

SabreBZM Operations Manual



BLADEWERX

SabreBZM Operations Manual

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Table of Contents

TABLE OF CONTENTS	2
GETTING STARTED.....	4
THE PARTS OF THE SABREBZM	4
CHARGING THE BATTERIES	4
IMPORTANT NOTICE CONCERNING BATTERY CHARGING CONSIDERATIONS AND PROGRAM VOLATILITY	5
TURNING THE UNIT ON	6
STARTING THE SABREBZM PROGRAM	6
CALIBRATION	8
ENERGY/EFFICIENCY CALIBRATION	8
<i>Spectrum Display</i>	10
<i>MCA Calibration</i>	10
<i>Peak Location Adjustment</i>	10
<i>Efficiency Calibration</i>	11
<i>Confirm Radon Peak Locations</i>	11
FLOW CALIBRATION	12
<i>Setup</i>	12
<i>NOTE: Ensure that the variable flow restriction does not completely cut off the airflow to the pump. The pump is not designed to operate at zero flow and the high vacuum could damage the pump diaphragm.</i> <i>Three Point Flow Calibration</i>	13
<i>Validation of Flow Calibration</i>	15
<i>Reassemble the Detector Head</i>	15
CALIBRATION EXPIRATION	15
CONFIGURATION	16
USER INTERFACE PROPERTIES	16
INSTRUMENT OPTIONS	17
<i>General Page</i>	17
<i>Logging Page</i>	18
<i>Isotope Page</i>	18
<i>Alarm Settings Dialog</i>	19
<i>Flow Page</i>	20
<i>RadNet Page</i>	20
STARTING A DOSE MEASUREMENT	22
RESPONSE CHECK ROUTINE.....	22
<i>Running the Response Check</i>	22
DOSE MEASUREMENT	24
<i>Operational Duration</i>	24
DOSE MEASUREMENT REPORTING.....	25
<i>Displaying Readings</i>	25
<i>Voice Annunciation</i>	25
<i>Activity, Concentration and Dose Calculations</i>	26
<i>Minimum Detectable Activity, Concentration and Dose</i>	27
ENDING A DOSE MEASUREMENT	29
RETRIEVING AND ANALYZING THE DATA	30
<i>Installing and Using Microsoft ActiveSync</i>	30
<i>Log Files Stored on the PocketPC</i>	30
<i>Importing the data into Microsoft Excel</i>	32
WIRELESS RADNET OPERATION.....	33
<i>General</i>	33
<i>Configuration</i>	33
SABREBZM STATUS CONDITIONS	38
SPECIFICATIONS	39

Getting Started

The Parts of the SabreBZM

The SabreBZM consists of a padded belt pack containing the electronics, battery and pump assemblies, and a detector head containing the detector, preamp, and a filter holder. An umbilical connects the detector head to the belt pack and protects the detector cable and vacuum line.

In the belt pack are two compartments, one for the pump, battery and SabreMCA multi-channel analyzer electronics, and a smaller compartment for the PocketPC.

In addition to the SabreBZM itself, the package contains an AC Adapter, a flow calibration fixture (the mating half to the filter holder), ear bud, a Sync cable and Software CD.

Charging the Batteries

Before the SabreBZM may be operated, the Lithium-Ion batteries—both the main battery and the battery in the PocketPC—must be fully charged. Both batteries can be charged by plugging the AC Adapter into a wall socket and plugging the power cord through a grommet in the side of the SabreBZM case and into the socket of the SabreMCA case. When the LED on the top of the SabreMCA is red, the battery is being charged. When the LED is green, the batteries are charged and the charger may be removed. The charging time is approximately 3 hours. After a full discharge, two charge cycles may be required.

When in operation, the main battery in the SabreBZM supplies power to the PocketPC keeping the PocketPC battery fully charged. However, the PocketPC can be charged separately from the SabreBZM using the separate AC Adapter and Sync cable provided.

NOTE: Don't confuse the PocketPC AC Adapter with the larger AC Adapter for charging the SabreBZM main battery. These chargers are not interchangeable!

To charge the PocketPC separately, unplug the SabreMCA cable from the PocketPC (press both side locks to disengage the connector) and remove the PocketPC from the SabreBZM. Plug the PocketPC AC Adapter into an AC outlet (115 VAC only). The other end plugs into the sync Cable connector, which then plugs into the PocketPC. Charge the PocketPC for two hours or until fully charged. Once charged, return the PocketPC to the SabreBZM and plug the MCA cable back in. *Both the PocketPC and the SabreBZM should be off when connecting the cable.*

Important Notice Concerning Battery Charging Considerations and Program Volatility

The SabreBZM has a rechargeable high-capacity battery that is used to power all functions including the pump, the SabreMCA, and the PocketPC. The PocketPC also has a built-in rechargeable battery that is recharged from the SabreBZM AC adapter (if the SabreBZM is connected to AC for recharging) or the high-capacity battery. The high capacity battery keeps the PocketPC internal battery charged whether or not the SabreBZM is turned on—indicated by a Red/Green LED on the PocketPC.

Some PocketPC models draw relatively high current even when turned off and, depending upon the specific PocketPC model, will discharge the high capacity battery in as few as 2 days or may take as long as two weeks. It is recommended that you keep the SabreBZM plugged into its battery charger when it is not in use. If the SabreBZM is to be stored for more than a few days without being connected to the battery charger, disconnect the PocketPC cable prior to storage to prevent the PocketPC from discharging the high capacity battery.

The BZM program and all configuration settings are maintained in the PocketPC's battery-backed internal memory. Should the PocketPC battery become discharged, this information is lost and must be re-loaded. Each BZM is shipped with a non-volatile SD memory card that is non-volatile and does not lose its memory when the PocketPC battery becomes discharged. This makes re-loading the BZM program and configuration settings simple and quick.

Turning the Unit On

With both batteries fully charged, you are now ready to turn the SabreBZM on. A switch located on the top of the SabreMCA turns on the power to the SabreBZM.

With the switch in the ON position, the pump will start and the PocketPC display will illuminate. If the PocketPC display is blank, press the small power button above the display.

Starting the SabreBZM Program

To start the SabreBZM program, remove the PocketPC stylus and tap the Start menu in the upper left corner of the screen. The Start Menu in Figure 1 will drop down listing the Bladewerx SabreBZM menu item. Tap the SabreBZM item to start the program.

NOTE: Once the SabreBZM program is running, you will not be able to perform any other PocketPC operations like running other applications or changing display or speaker volume settings. To change any settings or run other applications, close the SabreBZM program first.

The battery is checked on startup and if it is not fully charged (i.e., >90%), the program will prompt you whether or not to continue. Note that the battery level monitored is the main SabreBZM battery, not the PocketPC's internal battery.



Figure 1

The Response Check dialog is the first screen to be displayed after starting the SabreBZM program. The Response Check function will be covered later in this manual. For now, and until the SabreBZM is fully calibrated, tap the Cancel button to skip the Response Check.

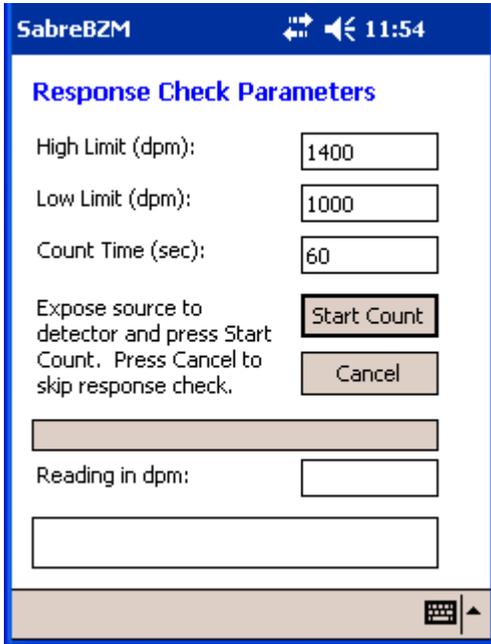


Figure 2

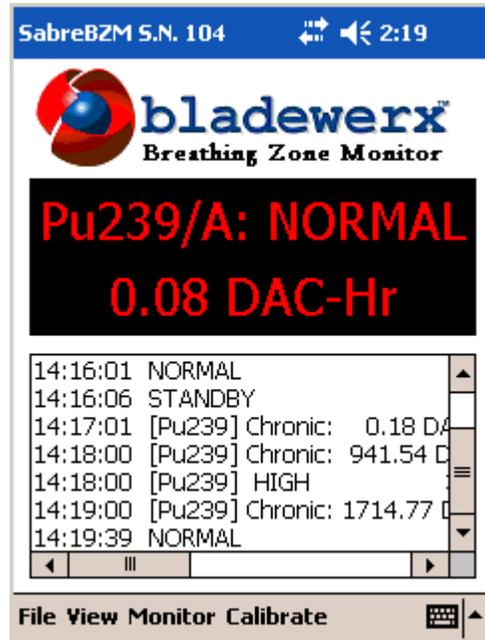


Figure 3

Figure 3 shows the basic display for the SabreBZM. It includes a digital meter display in the upper half of the screen and a log entry display in the lower half. The digital meter displays the current data and status of the selected isotope. The isotopes monitored by the SabreBZM are short-lived radon daughters: Po-214 and Po-218; and one additional isotope of interest—usually Pu-239. A suffix character is appended to the isotope name to denote the detail of the reading: Acute (/A) or Chronic (/C).

