LUDLUM MODEL 2100 & MODEL 2100-1 SAMPLE COUNTER OPERATOR'S MANUAL

July 2014

Version 1.3.0 / 54003N03

LUDLUM MODEL 2100 & MODEL 2100-1 SAMPLE COUNTER OPERATOR'S MANUAL

July 2014

Version 1.3.0 / 54003n03

LUDLUM MEASUREMENTS, INC.
501 OAK STREET, P.O. BOX 810
SWEETWATER, TEXAS   79556
325-235-5494, FAX: 325-235-4672

STATEMENT OF WARRANTY

Ludlum Measurements, Inc. warrants the products covered in this manual to be free of defects due to workmanship, material, and design for a period of twelve months from the date of delivery. The calibration of a product is warranted to be within its specified accuracy limits at the time of shipment. In the event of instrument failure, notify Ludlum Measurements to determine if repair, recalibration, or replacement is required.

This warranty excludes the replacement of photomultiplier tubes, G-M and proportional tubes, and scintillation crystals which are broken due to excessive physical abuse or used for purposes other than intended.

There are no warranties, express or implied, including without limitation any implied warranty of merchantability or fitness, which extend beyond the description of the face there of. If the product does not perform as warranted herein, purchaser's sole remedy shall be repair or replacement, at the option of Ludlum Measurements. In no event will Ludlum Measurements be liable for damages, lost revenue, lost wages, or any other incidental or consequential damages, arising from the purchase, use, or inability to use product.
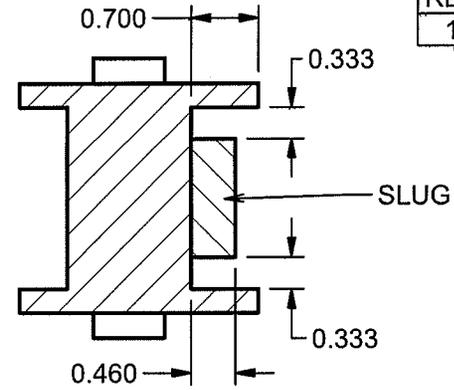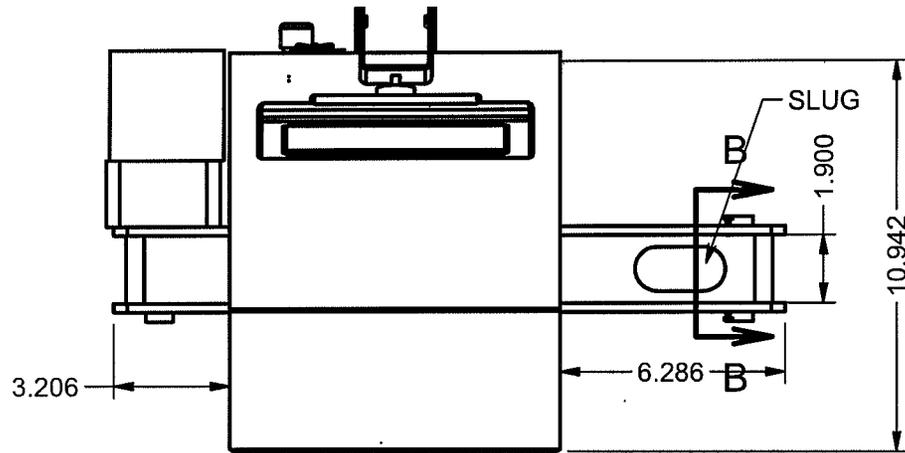
RETURN OF GOODS TO MANUFACTURER

If equipment needs to be returned to Ludlum Measurements, Inc. for repair or calibration, please send to the address below. All shipments should include documentation containing return shipping address, customer name, telephone number, description of service requested, and all other necessary information. Your cooperation will expedite the return of your equipment.

LUDLUM MEASUREMENTS, INC.
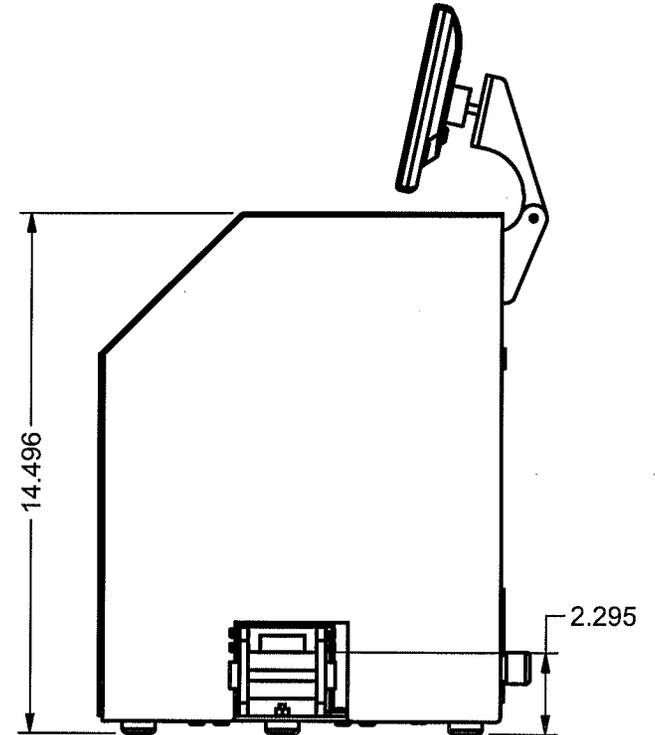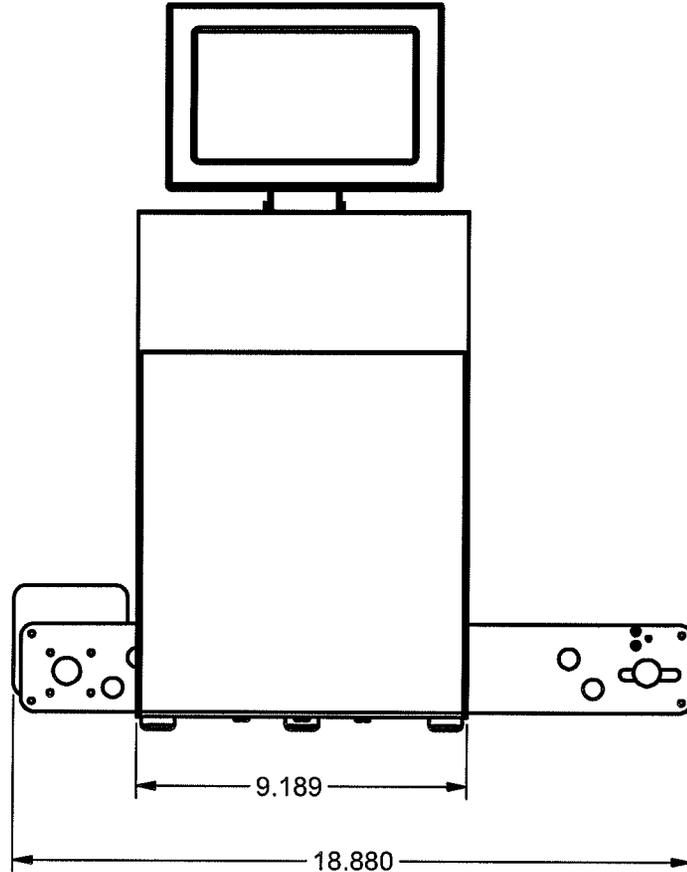**ATTN: REPAIR DEPARTMENT**
501 OAK STREET
SWEETWATER, TX 79556

