - Net_0)}{T_{WA}} + 1 \times Net_0} \right]^2 + \left[\frac{Error_{VOL}}{Volume} \right]^2} \times \frac{|Concentration|}{K_{DAC}}$$

Calculation of Minimum Detectable Dose - MDD

$$MDD = \sqrt{\left[\frac{MDA}{Activity} \right]^2 + \left[\frac{Error_{Flow}}{Flow_{Sample}} \right]^2} \times \frac{Dose}{K_{DAC}}$$

Where,

$Variance_0$ = Peak area variance for previous T_{WA}

$Variance_1$ = Peak area variance for most recent T_{WA}

Radon Mode Considerations

The SabreBPM² may be configured to operate as a radon progeny monitor, measuring and alarming on PAEC (potential alpha energy concentration) levels of milli-Working Levels (mWL), and dose estimates in mWL-h. Alternatively, if configured for SI units, the instrument will display radon concentration in µJ/m³ and dose estimates in µJ-h/m³.

The PAEC reading is treated as the primary isotope-of-interest and the chronic PAEC dose is shown as the default reading on the instrument (i.e. PAEC/C).

The PAEC is based on the individual radon decay product concentrations as measured off the filter. The beta-decay product Pb-214 is estimated from the concentrations of Po-218 and Po-214 before its contribution to the PAEC can be added. The thoron contributions from Po-212 and Bi-212 are also included in the PAEC result and, when Bi-212 is present, the 6.0 MeV peak counts are corrected for known contributions from Bi-212 before the ultimate energy yield of 13.69 MeV of Po-218 are summed.

While its contribution is not included in the PAEC result, the SabreBPM² does monitor for and report the concentration and dose estimate from Po-210.

SECTION

6

Retrieving & Analyzing the Data

The log files stored on the SabreBPM² on the SD Card or in the My Documents folder may be retrieved and analyzed on a PC, laptop or workstation, either over the USB connection, or over the Ethernet/WiFi network connection. The data can be imported into a spreadsheet or database and saved for future use.

NOTE: This operation can be performed while the SabreBPM² program is running, but it is sometimes preferable to end the dose measurement by exiting the application.

Ending a Dose Measurement

After a dose measurement period is complete, exit the SabreBPM² program by tapping the *File— Close* menu item. The program will terminate and close any open log data files. This should be unnecessary for continuous sampling mode operation.

Note that if password security is enabled, the user will be required to log in before the *File— Close* menu item will be accessible.

PC Syncing Software

To access the data on the SabreBPM², the user must install/enable **the Windows Mobile Device Center** software from Microsoft and then connect the SabreBPM² using the supplied USB cable. The 32-bit or 64-bit versions of WMDC for Vista can be found online on Microsoft.com as a free download (this version is compatible with Windows 7 and Windows 10). Many versions of Windows 7/10 already have the WMDC installed.

Connecting to a PC over USB

To connect to your SabreBPM², plug the **USB sync cable** from the computer to the mini-USB connection on the side of the unit. If the unit is turned on, the SabreBPM² should automatically connect with the computer.

A dialog will automatically pop up that requests to establish a permanent partnership. You do not need to set up the SabreBPM². Click **Connect without setting up your device**.

Once connected, the SabreBPM² will appear under 'Computer' in the File Explorer. Your computer may categorize it as a camera, phone or portable device.
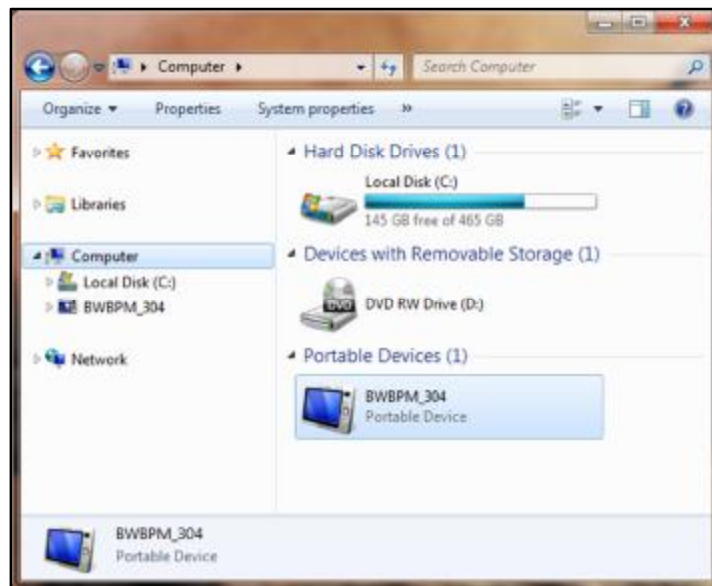
Double click the device icon in the File Explorer to open the files. The Bladewerx folder contains the log files on the SabreBPM² SD Card.

Connecting to a PC over a Network

To connect to your SabreBPM² over a WiFi or Ethernet network, you will need to know the network IP Address of the BPM from your IT staff who set up the instrument on the network. Open File Explorer and in the Network address filed, type in two slashes followed by the IP Address and hit Enter.
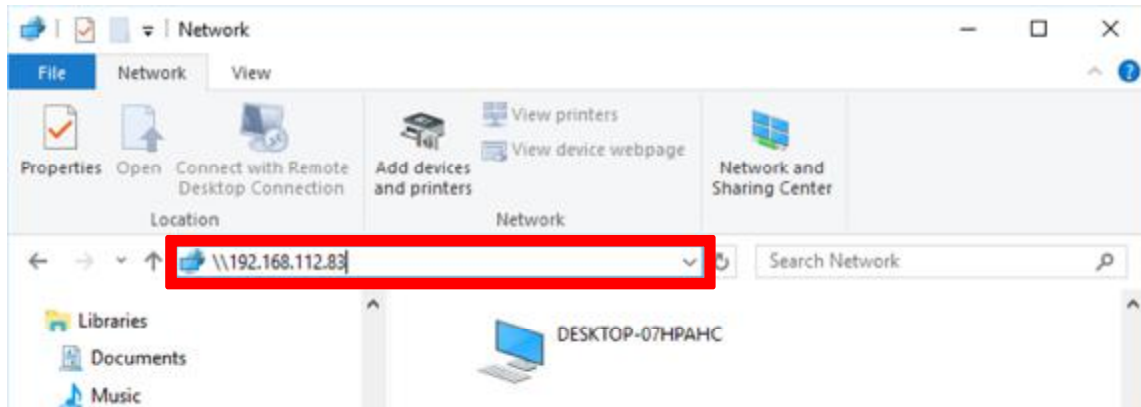
You will be prompted for you login credentials. The default **User name** is **Admin** and the default **Password** **bladewerx**. If you are not able to log in, check with your IT staff to see if they may have defined a different Password.