Toggle the currently displayed isotope by pressing the large Navigation Button at the bottom center of the PocketPC Up or Down. Toggling the Navigation Button side to side will display the current reading in different units (e.g. pCi, cps, DAC-Hr).

The log entry display in the lower half of the screen shows the list of Chronic readings for the isotope of interest, logged once a minute. You can scroll the list up and down, and also sideways to display additional information like the peak acute readings and minimum-detectable levels. Battery charge level is included at the end of the line in the log (e.g. "Batt.: 86%").

A menu bar across the lower left-hand portion of the screen provides access to the various configuration settings and other information. These menu items will be covered in detail later in this manual.

Calibration

To maintain accurate measurements of the isotope-of-interest, the SabreBZM must be calibrated periodically. The purpose of calibration is to insure that the peak-fitting algorithm knows where in the spectrum to expect the isotope peaks. The peak-fitting algorithm will fail (causing a POOR FIT status) and the instrument will fail to alarm properly if the peaks do not appear in the expected locations.

The calibration functions are accessed from the Calibration item on the SabreBZM menu. There are two steps to calibrating the SabreBZM: energy/efficiency calibration and flow calibration.

NOTE: The Pu-239 energy calibration step should always be performed before doing the efficiency calibration.

Energy/Efficiency Calibration

Energy/efficiency calibration consists of:

- Setting the position of the Pu-239 peak with a calibration source. This typically requires adjusting only the offset and the peak locator. The threshold, gain, and scale do not normally require adjustment.
- Adjusting the position of the Po-212 and Po-214 radon daughter peak locators relative to the position of the Pu-239 peak locator.
- Determining the efficiency to a Pu-239 calibration source.
- Running the SabreBZM with filter in place for four to eight hours so that a radon daughter spectrum is accumulated in order to confirm the radon daughter peak locator positions.

To begin the energy/efficiency calibration, tap *Calibration – Energy...* on the menu. The Energy Calibration dialog will be displayed showing the energy calibration settings and a window of the spectrum.

Internally, the SabreMCA utilizes a 1024-Channel discriminator, whose output can be translated to the 256-channel MCA output through four configuration settings. The four fields at the top of the screen, Gain, Thresh, Offset and Scale, control the translation of the SabreMCA discriminator

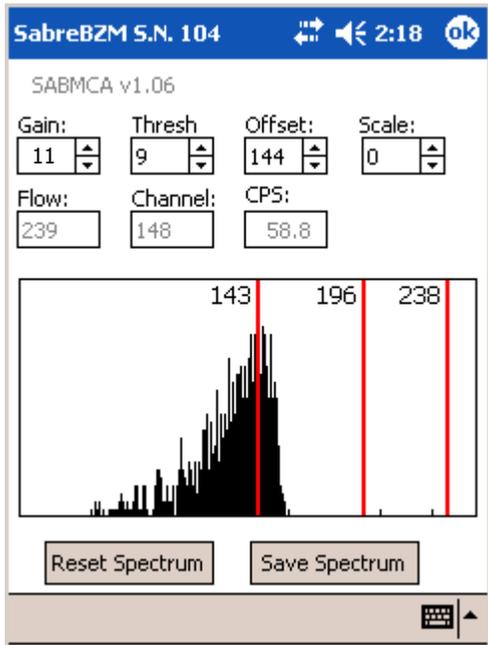


Figure 4a

output and affect the location, width, spacing and offset of isotope peaks on the 256-channel spectrum. These values are stored permanently on the SabreMCA board and in most cases do not need to be changed from the factory settings. Changing any of the four values will result in new values being permanently stored on the board.

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. Shifting to the next Scale will bring the peaks back into view on the spectrum. *Default Gain is 11 and should not normally be changed.*

Thresh—(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 4.*

NOTE: As Gain is increased, the noise amplitude will increase proportionally, requiring a compensating increase in Threshold level.

Scale—(Range 0 to 2) This value controls the binning or compression of the 1024-channel discriminator output into the 256-channel spectrum value. A value of zero results in no compression. A value of one does 2:1 compression, binning 512 channels of the discriminator output into 256 spectrum channels. A value of two does 4:1 compression, binning all 1024 channels of the discriminator output into 256 spectrum channels. *Default Scale is 0 and should not normally be changed.*

Offset—(Range 0 to 255, Resolution 8 channels) This value shifts the 256-channel spectrum the defined number of channels to the left. It is related to the Scale setting by controlling the 256-channel window on the scaled discriminator output. If the Scale is zero, the Offset will allow the output of any consecutive 256 channels, from discriminator channel 1 to channel 512. If the Scale is one, Offset will allow the display of any 512-channels over the 1024-channel discriminator range (binned down to 256 spectrum channels). If the Scale is two, the

Offset has no effect and the entire 1024-channel discriminator output is compressed 4:1 to the 256-channel spectrum. *Default Offset is 136, the value should typically be 128, 136, or 144.*

Spectrum Display

The lower half of the display shows the current spectrum from channel 25 through channel 255 (the lower 25 channels are not displayed due to screen limitations). The vertical scale adjusts automatically to display the highest peak.

Three red lines (left to right) identify the locations where the isotope-of-interest peak, and the Po-218 and Po-214 radon-daughter peaks are expected. The numbers at the top of each red line correspond to the channel number that the line identifies as the peak location.

NOTE: For the purposes of this manual, the source isotope will be identified as Pu-239, however, if a different isotope-of-interest is selected, the source used should match the isotope selected.

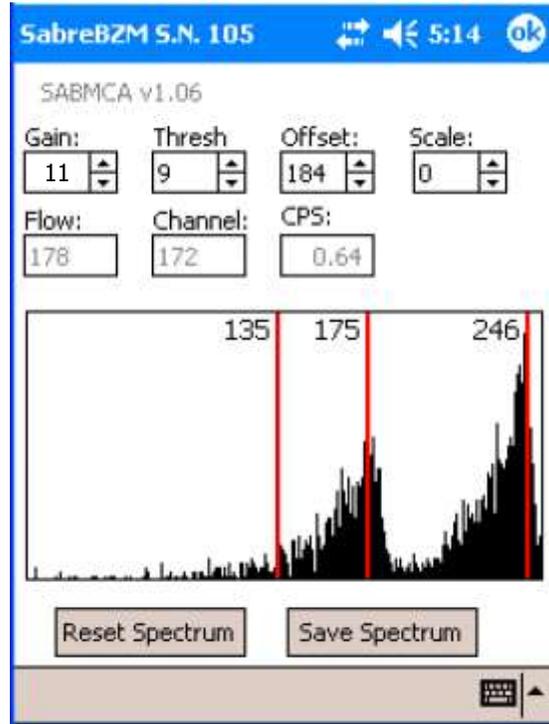


Figure 4b

MCA Calibration

Begin the calibration by removing the filter holder and placing a Pu-239 source under the detector so that the peak builds up near mid scale. If an adjustment is necessary, you may reset the spectrum by tapping the *Reset* button so that changes to the Offset or Gain may be observed more accurately. The Gain, Threshold, Offset and Scale settings interact such that the Pu-239 peak is approximately mid-scale and the Po-214 peak (7.69 MeV) is just below max scale so that the saddle between the Po-212 (8.78 MeV) and Po-214 is in channel 255. In most cases, the default values for Gain and Scale should not be changed from the defaults listed previously.

Peak Location Adjustment

Adjust the offset setting so that the Pu-239 peak is close to channel 134. Note that the offset setting can only be adjusted to one of the following values: 176 or 184 or 192. If none of these offset settings put the Pu-239 peak within the range of 130 to 142, the gain or scale settings could be set inappropriately, or the unit could need repair.

Peak location is performed by adjusting the red lines on the spectrum display to coincide with the actual peak locations. Move the lines by tap-and-holding the stylus on the line until a circle of red dots appear, then dragging the line to the new location. Set the lower reference line on the Pu-239 peak ensuring that it is in the range of 130 to 142. Set the upper two reference lines to coincide with the Po-218 and Po-214 peaks mathematically as the Pu-239 peak location plus 43 and plus 104. Typical values are Pu-239 in channel 134, Po-218 in channel 177 and Po-214 in channel 237. Due to different Pu-239 source attenuation (i.e. energy absorption), these values may vary slightly.

When the red peak locating lines have been set, tap the ok button to exit the energy calibration dialog. A prompt will require confirmation of the changes at which time the three peak locations for peak-fitting are saved on the PocketPC and the MCA configuration settings are saved on the SabreMCA.

Tapping the Save Spectrum button will save the spectrum in the \My Documents\ folder under the name "EnergyCalSpectrum.csv". Early versions of the software named the file "Spectrum.csv" and stored it at the root of \My Device\. All the SabreBZM-generated files are saved together and updated to a PC during an ActiveSync synchronization.

Efficiency Calibration

To begin the efficiency calibration, tap *Calibration - Efficiency...* on the menu. The Efficiency Calibration dialog will be displayed showing the current efficiency.

To perform the efficiency calibration, a stainless steel Pu-239 source of active diameter of 1.00 inch should be used. A source of at least 10,000 dpm should be used for the calibration.

Enter the source activity in dpm into the *Activity in DPM* edit field.

Now, place the source under the detector, maintaining its distance from the detector the same as the distance of the filter from the detector. The source should be centered on the detector.

Tap the *Start Calibration* button to start the measurement. The routine will perform a count, peak-fitting just the counts under the isotope-of-interest peak (Am-241 in-growth is ignored), and display the Net CPM and calculated 4-Pi Efficiency. When the count completes, the final calculated efficiency will be displayed. Depending on the source quality and active area, an efficiency between 25 and 32% should be expected.

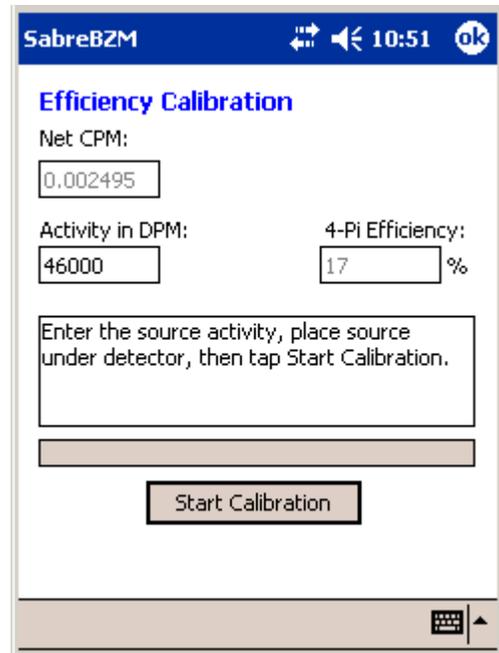


Figure 5

Repeat the calibration if desired or remove the source and *Close* the Efficiency Calibration dialog, responding to the confirmation prompt to save the new setting. Once the Pu-239 peak is in position, efficiency calibration should be performed.

Confirm Radon Peak Locations

Remove the source, replace the filter holder (with a filter in place) and let the SabreBZM accumulate a radon spectrum so that the Po-218 and Po-214 peaks are easily identifiable.

To confirm the radon peak locations (which were set previously mathematically relative to the Pu-239 peak location), reset the spectrum and start a four- to eight-hour radon spectrum accumulation.

Note: It is very important to reset the spectrum prior to starting the new four-to-eight hour radon spectrum accumulation. This will allow the best viewing of new radon daughter counts.

The entire Po-214 peak should be visible and appear just below the upper end of the spectrum. Adjust Po-218 and Po-214 peak locators to match the actual peak locations. This should not require more than an adjustment of plus/minus 6 channels.

NOTE: The high energy Po-212 peak should not be visible in the spectrum window.

Flow Calibration

The SabreBZM sample flow is estimated by monitoring the pump current. As the pump works harder, the pump current increases. The SabreBZM program monitors the current and converts the 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.

Setup:

This procedure requires the following:

- Rotameter 0 – 5 LPM
- Tygon tubing
- Variable Restriction device (i.e. clamp, needle valve)
- Flow calibration aid: mating half to the Millipore filter holder



Figure 6

Turn the SabreBZM off and remove the filter holder. Remove the filter and carefully lay the detector head aside, being careful to protect the exposed face of the detector. Plug the provided flow calibration fixture into the filter holder in place of the removed detector head assembly. Using Tygon tubing, connect the mating filter holder portion to the Rotameter. Next, connect the variable restriction device on the inlet side of the Rotameter, so as to maintain the Rotameter at the same pressure as at the filter holder.

NOTE: Ensure that the variable flow restriction does not completely cut off the airflow to the pump. The pump is not designed to operate at zero flow and the high vacuum could damage the pump diaphragm.

Three Point Flow Calibration

Turn on the SabreBZM, start the SabreBZM program, and enter the Flow Calibration routine. Adjust the variable flow restriction to approximately 1.5 LPM, enter the actual flow reading from the Rotameter into the Measured Flow box (Figure 7), and tap the *Start Calibration* button.

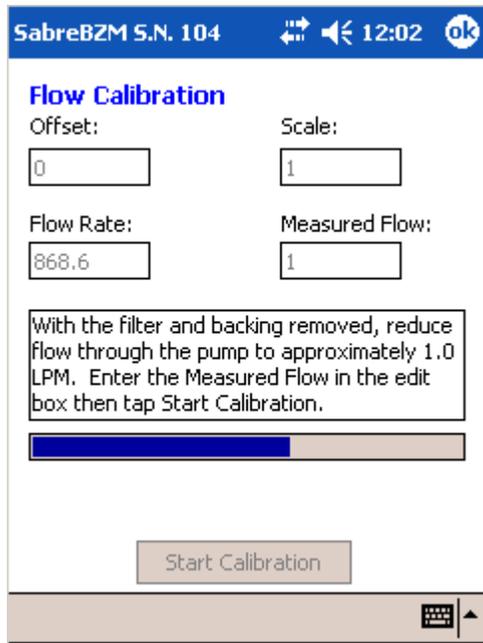


Figure 7

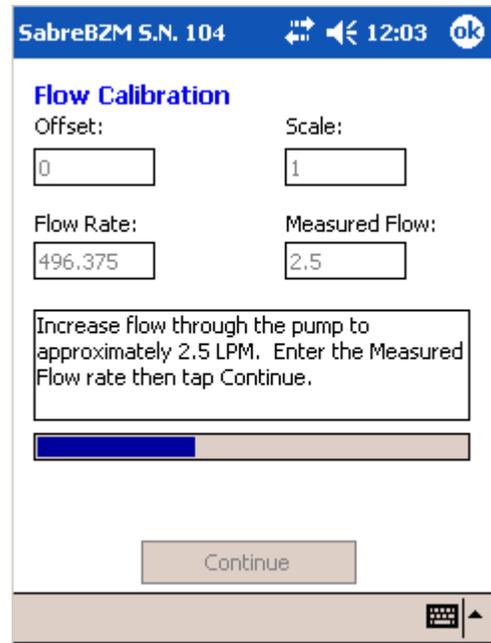


Figure 8

When prompted, adjust the variable flow restriction to approximately 2.5 LPM, enter the actual flow reading from the Rotameter into the Measured Flow box (Figure 8), and tap the *Continue* button.

When prompted, adjust the variable flow restriction to its full open position providing maximum flow, enter the actual flow reading from the Rotameter into the Measured Flow box, and tap the *Continue* button.

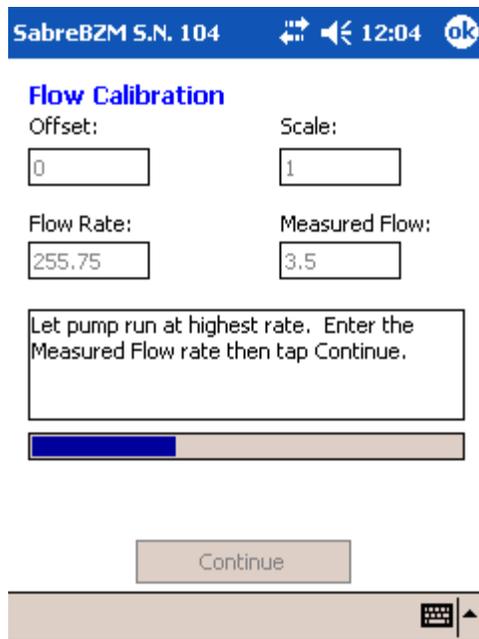


Figure 9

Validation of Flow Calibration

When prompted, adjust the variable flow restriction to approximately 3.0 LPM, enter the actual flow reading from the Rotameter into the Measured Flow box (Figure 10), and tap the *Validate* button.