Once connected, the SabreBPM² shared folders will be displayed in the File Explorer.
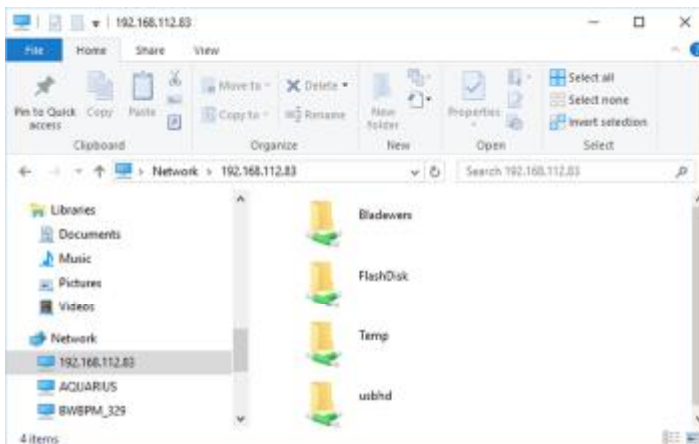
The Bladewerx folder contains the log files on the SabreBPM² SD Card.
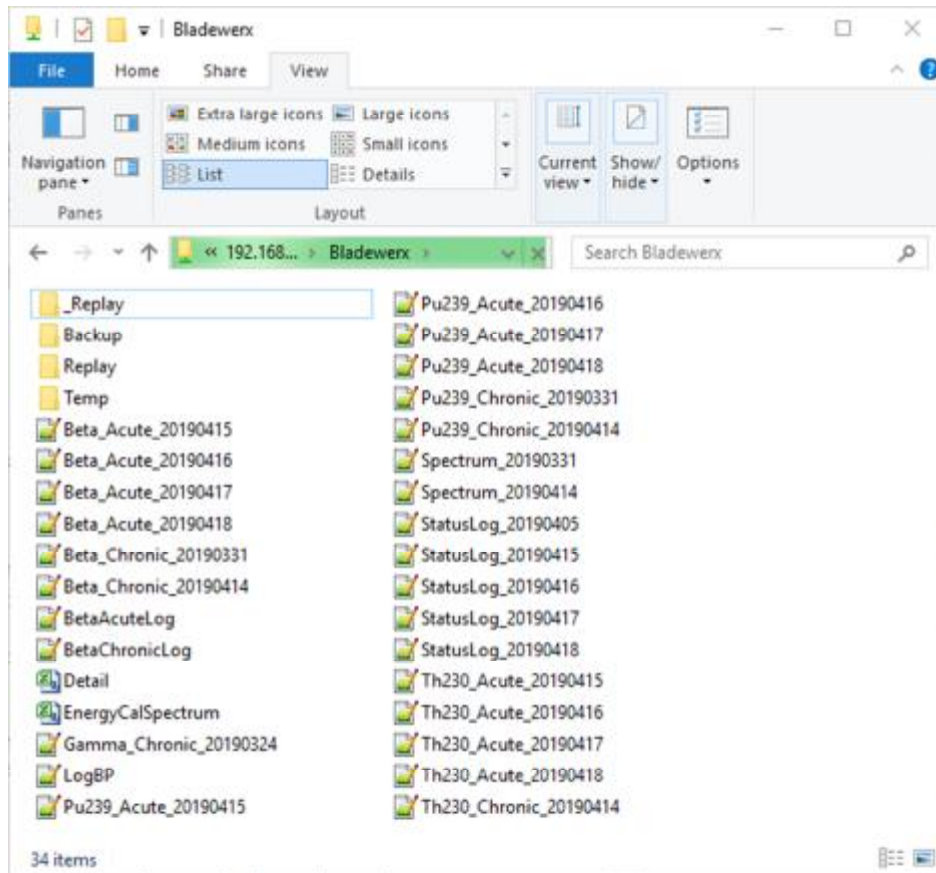
Each log file contains time stamps in the name of the file. They are formatted with YYYY being the year, MM being the month, and DD being the day of the file creation. Each file begins with a header line describing the individual fields. Each subsequent entry in the log files is stamped with the time and date of its creation. The list below describes the files and their contents:

Beta_Acute_YYYYMMDD.txt—This text file contains the log of acute beta readings archived during the SabreBPM² dose measurement period. New acute log files are started *daily at midnight*.

Beta_Chronic_YYYYMMDD.txt—This text file contains the log of chronic beta readings archived during the SabreBPM² dose measurement period. New chronic log files are started *weekly on Sunday morning at midnight*.

Gamma_Acute_YYYYMMDD.txt—This optional text file contains the log of acute gamma Net CPS readings archived during the SabreBPM² dose measurement period. Logging is enabled/disabled on the **Logging** tab of the **Instrument Options** dialog. New acute log files are started *daily at midnight*.

Gamma_Chronic_YYYYMMDD.txt—This optional text file contains the log of chronic gamma Net CPS readings archived during the SabreBPM² dose measurement

period. Logging is enabled/disabled on the **Logging** tab of the **Instrument Options** dialog. New chronic log files are started *weekly on Sunday morning at midnight*.