Calibration is complete at the conclusion of the validation step and can be repeated if desired. Otherwise tap *OK* and a confirmation dialog will allow the new settings to be accepted and saved, or rejected.

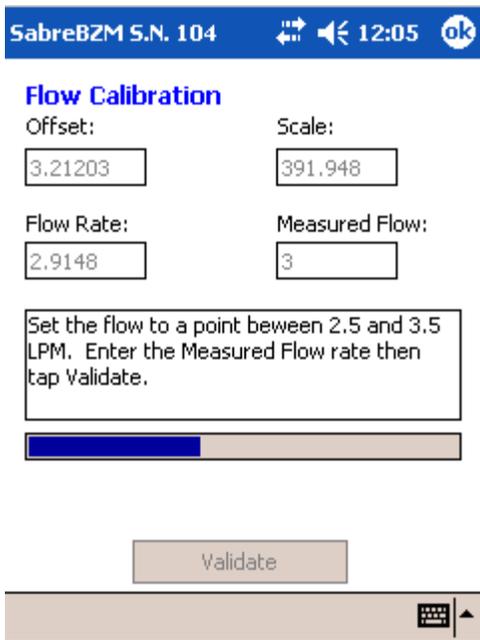


Figure 10

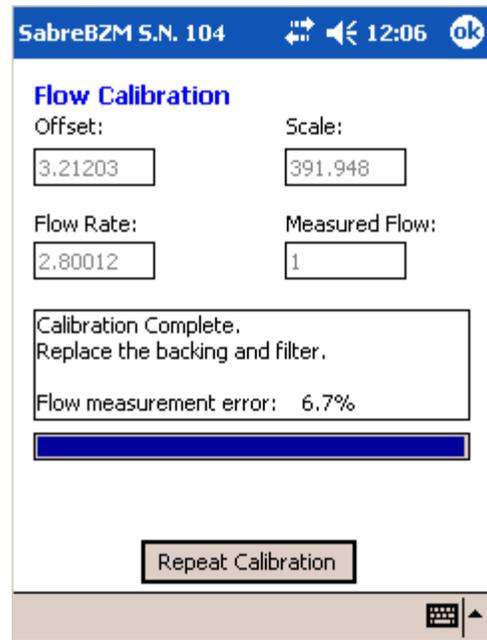


Figure 11

Reassemble the Detector Head

Remove the calibration fixture from the filter holder, replace the filter and reconnect the filter holder to the detector head, making sure that the halves are pressed firmly together.

Calibration Expiration

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

- A user-defined number of days since the last calibration have elapsed. *Default is 180 days.*
- The unit has exceeded the user-defined number of hours of run-time since the last calibration. *Default is 200 hours.*

When the calibration expires, the SabreBZM display will indicate *OUT OF CAL* and the voice output will indicate “Out of calibration.”

SECTION
3

Configuration

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

User Interface 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 Properties dialog.

Voice Update Frequency

The *Normal* and *Abnormal* settings control the frequency with which voice annunciations are made. While the instrument is in a normal status condition, the voice annunciation of the reading will occur at the interval specified by the *Normal* setting. Units are in seconds. *Default is 60 seconds.*

Any abnormal condition will cause voice annunciations to occur at the more frequent interval specified by the *Abnormal* setting in seconds. *Default is 15 seconds.*

Meter Update Frequency

The *Normal* and *Abnormal* settings control the frequency with which the meter display is updated. While the instrument is in a Normal status condition, the meter display of the reading will occur at the



Figure 12

interval specified by the *Normal* setting. Units are in seconds. *Default is 1 second.*

Any abnormal condition will cause meter updates to occur at the more frequent interval specified by the *Abnormal* setting. *Default is 1 second.*

User Controls

The *Alarm Acknowledge by menu only* check box, when checked, required that alarms are acknowledged and cleared only from the Monitor – Acknowledge Alarm menu selection. When unchecked, alarms may be acknowledged and cleared either from the menu, or by pressing the large Navigation Button on the lower center face of the PocketPC.

Instrument Options

The Instrument Options dialog controls the functional behavior of the SabreBZM. Access the dialog from the menu by tapping *Monitor – Instrument Options...* The dialog consists of five pages of settings and information: a General page, a Logging page, an Isotope page, a Flow page, and a RadNet page. Each page is accessed by tapping the corresponding tab at the bottom of the dialog.

General Page

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

Window Settings

Acute Window—This setting defines the count time 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 60 Seconds.*

Chronic Window—This setting define the count time used to determine the Chronic Dose, Concentration, NetCps and Activity. Longer times provide better sensitivity and lengthen the dose integration time. *Default is 60 Minutes.*

Calibration Expiration Settings

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

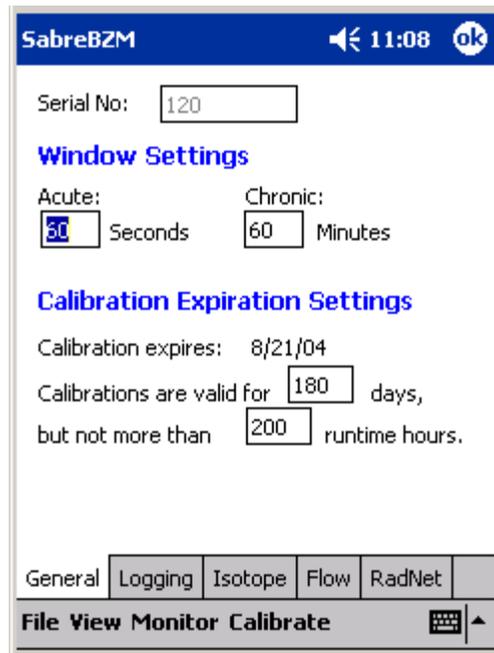


Figure 13

Calibrations are valid for XXX days—This field sets the maximum number of days between calibrations. *Default is 180 days.*

But not more than YYY runtime hours—This field sets the maximum number of hours of SabreBZM runtime between calibrations. *Default is 200 hours.*

Logging Page

The *Logging Interval* settings control the data logging behavior of the SabreBZM. Several types of log files are created on the PocketPC during operation. See *Retrieving and Analyzing the Data* for more information on the log files.

Log Acute readings every—This setting controls the frequency which Acute readings are written to the Pu239_Acute.txt file. *Default is 5 Seconds.*

Log Spectrums—This setting controls whether spectrum snapshots are written to a log file. 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 logged. Each spectrum filename created has the format SpectrumHHMM.txt, where *HH* represents the elapsed time hours since the start of the measurements, and *MM* represents the minutes. *Default is 10 Minutes.*

Isotope Page

This page defines the parameters concerning the measurement isotope-of-interest. By default, the isotope of interest is Pu-239, however, this isotope may be changed to support the measurement of other alpha-emitting isotopes. Note that the radon daughters of Po-214 and Po-212 are always monitored and used in the background subtraction algorithm.

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

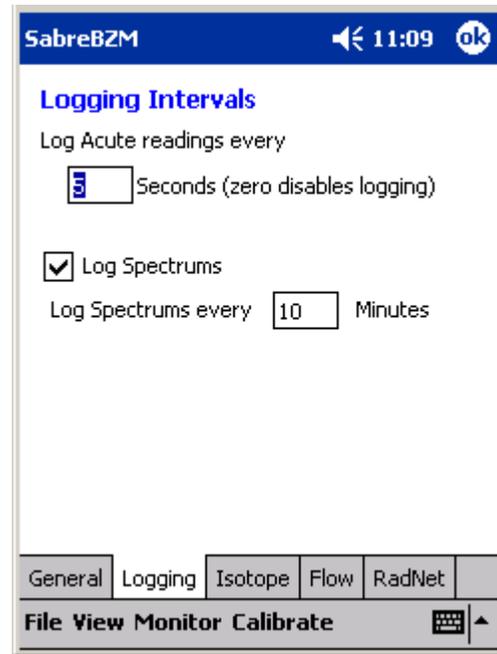


Figure 14

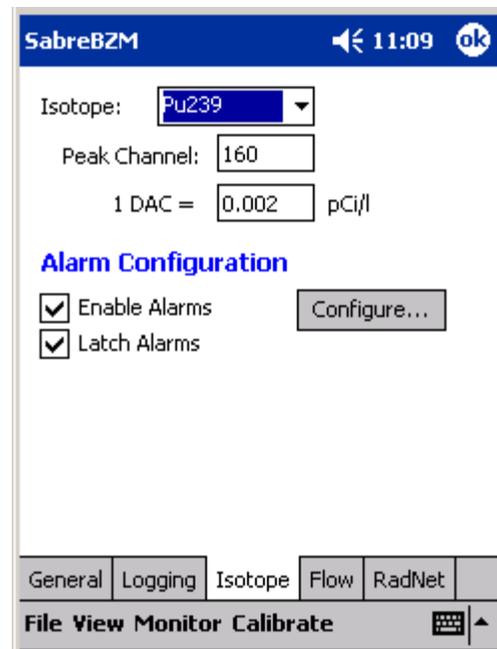


Figure 15

Peak Channel—This setting identifies the channel where the peak of the selected isotope-of-interest is expected by the peak-fit algorithm. Although it can be changed from this dialog page, normally, it is set during the calibration procedure. *Default is channel 160.*

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 0.002 pCi/liter/ DAC.*

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 Alarm checking performed.*

Latch Alarms— This checkbox configures whether alarms are latching or non-latching. Latching alarms must be acknowledged by the user before the alarm status will be cleared. Non-latching alarms will clear automatically once the reading drops below the alarm set point. If checked, alarms must be cleared manually through the *Monitor - Acknowledge Alarm* menu item, or with the Navigation Button (if not disabled). *Default is Latching.*

Configure...—This button calls up alarm settings dialog to configure the alarm set points for the isotope-of-interest.