Pu239_Acute_YYYYMMDD.txt—Implemented in alpha-beta mode, this text file contains the log of acute readings archived during the SabreBPM² dose measurement period. Note: the file name may be different if Pu-239 is not defined as the isotope-of-interest. New acute log files are started *daily at midnight*.

Pu239_Chronic_YYYYMMDD.txt— Implemented in alpha-beta mode, this text file contains the log of chronic readings archived during the SabreBPM² dose measurement period. Again, the file name may be different if Pu-239 is not defined as an isotope-of-interest. New chronic log files are started *weekly on Sunday morning at midnight*.

StatusLog_YYYYMMDD.txt—This text file contains a copy of the readings and status changes logged to the SabreBPM² display during dose measurement. It includes a listing of any alarm and the time at which it occurred, along with chronic and peak acute readings. A new status log files is started *daily at midnight*.

Spectrum_*YYYYMMDD*.txt—These text files contain chronic spectrum snapshots at fixed (user-defined) intervals during the dose measurement period. Part of the filename is a timestamp indicating the year(YYYY), month(*MM*), and day(dd) into the dose measurement when the spectrum was archived. Each line in the file contains a set of peak-fit coefficients, a 255-channel spectrum of raw counts, and a 255-channel spectrum of the cumulative peak fit. A new spectrum log file is started *weekly on Sunday morning at midnight*.

EnergyCalSpectrum.csv—This *comma-separated-variable* format text file contains the last spectrum from the Energy Calibration if it was saved. Files with the *.csv* extension can be opened directly from Microsoft Excel.

In addition to the standard log files, there may be one or more 'debug' log files. These files can be enabled/disabled with a Registry setting. Call Bladewerx Support for details.

BetaAcuteLog.txt—this file includes data used to determine the Acute Net Beta reading from the Gross Beta counts. It is deleted and a new log started when the SabreBPM² application starts.

BetaChronicLog.txt—this file includes data used to determine the Chronic Net Beta reading from the Gross Beta counts. It is deleted and a new log started when the SabreBPM² application starts.

LogBP.txt—this file contains the log of barometric pressure (kPa) and temperature (°C) readings. It is deleted and a new log started when the SabreBPM² application starts.

Once the SabreBPM² log data has been retrieved, you may disconnect the USB cable from the computer to the unit. Disconnecting the USB cable will not affect the operation of the unit nor the files copied or synced.

Graphing data in Excel – Manually

Data can be imported in Microsoft Excel and then manually graphed by following these instructions. Alternatively, the data can be graphed using the Excel templates on your CD, as described in the next section.

- Open a blank spreadsheet and select the *Data tab - Get External Data – From Text*

- Find the beta chronic log file in the folder you synced or copied it to earlier and open it

- Proceed through the Text Import Wizard with these selections: *Delimited – Comma (not Tab) – Date MDY – Finish – OK (=A1)*

- The data can now be graphed as desired

- Save the spreadsheet to preserve the link to the imported data, for refresh later

Graphing data in Excel – with Templates

The **best method** for viewing data is to use the **Excel templates** on your **CD** to graph the data. The customer CD included with your order contains example Excel spreadsheets for displaying Chronic/Acute data and spectrums. They can easily be customized for your needs. There is one main template provided, but your CD may contain more templates depending on the configuration of your unit.

Spectrum Chart

Open the Excel document labeled **Data Charting Template**. You should see a chart of the spectrum, showing mostly the Radon daughter counts in three peaks on the right side. This first chart in the template is called the **Spectrum Animate Chart** which displays the spectrum data over time in a moving graph. You can press the **Animate** button to play the time-lapse graph of the previously imported spectrum data.

Follow the instructions to refresh the template with new data from your unit.

Spectrum Animate Chart
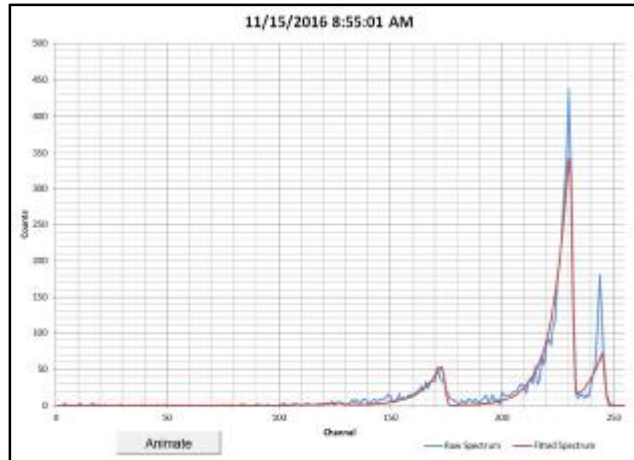
- Click the **Spectrum Data** tab to view the raw data. Click on any cell to begin

- To import new data, select the **Data** menu tab and click **Refresh** (not Refresh All)
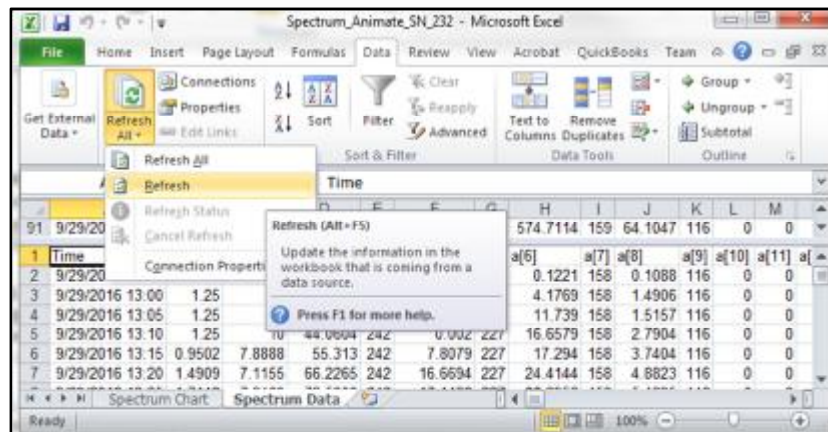
- Navigate to the folder where you synced or copied the log files to earlier. Find the spectrum file labeled Spectrum_*YYYYMMDD* and **import** it.

- Click back to the **Spectrum Chart** tab and press the Animate button again to view the new spectrum time-lapse.

- Double click the **Y-axis** and adjust as needed to keep the whole spectrum in view. A Fixed Maximum value of 500 or 1000 is recommended. Auto is difficult to interpret.

Chronic & Acute Charts

The subsequent tabs are charts for the Acute and Chronic windows for both Alpha and Beta data. You can follow the same instructions as above to refresh the template with new data from your unit. These points are supplemental and may help with instruction:

- Because there are several data tabs, you can either select **Refresh All** from the first data tab and choose the files one after the other *in order*; or select **Refresh** from each tab and choose one file at a time.

- When formatting the **Y-axis**, the whole chart does not need to be in view, as the minimum detectable line will likely be too high in the beginning to achieve good readability of the rest. The chart is best read when the typical readings are within the bottom fifth of the chart. See the example chart below for typical appearance. Once formatted, leave the axis set for better comparisons between data files.

- The **X-axis** may also need to be formatted for different dose measurement lengths. The length in time is automatic but the **major unit** needs to be fixed. For 1 hour increments use 0.04166666, for 2 hours use 0.08333333, for 4 hours use 0.16666666, and for 8 hours use 0.33333333.
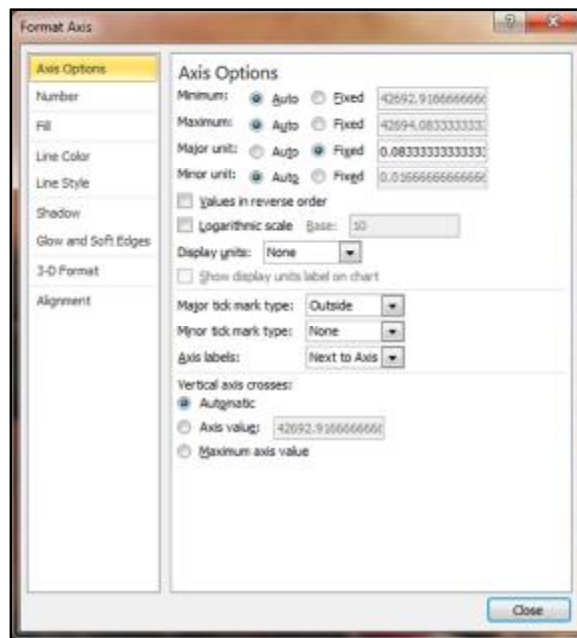
Beta Chronic Chart	Beta Acute Chart

Alpha Chronic Chart

SabreBPM SN_232
Alpha Chronic: 240-minute window

Alpha Acute Chart

SabreBPM SN_232
Alpha Acute: 150-second window
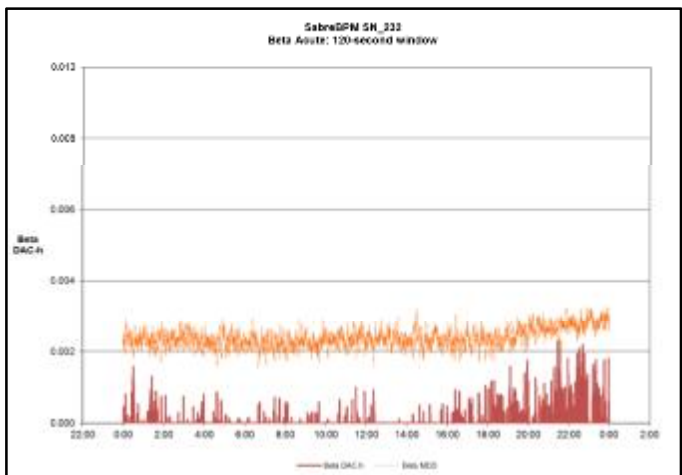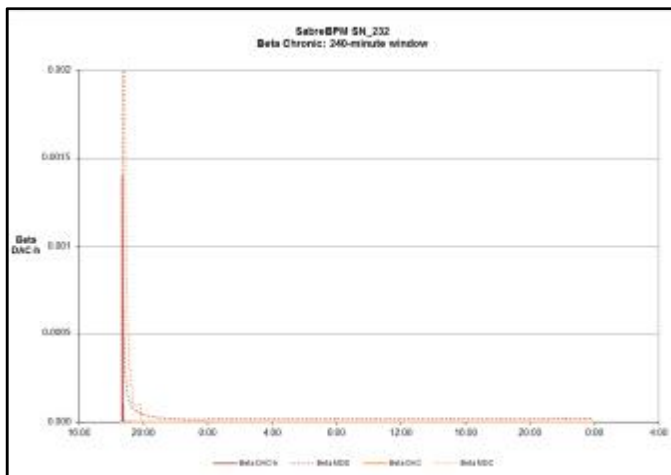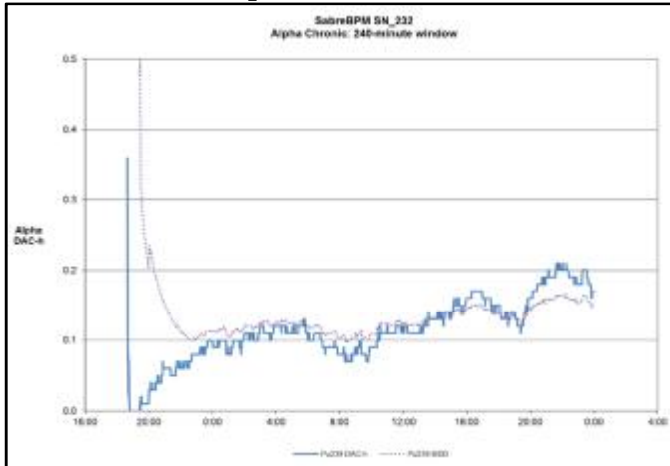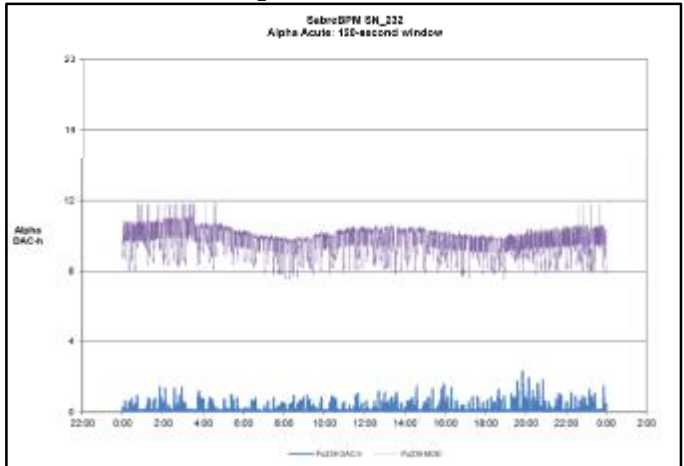
RadNet Operation