Alarm Settings Dialog

This dialog is accessed through the Isotope page of the Instrument Options dialog. It allows configuration of the acute and chronic alarm set points for dose and concentration alarms.

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 200 DAC-h.*

Net count rate (cps)—This setting determines the alarm set point for the acute Net Cps. Currently disabled. Cannot be edited.

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, and therefore, on the dose and concentration sensitivities. The setting is used to determine the sigma factor which is

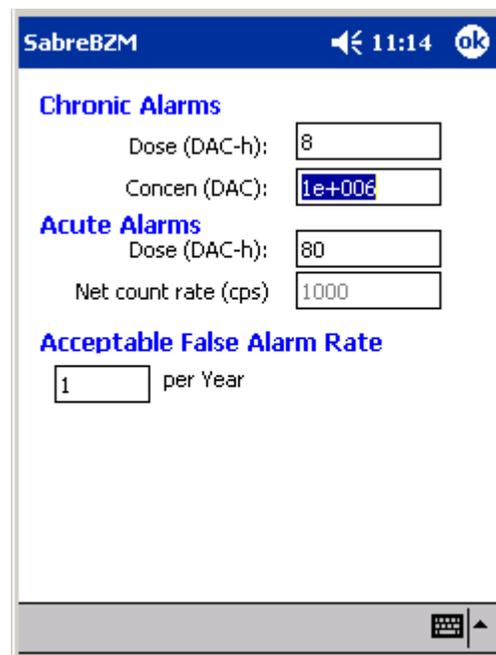


Figure 16

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 1 false alarm per year.*

Flow Page

This page defines the alarm and failure limits on the sample flow measurement.

Flow Properties

Low Limit—This setting defines the limit in liters per minute below which the SabreBZM will indicate a LOW FLOW status. A low flow status can indicate a loaded or wet filter. *Default is 2.5 LPM*

High Limit—This setting defines the limit in liters per minute above which the SabreBZM will indicate a HIGH FLOW status. A high flow status can indicate a leaking or disconnected vacuum line. *Default is 4.5 LPM.*

Low Fail Limit—This setting defines the limit in liters per minute below which the SabreBZM will indicate a FLOW FAIL status and go out of service. A flow fail status can indicate a kinked or clogged vacuum line. *Default is 0.5 LPM.*

RadNet Page

This page contains the setting for RadNet broadcasts for SabreBZM units with the wireless RadNet Option installed.

Broadcast Measurements—This checkbox enables or disables the transmission of measurement packets to RadNet clients. It is currently enabled and cannot be changed.

Measurement Type List Box—This 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. Currently not functional.*

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

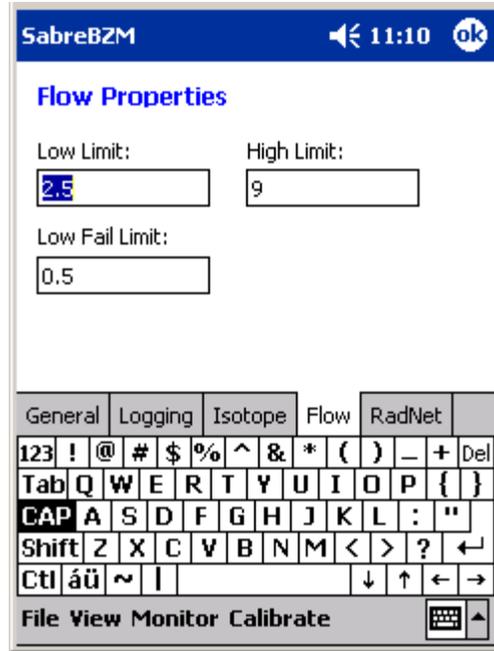


Figure 17

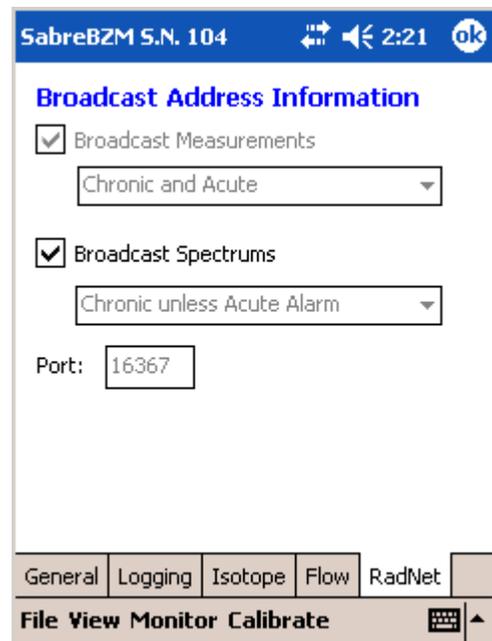


Figure 18

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. Currently not functional.*

Starting a Dose Measurement

Response Check Routine

Before starting a dose measurement, the SabreBZM should be tested to make sure that it is operating properly and in calibration. The Response Check routine provides a convenient method for insuring proper operation of the SabreBZM, prior to putting it in operation.

The purpose of the Response Check is to verify that a consistent activity is reported when a source of known activity is placed under the detector. A Response Check verifies that the detector and SabreMCA are functioning properly, and it verifies that the isotope is correctly identified and the peak area properly measured, that the efficiency has not changed, and it gives an indication of whether the data is consistent with previous Response Checks.

The source, which should be of the same isotope as the isotope-of-interest the SabreBZM is configured to measure, should be of 37 mm overall diameter and have an active (plated) diameter of 1.00 inch. This will closely model the active area of a filter and provide the most accurate assurance of repeatable geometry.

Running the Response Check

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

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 is precise enough to reliably fall within the limits. The tolerance of $\pm 10\%$ is only a suggested limit and actual tolerances will vary based on source activity and Count Time.

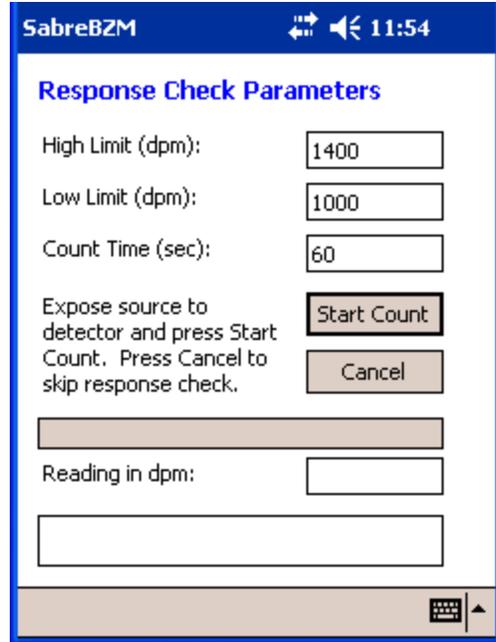


Figure 19

Remove the filter holder, exposing the detector head, and place the source under the detector. 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 while in the holder.

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 is displayed and the results of the test displayed and voice annunciated.

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. In the event the Response Check fails, it is up to the user to determine whether the instrument is still serviceable. A reading slightly out of range may indicate only that the unit should be Response Checked again and the results compared to historical records. A reading significantly out of range is a warning that the instrument is not operational!

When the test is complete, remove the source, insert a clean filter and reconnect the filter holder and detector head.

Tap the *Cancel* button to exit the Response Check routine.

Note

To repeat the Response Check, tap the *Monitor* menu item and select *Response Check...* or, tap *File—Close* to close the SabreBZM program and then run the program again.