General

SabreBPM² units ordered with the WiFi or Ethernet RadNet Output option come equipped with an RJ-45 Connector for connection to a local network, or 802.11b-compatible wireless module and internal antenna, and are configured to allow broadcasting of RadNet measurement and spectrum UDP-packets to the local Class-C Subnet.

These packets may be received and displayed by the **Bladewerx RadNet Client** software, using the default **UDP Port 16367**. When using the WiFi Option, a wireless access point (WAP) is required to receive the transmissions from the SabreBPM² and relay those transmissions either via an Ethernet cable or via a second wireless link to the **RadNet Client** workstation.

The concentration readings and spectrums from up to fifty SabreBPM²s may be displayed on a single **RadNet Client** workstation.

Configuration

SabreBPM²s purchased with the RadNet Output Option come preconfigured for operation with Ethernet or a wireless access point; however, site security requirements may require changes to the setup.

Exact details of the setup are not provided here but sufficient information is included that will enable a network administrator or user experienced in network setup to perform the configuration.

Wireless Access Point Configuration

If a wireless access point (WAP) was also ordered from Bladewerx, an industrial-grade access point capable of extended range operation is provided. Configuration of the WAP is through a web browser. Connect the WAP to the PC using an Ethernet "crossover cable" or a cable into a network hub. The WAP comes pre-configured and includes a configuration certificate.

Wireless Access Point (WAP) Configuration Summary

WAP Brand:	D-Link	Setup Date:	8/20/15
WAP Model No:	DAP-AP2690B1	Login Name:	admin
WAP S/N:	PVF62F1000199	Login Password:	
WAP Firmware Ver:	3.01	Security Profile Name:	N/A
WAP Name:	BWX150820		
Host (WLAN) Side		**Client (LAN) Side**	
Default Gateway:	N/A	IP Address:	192.168.0.50
DHCP Client:	Enabled	Subnet Mask:	255.255.255.0
Starting Address	192.168.0.200	Gateway Address	0.0.0.0
Ending Address	192.168.0.239		
SSID:	Bladewerx	Channel:	Automatic (2.4GHz)
WEP/WPA:	128-bit WEP	Key Type:	Shared
KEY1:	332AF3DF083633478B32DA1BC8		

To change the configuration, run a web browser program and access the WAP by entering the IP address in the address bar, as defined on the configuration sheet on the Client (LAN) Side. When connected, log-on with "admin" as the User. No password is required.

In the event that the WAP no longer responds to the assigned address, reset the WAP back to factory defaults by referring to its manual

RadNet Client Workstation Configuration

In order to communicate with the SabreBPM², the SabreBPM² and client workstation must be configured with compatible IP Addresses in the same Class-C range. Choose addresses that do not conflict with each other.

If the client workstation is operating wirelessly, be sure to set up the SSID of "Bladewerx" and use 128 bit WEP Encryption with the passphrase "Password" or the hex key **332a f3df 0836 3347 8b32 da1b c8**.   Other encryption schemes are supported, including WPA and WPA2.

Section

8

ASCII Operation

General

SabreBPM² units ordered with ASCII Output options broadcast data clear text data every minute for reception by plant monitoring systems via a serial RS-232 link, Ethernet, or a 802.11b/g WiFi link. Regardless of the transport method, these messages may be received and processed by any of a number of common plant data acquisition systems.

Instruments configured for the **RS-232 ASCII Output** option typically require a network translator device to relay the RS-232 information onto a plant-wide TCP/IP network.

Units ordered with the **Wireless ASCII Output** option come equipped with an 802.11b/g compatible wireless module and antenna for wirelessly broadcasting the ASCII log data. A wireless access point (WAP) is required to receive the transmissions from the SabreBPM² and relay those transmissions either via an Ethernet cable to a network workstation, or via a second wireless link to the workstation.

Units ordered with the **Ethernet ASCII Output** option may be plugged directly into a network port with a Cat5 or Cat6 cable.

Configuration of RS-232 Connections

The serial RS-232 port on the SabreBPM² is a 2-wire output-only serial connection using an RJ-9 connector (TXD, GND signals). Terminal emulators should be configured for 19,200 baud, 8 data bits, no parity, and 1 stop bit (19,200 bps, 8, N, 1).

RJ-9 Pin-out	Name	Function
1 & 4		No Connect
2	TXD	Transmit from unit
3	GND	Signal ground

Configuration of Wireless Connections

The SabreBPM² with the **Wireless ASCII Output** option includes an 802.11b/g WiFi module and antenna. Configuration of this is covered in Section 8 on the **WiFi RadNet Option**.

Standard Log Data Format

The log data is reported in comma-delimited format. Each channel is transmitted in a string of data, with multiple strings each minute depending on the unit configuration. The text fields are terminated with a <cr><lf> sequence. Below is an example of 1 minute of strings.

BWBPM_304, 68551.00, Am241/C, 0, 0.0054, 0.0000, 0.0275, 0.0030, 5.87, 6703.4, 04711

BWBPM_304, 68551.00, Beta/C, 0, 0.0000, 0.0000, 0.0000, 100.0000, 5.87, 6703.4, 04805

The following header describes the fields.

Name	Time	Chan	Status	Concen	MDC	Dose	MDD	Flow	Volume	Checksum

Where,

Name is a string which uniquely identifies the instrument (BWBPM_304)

Time is the elapsed time in seconds since the filter was changed or the instrument reset

Chan is the name of the channel (e.g. Pu239, PAEC, ROI_1, BETA, GAMMA)

Status is an integer value as follows:

Initializing	-1	Alarm_High	18	Fail_Det	32	Fail_Poor_Fit	36
Normal	0	Flow_Low	24	Fail_Low_Batt	33	Fail_Flow	37
Standby	40	Flow_High	25	Fail_Int_Comm	34	Fail_Calib	38

Concen is the derived airborne concentration in units of DAC (floating point)

MDC is the minimum detectable concentration in DAC (floating point)

DAC-h is the estimated worker dose in units of DAC-h (floating point)

MDD is the minimum detectable dose in units of DAC-h (floating point)

Flow is the sample flow rate in liters per minute

Volume is the total sampled volume since filter change/reset in liters

Checksum is a 16-bit Checksum calculated on the characters of the string up to, but not including, the last comma. Calculation is modulo-65,536 (2-byte unsigned integer).

Each single-line record contains the log data for one channel, depending on the instrument type and configuration. All units will include the beta information. Units with the Alpha option will include the IoI 1 information, and if the unit has a second IoI defined, it will include the IoI 2 information. Each data record will appear on a separate line.

Appendix

I

Status Conditions

Status	Description
INITIALIZING	SabreBPM² program initialization (momentary status)
NORMAL	Operating normally, alarm levels below limit
HIGH	Dose or Concentration set point has been exceeded
LO FLOW	Flow rate is below Low Limit
HI FLOW	Flow Rate is above High Limit
FLOW FAIL	Flow Rate is below Fail Limit
DET FAIL	No counts received from detector in 15 minutes
LOW BATT	Battery level is below 25%
MCA FAIL	No communications with SabreMCA
POOR FIT	Could not fit the spectrum with the defined isotopes. Possible unknown isotope.
OUTOFCAL	Calibration has expired

| OVERRANGE | The detector is receiving too high a count rate to process. This is a failed condition. |
| STANDBY | Instrument is in a calibration dialog. |

Appendix

Network File Access

When enabled at the factory, the SabreBPM/Alert Ethernet and WiFi communications provide remote access of log files without using the USB Windows Mobile Device Center connection. File sharing has been enabled on the SabreBPM/Alert so that instruments accessible on the network can be accesses from Windows File Explorer.

Open a File Explorer window and type the following in the address bar, substituting the actual IP Address of the instrument for the "192.168.0.32" in the following example:

\\192.168.0.32**Bladewerx**\

When prompted for a Username and password, enter **ADMIN** for the username and **Bladewerx** for the password.

When connected to the instrument you should see the files appear in Explorer.
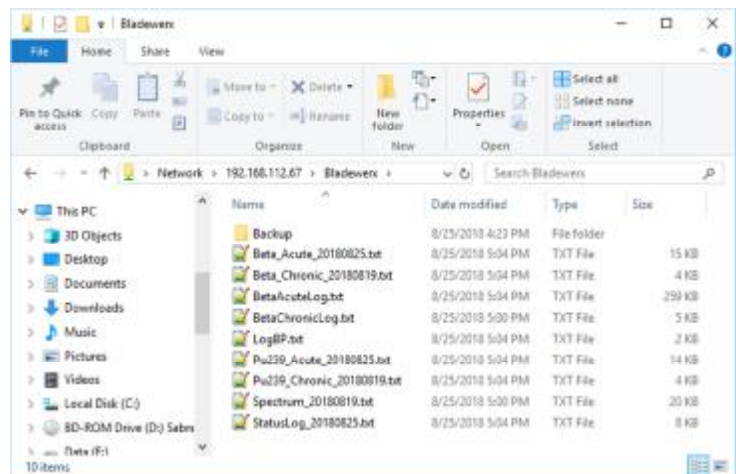
Troubleshooting

On Windows 7 and Windows 10, Connections may fail. The following description will fix the problem in most cases:

> The default security settings of Windows Vista and Windows 7 block the login into the Colibri's web interfaces.
> In order to enable the access, the security policy for NTLMv2 needs to be changed:

1. Start -> Run
   `secpol.msc`
2. Go to
   `Local Policies` -> `Security Options`
3. Edit the properties of the Policy
   `Network security: LAN Manager authentication level`
4. Change the level to
   `Send LM & NTML -use NTLMv2 session sec if negotiated`
5. Reboot your operating system

In addition, the firewall settings may need to be changed on your PC. Try disabling the Anti-Virus/Firewall for a few minutes to see if the connection can be established. If so, then the AV/Firewall settings are causing the problem.

Remote Administration

The use of logon credentials and security on the Sabre can be administered through a web page.

The Remoteadmin (Windows CE Remote Management Tool) allows you to

- share files and printers
- manage user accounts.

To access RemoteAdmin, open your web browser and type the following address:

"http://[sabre ip address]"

or

"http://[sabre ip address]/remoteadmin/"

Enter the password **Bladewerx**. This action enables the user **admin** and it can be used in further sessions of remoteadmin, webadmin, telnet etc.