Dose Measurement

Once the Response Check is completed, the SabreBZM enters normal operation and begins monitoring for the isotope-of-interest. The instrument will begin measuring dose and concentration immediately and can alarm on a measurable activity, however, the minimum-detectable levels of concentration and dose will be elevated until the Acute and Chronic Window times have elapsed. Until the full window times have elapsed, the SabreBZM 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 60 seconds (using the default Acute Window time), the Acute MDD will be elevated, and, for the first hour (again, using the default Chronic Window time), the Chronic MDC and MDD will be elevated. To alarm during these periods, the dose or concentration must exceed the minimum-detectable or the alarm set point—*whichever is higher!*

Operational

Duration

The SabreBZM will operate, under normal conditions, for approximately eight hours before the battery level forces a shutdown. The battery brand and capacity, as well as the use of wireless reporting capability, can affect the run time.

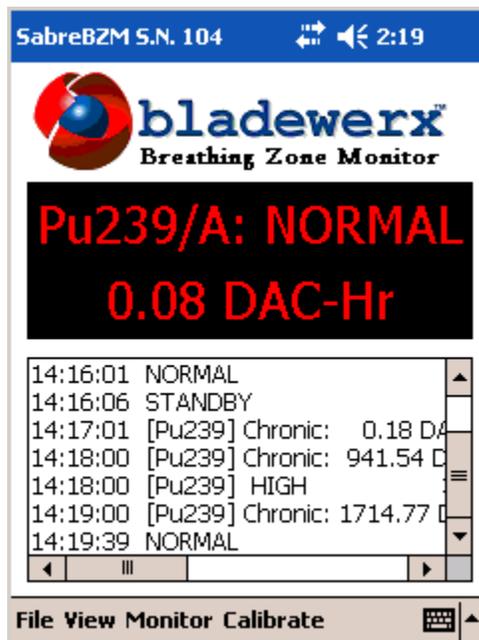


Figure 20

Dose Measurement Reporting

Displaying Readings

The SabreBZM meter displays readings on a continual basis during operation. The default meter display is the Acute Dose reading for the isotope-of-interest. The Dose, Concentration, activity and net count rate for the isotope-of-interest—as well as the radon daughters, Po-124 and Po-218—may be displayed as well through the use of the Navigation Button at the bottom of your PocketPC.

To select between Acute and Chronic readings and the different isotopes, press the Up/Down directions.

Note

Acute readings are denoted by the isotope name, followed by a **/A**. Chronic readings are denoted by a **/C**. For example, the Pu-239 Acute reading is labeled, **Pu239/A** and the Pu-239 Chronic reading by **Pu239/C**.

To select between DAC-h, DAC, NetCps and pCi/l, press the Right/Left directions of the Navigation Button.

In the event of an alarm, the SabreBZM will automatically display the isotope-of-interest chronic or acute reading that caused the alarm.

Voice Annunciation

In order to allow hands-free operation, the SabreBZM has voice output of readings, status changes and alarms. The operator can simply rely on the PocketPC speaker or use the included ear plug which may be plugged into the audio output connector on the top of the PocketPC.

By default, readings are voice announced every minute during normal operation. This reporting frequency can be changed by the user, under the *File - Properties...* dialog. By default, reading and status are announced every fifteen seconds whenever the instrument is in a failed or alarmed status. Again, this reporting frequency can be changed.

Activity, Concentration and Dose Calculations

Concentration Calculation Method

The curve fit function produces coefficients for each isotope that correspond to the counts under the peak. In order to calculate a concentration, the counts for each peak 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 isotope, two different time intervals are used to determine concentrations and are referred to as the “fast window” and “slow window” times (sometimes called ‘acute’ and ‘chronic’). The peak counts—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 previous minute and also the minute previous to it, are calculated. 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.

Concentration Equation

The concentration equation used for the fast and slow 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 slow/fast window time in seconds¹
 Net_0 = Net counts from $T - 2T_{WA}$ to $T - T_{WA}$
 Net_1 = Net counts from $T - T_{WA}$ to T
 Cal = Calibration constant
 Eff = Detector efficiency (4-Pi)

¹ The actual window time 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.

Yield = Isotope Alpha yield
Vol_{Sample} = Sampled volume in last *T_{WA}*
K_{DAC} = DAC conversion factor (equals one if DAC not used)
 λ = decay constant, $\lambda = \frac{\ln(2)}{T_{1/2}}$ where, *T_{1/2}* = isotope half-life

A mass flow sensor is used to accurately determine the volume of air collected on the filter paper during the count time.

Dose Calculation

The Sabre program calculates dose according to the activity collected on the filter paper. Because the Sabre 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 Sabre filter has been accumulating activity. For instance, if an Sabre has been sampling air at 1 CFM for 40 hours, and the activity of Pu-239 is 15 dpm, the worker dose is not 2 DAC-h, but is dependent on how much of the 40 hours the worker spent inside the room being monitored. 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.

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

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

Where,

- T_{WA}* = Actual slow/fast window time in seconds'
- Net₁* = Net counts from T - *T_{WA}* to T
- Cal* = Calibration constant
- Eff* = Detector efficiency (4-Π)
- Yield* = Isotope Alpha yield
- K_{DAC}* = DAC conversion factor (equals one if DAC/DAC-h not used)

Minimum Detectable Activity, Concentration and Dose

Uncertainties in Peak Counts

In most ROI-based Alpha-CAM's, the minimum detectable 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 SabreBZM, the minimum detectable concentration (MDC) is not directly related to the spectrum counts, but to the uncertainty in the curve fit.

When the curve fit is completed each second, values are returned which represent the counts under each peak. As described earlier, these values are statistically distributed about the ‘true’ peak areas and have known probabilities of being within 1-sigma, 2-sigma, etc. of the true area. A characteristic of the curve fit algorithm is that in the course of solving the minimization problem, a “covariance matrix” is calculated which described the errors associated in the solution. This covariance matrix identifies, on its diagonal, the variances of each coefficient—including the peak area coefficients. In other words, the curve fit routine returns the actual variances for the peak areas so that uncertainties due to interfering isotopes (I.e. background) have already been considered.

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

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

Calculation of the Minimum Detectable Concentration

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

Calculation of Minimum Detectable Dose

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

Where,

Variance₀ = Peak area variance for previous *T_{WA}*

Variance₁ = Peak area variance for most recent *T_{WA}*

SECTION
6

Ending a Dose Measurement

After a dose measurement period is complete, exit the SabreBZM program by tapping the *File—Close* menu item. The program will terminate and close any open logging files.

The SabreBZM should then be plugged into the charger and the PocketPC removed and connected to the Sync cable for charging and log file archiving. After archiving is complete, the PocketPC can either be left plugged into the Sync cable for charging or re-connected to the SabreBZM for charging.

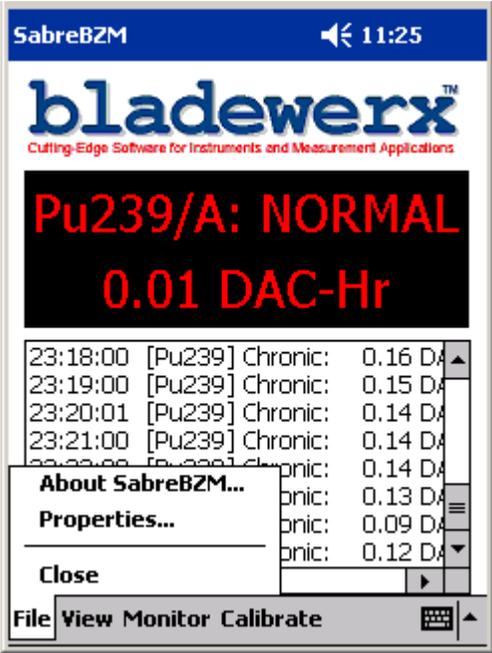


Figure 21

A gray square graphic with the word "SECTION" in bold black uppercase letters at the top and a large white number "7" in the center.

Retrieving and Analyzing the Data

The log data files stored on the SabreBZM may be retrieved and analyzed on a personal computer, laptop or workstation. The data can be imported into a spreadsheet or database and archived for future use.

Installing and Using Microsoft ActiveSync

To access the data on the SabreBZM, the user must install the ActiveSync (for Windows XP) or Windows Mobile Device Center (for Windows 7/8) software from Microsoft and then connect using the supplied USB Sync cable. The manufacturer's manual provided with the PocketPC will provide detailed instructions for installing ActiveSync or WMDC and connecting the Sync cable. Please refer to the PocketPC manufacturer's documentation.

Once the mobile sync software is installed on a PC, the SabreBZM PocketPC may be unplugged from the SabreMCA cable.