For any further accesses to the RemoteAdmin page, you will be asked to log in:

The RemoteAdmin client allows the changing of the password, the addition of users and setting file sharing permissions.

Technical References

There is a web interface on a PC connected to the SabreAlert to help set up shared folders and file sharing:

https://developer.toradex.com/knowledge-base/webinterface

On the SabreBPM/Alert you can enable authentication.

```
[HKEY_LOCAL_MACHINE\Services\Smbserver\Shares]
    "UseAuthentication"=dword:1
    "NoSecurity"=dword:0
```

https://stackoverflow.com/questions/39689835/smb-filesharing-on-windows-ce-6

Editing the Alpha Isotopes Database

The alpha isotopes that appear in the drop down lists for selection as the Iso 1 and Iso 2 isotopes-of-interest are taken from a comma-delimited text file on the FlashDisk/User folder on the SabreBPM². This file **Isotopes.csv** is user-editable from a text editor like the *Windows Notepad*, or from *Microsoft Excel*.

	Isotope	keV	Halflife	DACfac	AlarmConfig	AcuteDoseAlm	AcuteRateAlm	ChronicDoseAlm	ChronicConcenAlm
2	Cm244	5800	5.72E+08	9.00E-03	1540	2.00E+02	1.00E+03	2.00E+01	1.00E+03
3	Am241	5480	1.36E+10	2.22E+02	1540	2.00E+02	1.00E+03	2.00E+01	1.00E+03
4	Pu238	5490	2.77E+09	6.00E-03	1540	2.00E+02	1.00E+03	2.00E+01	1.00E+03
5	Po210	5305	1.20E+07	1.00E+00	1540	2.00E+02	1.00E+03	2.00E+01	2.00E+01
6	Pu239	5150	7.61E+11	5.00E-03	1540	2.00E+04	1.00E+03	2.00E+04	1.00E+03
7	U234	4760	1.00E+15	7.00E-02	1540	2.00E+02	1.00E+03	2.00E+01	1.00E+03
8	U235	4380	1.00E+15	8.00E-02	1540	2.00E+02	1.00E+03	2.00E+01	1.00E+03
9	U238	4180	1.00E+15	8.00E-02	1540	2.00E+02	1.00E+03	2.00E+01	1.00E+03
10	MixedU	4300	1.00E+15	8.00E-02	1540	2.00E+02	1.00E+03	2.00E+01	1.00E+03
11	Th230	4680	2.43E+12	3.00E-03	1540	2.00E+01	1.00E+03	8.00E+00	8.00E+00
12	Th232	3990	2.22E+16	3.00E-03	1540	2.00E+02	1.00E+03	2.00E+01	2.00E+01
13	Source	4950	7.61E+11	5.00E-03	1540	2.00E+04	1.00E+03	2.00E+04	1.00E+03
14	ROI_1	3.6E+08	1.00E+15	5.00E-03	1540	2.00E+01	1.00E+03	2.00E+01	2.00E+01
15	ROI_2	2.62E+08	1.00E+15	8.00E-02	1540	2.00E+01	1.00E+03	2.00E+01	2.00E+01
16	PAEC	0	1.00E+10	2.00E-01	1540	8.00E+02	1.00E+03	2.00E+02	2.00E+01

The columns are as follows:

Isotope—this defines the name which is used for the display and log files. It can be at most six characters. The Source entry is for a user-defined source isotope.

> **ROI_1 and ROI_2 are dedicated to the region-of-interest mode and the names or values must not be changed.**

> **PAEC is for the radon mode operation. Its name or values should not be changed.**

keV—this column defines the average alpha energy of the isotope

Halflife—this field specifies the halflife in minutes

DACfac—this field is the DAC Factor used to convert from pCi/l to DAC (e.g. 0.005 pCi/l = 1 DAC)

AlarmConfig—this field defines the allowable alarms for the isotope. It should be set to **1540** in all cases.

Alarms—these four columns define the alarms in DAC and DAC-h. Typical default alarm levels are 200 DAC-h and 1000 DAC for the Acute and 20 DAC-h and 100 DAC for the Chronic. **These values are updated from the SabreBPM² application when changed under the Alarm Settings dialog.**

When editing is completed, save the file again with the same name (Isotopes.csv). **Do not save it in Excel format!**

Appendix

IV

Iodine and Noble Gas Monitoring

The SabreBPM can effectively monitor for I-131 or noble gasses when carbon-impregnated filters are used as the collection medium. In most cases a second SabreBPM is used in the upstream air-sampling path to remove most particulates (especially radon decay products)—and to monitor for any beta particulate isotopes. The following diagram illustrates the typical dual-SabreBPM configuration.
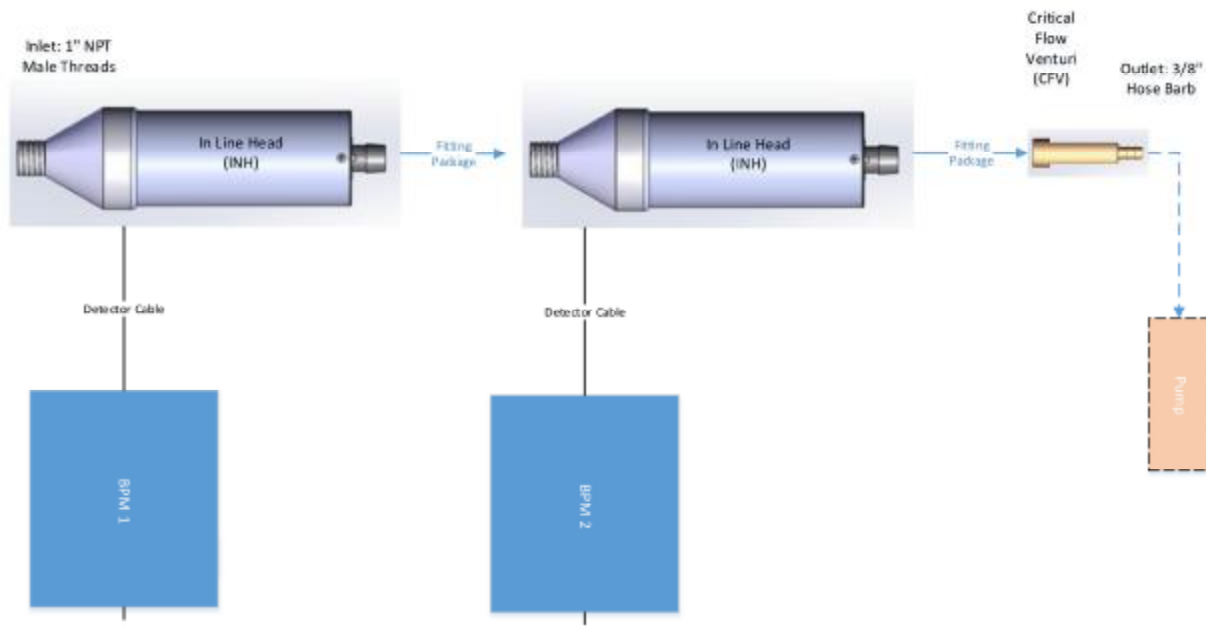
In this example, the SabreBPM_1 would be the particulate CAM and SabreBPM_2 would be the Iodine CAM. External pumps are almost always used in a dual-CAM configuration. The Iodine CAM may be set up with a carbo-impregnated filter only, or with a *Spedan*™ filter on top of the carbon-impregnated filter in high radon areas.