Plug the PocketPC into the Sync cable. After a few moments, the PC and PocketPC should automatically connect. When the dialog is presented that asks whether a Permanent or Guest Partnership be established, select Permanent, then click *Next* and disable all options except *Files* (We do not want *tasks*, *contacts* and *appointments* to be copied from the PC to the PocketPC).

Log Files Stored on the PocketPC

Once connected to the PocketPC, the mobile device sync program window is displayed on the PC and file synchronization will occur. When a partnership is created, a folder is created on the PC in the *My Documents* folder with a name corresponding to the PocketPC name (e.g. *BWSABR_212 My Documents*) and includes all the SabreBZM log files. The following list describes the files and their contents:

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

Pu239_Acute.txt—This text file contains the log of acute readings archived during the SabreBZM dose measurement period. Note: the file name may be different if Pu-239 is not defined as the isotope-of-interest.

Pu239_Chronic.txt—This text file contains the log of chronic readings archived during the SabreBZM dose measurement period. Again, the file name may be different if Pu-239 is not defined as the isotope-of-interest.

SabreLog.txt—This text file contains a copy of the readings and status changes logged to the SabreBZM 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.

SpectrumHHMM.txt—These text files contain chronic spectrum snapshots at fixed intervals during the dose measurement period. Part of the filename is a timestamp indicating the hours (*HH*) and minutes (*MM*) into the dose measurement when the spectrum was archived. For example, *Spectrum0450.txt* is the chronic spectrum archived 4-hours and 50-minutes into the dose measurement whose accumulation spanned the time from 3:51 through 4:50 (assuming a Chronic Window time of 60 minutes).

You may select any or all of the log files and copy them to a more permanent storage location on the PC using drag-and-drop or copy-paste or any other standard Windows file copy operation. The files can then be opened, imported into a spreadsheet or printed.

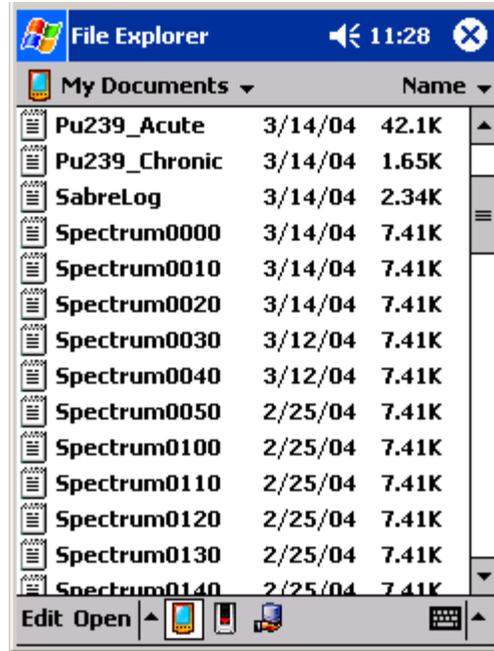


Figure 22

Importing the data into Microsoft Excel

All files, except the SabreLog.txt are in *comma-separated-variable* (*.csv) format and, if renamed with the .csv extension can be opened and viewed directly from Microsoft Excel by simply double-clicking on the file.

A more convenient method for viewing different sessions of SabreBZM files is to open a blank Excel spreadsheet and select *Data—Get External Data—Import Text File...*

Next, select the SabreBZM log file from the ActiveSync folder and import it into cell A1. The data can now be graphed and analyzed. Save the spreadsheet to preserve the link to the imported data.

To examine the SabreBZM data from a different session it is only necessary to open the previously saved spreadsheet, then select *Data—Refresh Data* and select the new log file.

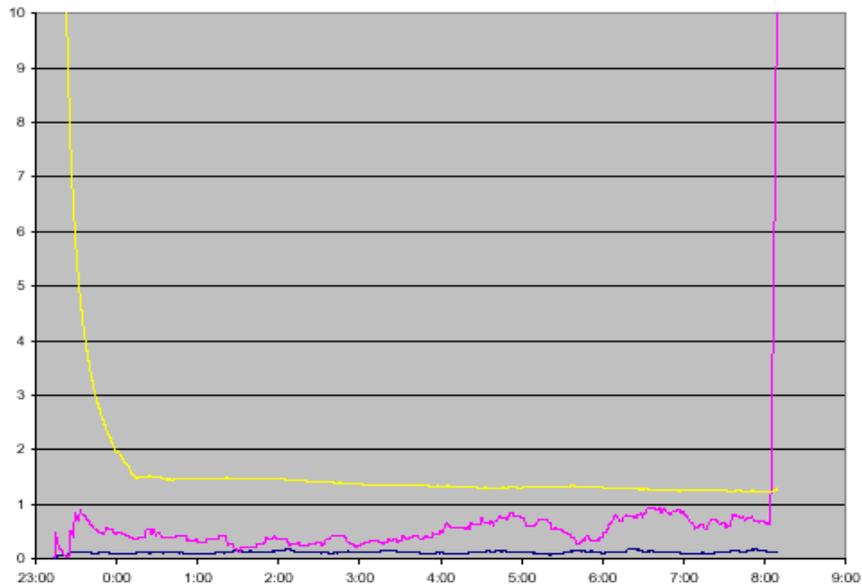


Figure 23

Closing ActiveSync/WMDC

Once the SabreBZM log data has been retrieved, you may remove the PocketPC from the cable.

Wireless RadNet Operation

General

SabreBZM units ordered with the wireless RadNet Output option come equipped with a 802.11b-compatible wireless smart card and are configured to allow broadcasting of RadNet Alpha CAM measurement and spectrum packets. These packets may be received and displayed by RadNet Client software available from several sources, including Bladewerx. A wireless access point (WAP) is required to receive the transmissions from the SabreBZM and relay those transmissions either via an Ethernet cable to the RadNet Client workstation, or via a second wireless link to the client workstation. The concentration readings and spectrums from up to nine SabreBZMs may be linked to a single RadNet Client workstation.

Configuration

SabreBZM s purchased with the RadNet Output Option come preconfigured for operation with the wireless access point, however, site security requirements may require changes to the setup. The tables below are included to provide a brief guide to the wireless configuration of the SabreBZM. 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 and Network Setup

The SabreBZM is shipped configured as follows:

Device Name	BWBZM_xxx where xxx represents the SabreBZM serial number (e.g. BWBZM_127)
Description	Bladewerx SabreBZM
IP Address	192.168.0.xxx where xxx represents the SabreBZM serial number (e.g. 192.168.0.127)
Subnet mask	255.255.255.0
Network name SSID	Bladewerx

Connects to	Work
WEP encryption	Enabled (128-bit)
Network Authentication	Disabled
Key provided automatically	Disabled
Network Key	332a f3df 0836 3347 8b32 da1b c8
Bluetooth	Disabled
ActiveSync USB connection	Enabled

Netgear WAG102 Wireless Access Point

The Netgear WAG102 wireless access point (WAP) is an industrial-grade access point capable of extended range operation and can be operated in a Repeater mode. Configuration of the WAP is through a web browser such as *Internet Explorer*. Connect the WAG102 to the PC used to configure the WAP using a Ethernet “crossover cable” or a cable into a network hub. Run the browser program and access the WAG102 by entering the IP address 192.168.0.115 (if a different address has been factory-set, the IP Address will appear on a label underneath the WAP) in the address bar. When connected, the log-on screen will display. Enter “Admin” as the User and “master” as the password.

Name	Admin
Password	master
IP Address	192.168.0.115 where multiple access points are used, number sequentially (e.g. 116, 117, 118, etc.)
Subnet mask	255.255.255.0
Network name SSID	Bladewerx
WEP Authentication Type	Shared Key
WEP encryption	128 bits
WEP Passphrase	Willcox45

In the event that the WAG102 no longer responds to the 192.168.0.116 address, reset it back to Netgear factory defaults by holding down the *Reset* button on the rear of the chassis for ten seconds then releasing. After the *Test* light goes out, the unit may be reconfigured. Run the web browser and enter 192.168.0.228, the Netgear factory default IP address. At the login screen enter *admin* for the User Name and *password* for the Password. The unit may then be set up according to the settings table above.

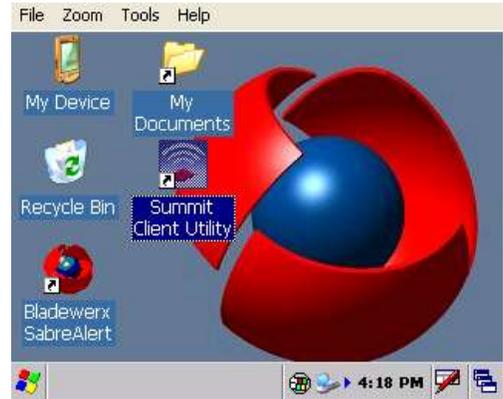
RadNet Client Workstation Setup

In order to communicate with the SabreBZM and wireless access point, the client workstation must be configured with a compatible IP Address in the 192.168.0.xxx Class-C range. Choose an address that does not conflict with the addresses of the SabreBZMs or the wireless access point(s) (e.g. 192.168.0.12). Addresses below 115 are usually safe.

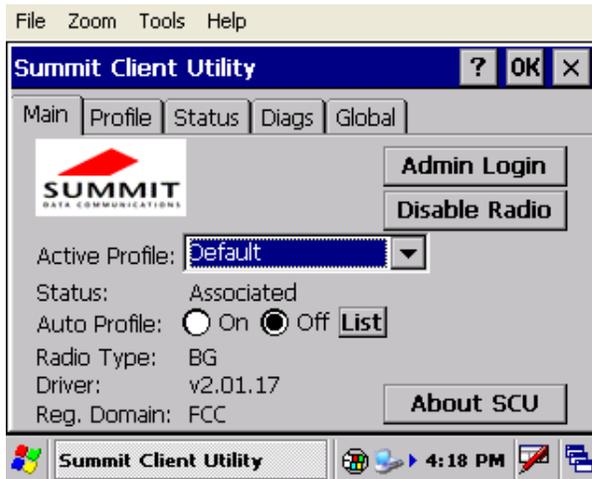
If the client workstation is operating wirelessly, be sure to set up the SSID of “Bladewerx” and use 128 bit WEP Encryption with the passphrase “Willcox45” (or the hex key 332a f3df 0836 3347 8b32 da1b c8). Select “Infrastructure mode” or “Access Points Only.”

SabreBZM Summit WiFi Client Setup

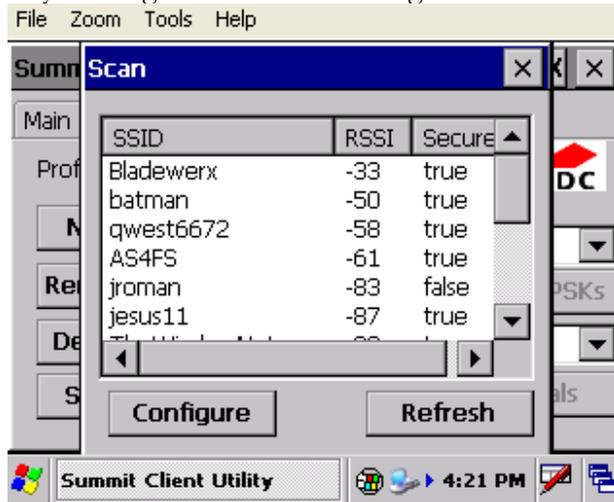
1. Run Summit Client Utility on the SabreBZM Desktop by double-clicking on the icon. Also, make sure the wireless access point is plugged in and ready to use, as this procedure cannot be performed without it.



2. When the Summit Client Utility window appears, you need to first login by clicking on “Admin Login” which is located under the “Main” tab. Enter the Admin Password: SUMMIT. Click “OK”.



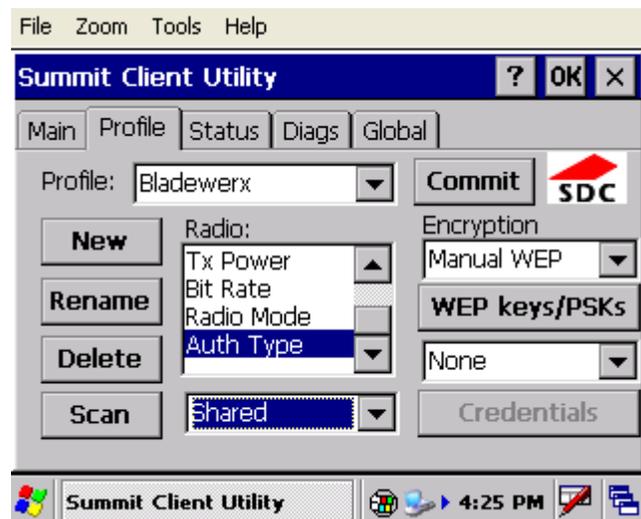
3. Next, navigate to the “Profile” tab, and click on “Scan”. In the window that appears, highlight “Bladewerx” by clicking on it and hit “Configure”.



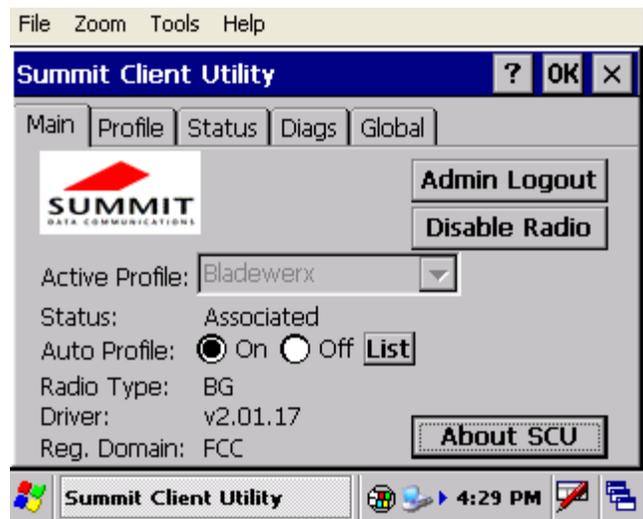
4. A dialog box will ask if you want to “Create a new profile”. Click “Yes,” and then enter the WEP Key:
332af3df083633478b32da1bc8



5. Still in the “Profile” tab, change the “Auth Type” to “Shared,” and then hit “Commit”.

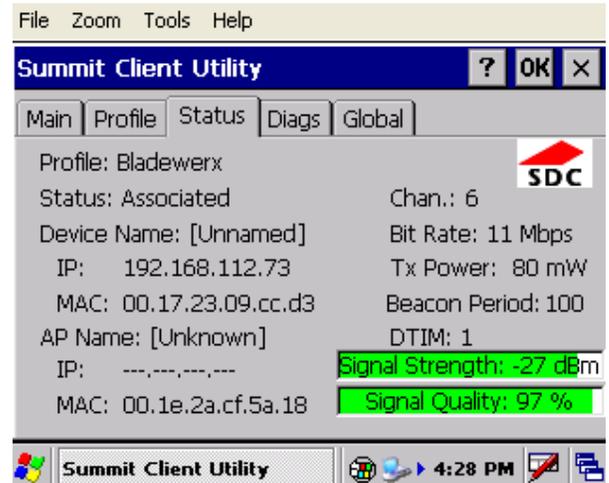


6. Now go back to the “Main” tab. Click on the “List” button and click on the white box next to “Bladewerx” so that a black check mark appears. Click “OK”. On the “Main” screen, turn the “Auto Profile” on. Then click “OK” in the top right-hand corner. The program will close.



7. Put the SabreAlert to sleep by pressing the red power button on the side of the case. Then turn it back on. There should be a wireless icon (a series of green bars) on the taskbar at the bottom of the screen.

8. Figures 7, 8, and 9 are screen captures of what each tab should look like when this procedure has been completed.



SabreBZM Status Conditions

Status	Description
Initializing	SabreBZM program initialization (momentary)
Normal	Operating normally
High Alarm	Dose or Concentration set point has been exceeded
Low Flow	Flow rate is below Low Limit
High Flow	Flow Rate is above High Limit
Detector Fail	No counts received from detector
Low Battery	Battery is almost expired
Internal Comm	No communications with SabreMCA
Poor Fit	Could not fit the spectrum with the defined isotopes
Flow Fail	Flow Rate is below Fail Limit
Out of Calib	Calibration has expired

Specifications

Sampling Head and Flow

- 37 mm Filter holder
- Detector: Solid-state silicon (450 mm² active area)
- Pump: diaphragm-type, 2.5 – 4.0 LPM

Data Analysis

- MCA: 1024-channel analyzer binned to 256 channel spectrum
- Peak-fitting algorithm
- Acute (fast response) and Chronic (high sensitivity) dose determinations
- Processor: *Windows CE*-based PocketPC, 624 MHz *Marvell* PXA270 processor

Physical

- Battery powered: 8.4 V Lithium-Ion, 4.1Ah (8 Hr run-time)
- Weight: 2.6 lbs (1.2 kg)
- Dimensions: (W x H x D) 10 x 7 x 3 in.
- Temperature: 0 to 122 °F (-17 to 50 °C)
- Humidity: 5 to 100% (non-condensing), splash-proof electronics