The SabreBPM²'s Sensitivity to Iodine-131

The decay scheme of Iodine-131 (I-131) includes a 606 keV and 637 keV betas with 89% and 7% abundance respectively, which the SabreBPM can readily detect. Depending on the beta threshold setting, the SabreBPM has a typical efficiency for Sr/Y-90 (546 keV and 2.28 MeV max beta energy) of 12-18% (4-Pi) with a bare source and 11-15% with a 1.5 micron filter on top of source. Since the SabreBPM detector depletion depth of 300 μm has a fairly flat energy response above 500 keV, the counting efficiency to I-131 can be expected to be similar to that of Sr/Y-90.

Configuring the SabreBPM for Iodine Monitoring

The SabreBPM is made sensitive to Iodine in gaseous form by passing the gas through a carbon impregnated filter paper to absorb and retain I-131. This filter is placed in the sampling head in place of the normal particulate filter.

In this configuration, background-compensated beta counts will be reported as I-131. The SabreBPM background compensation algorithm automatically corrects the gross beta reading for radon, based on a spectral analysis of the alpha spectrum.

When to Use a PTFE Filter Together with the Carbon-Impregnated Filter

Even in configurations where a particulate monitor is installed upstream of the Iodine CAM, a fraction of radon decay products will pass through the upstream particulate filter and be captured by the carbon-impregnated Iodine filter, causing a smeared alpha spectrum. In most cases, the radon compensation algorithm will effectively subtract the beta background from RDP-emitters from the I-131 measurement.

As long as the alpha counts due to radon decay products are small, the peak fit algorithm will perform radon compensation acceptable, however, in high radon background situations—or when not configured with an up-stream SabreBPM to remove alpha/beta particulates from the airstream prior to reaching the Iodine monitor —placing a *Speclon* particulate filter paper over the carbon filter will provide the ability to monitor for I-131 in air while improving compensation for radon background. The *Speclon* pre-filter will produce greatly improved RDP resolution and hence radon compensation.

Both the carbon impregnated filter and a standard membrane type filter can be installed simultaneously in the SabreBPM radial entry head with no modifications to the head (small adjustments to the filter holder retaining screws may be necessary).

The additional filter will cause increased pressure drop on the system and the flow rate should be checked to verify that the Critical Flow Venturi is still regulating to approximately 2 CFM.

Filter Ordering

- Standard *Speclon™* PTFE membrane-type filters are available from Bladewerx, part number BSP-FILT-15B037, 37mm diameter 1.5 μm *Speclon 1.5* filter. When used with an external pump where the flow rate is in excess of 20 LPM, BSP-FILT-50B037, 37mm diameter 5 μm *Speclon 5* filter should be used. To ensure good resolution alpha spectrums, PTFE membrane-type media should be used.

- Carbon impregnated filters (37mm diameter) are available from Bladewerx, part number BSP-FILT-CB037, or from Hi-Q Environmental Products Co., part number FPACI-37. For this media at flow rate of 1 CFM, the Iodine retention efficiency is approximately 90%. At a 2 CFM flow rate, it is approximately 85%.

Appendix

V

Specifications

Sampling Head and Flow

- § 37 mm Filter holder masked to 25 mm collection diameter
- § Detector: Solid-state silicon 300-µm-depleted (450 mm² active area)
- § Pump: diaphragm-type, 7.0 LPM with no load

Beta Data Analysis

- § Dual threshold (beta with alpha cutoff) gross counting board
- § Fixed background subtraction with subtraction factor
- § Optional guard detector subtraction with subtraction factor
- § Radon background subtraction with subtraction factor
- § Acute (fast response) and Chronic (high sensitivity) dose determinations
- § Typical 15% efficiency for SrY-90, 8% for Tc-99

Alpha Data Analysis

- § MCA: 1024-channel analyzer binned to 256 channel spectrum
- § Alpha Peak-shape-fitting algorithm
- § Po-212, Po-214, Po-218, (optional one or two isotopes-of-interest or regions-of-interest)
- § Acute (fast response) and Chronic (high sensitivity) dose determinations
- § Typical 28% efficiency for Pu-239

Physical

- § Battery powered: 7.2V Lithium-Ion, 6.6Ah
- § Weight: 8.3 lbs (3.8 kg)
- § Dimensions: (W x H x D) 10 x 12 x 5 in.
- § Temperature: 0 to 122 °F (-17 to 50 °C)