800-622-0828   325-235-5494
FAX 325-235-4672

SLUG

0.700

0.333

SLUG

0.333

0.460

SECTION B-B
SCALE 1 / 2

B

B

1.900

10.942

3.206

6.286

14.496

2.295

9.189

18.880

9.243

22.174

12.025

Table of Contents

Section
1

Introduction

The Model 2100 Sample Counter is used to detect gamma radiation in or on small (approximately 5 cm {2 in.}) samples. The instrument features an internal gamma scintillation detector and either a small automated conveyor to feed the sample into the chamber or a sample tray or a manually operated sample tray (Model 2100-1). The chamber is shielded with lead, making it fairly heavy. The Model 2100 is designed to be user friendly. Users put the sample on the input conveyor in normal operation or put the sample in tray and press the count button and see status clearly on the 20.3 cm (8 in.) color liquid crystal display (LCD). A sample that triggers the ALARM can be either recounted or fed out of the chamber.   The unit measures background radiation levels and runs diagnostic routines whenever it is not measuring samples.

It is important to understand that the instrument is sensitive to changes in background radiation levels. Cosmic radiation and radon gas are two variables that cause background radiation to change. In order to detect small amounts of radiation from an unknown sample, the instrument must know the pre-existing background radiation level. It does this by measuring the background radiation at power-up and any time the unit is not busy counting unknown samples. It then automatically calculates and sets an alarm point above the background radiation.

In addition to the color display, a loud audio device is used to alert personnel in the event of an alarm. The unit also has a relay output that can be used to trigger other alarm devices. The Model 2100 also has an Ethernet output that can be used with optional software, to log events, to view status remotely, and to alert personnel by email. Remote displays are also optional, which allow an additional display to be connected through an Ethernet network, and to remotely display the current status.

Statistics are used extensively to determine whether changes in the radiation level are normal or not. There are three counting modes to maximize throughput, sensitivity, or to fix the count time. Instrument technicians have password-protected access to advanced automated routines to calibrate or verify operation.

The Ludlum Model 2100 or 2100-1 may be purchased with an additional option that is useful for periodic testing. Part number 2433-504 is a simulated 0.1 Bq/g

^{60}Co source. This test source is NOT considered radioactive, yet may be used to confirm the measurement sensitivity of the Model 2100 or 2100-1. Many regulations mandate the detection of this amount of radiation in steel.

Section 2

Features

- Large 20.3 cm (8 in.) color LCD with touch-screen interface

- Optional remote display through Ethernet network

- Three counting modes to maximize throughput, sensitivity, or to fix the count time

- Automatic background updating

- Automatic diagnostics

- Form C alarm relay 3-pin connector (common, normally open, normally closed)

- Individual channel and sum channel alarms

- Two levels of password security

- Single Board Computer (SBC) running the Windows 7 Operating System

- Sample alarm points and low/high background alarm points

- Manually enter sample ID, scan ID using barcode, read sample ID from text file.

Section	Software License Agreement
3	

BY INSTALLING THIS SOFTWARE, YOU ARE CONSENTING TO BE BOUND BY THIS AGREEMENT. IF YOU DO NOT AGREE TO ALL OF THE TERMS OF THIS AGREEMENT, DO NOT INSTALL THE PRODUCT.

Single User License Grant: Ludlum Measurements, Inc. ("Ludlum") and its suppliers grant to Customer ("Customer") a nonexclusive and nontransferable license to use the Ludlum software ("Software") in object code form solely on a single central processing unit owned or leased by Customer or otherwise embedded in equipment provided by Ludlum.

Customer may make one (1) archival copy of the Software provided Customer affixes to such copy all copyright, confidentiality, and proprietary notices that appear on the original.

EXCEPT AS EXPRESSLY AUTHORIZED ABOVE, CUSTOMER SHALL NOT: COPY, IN WHOLE OR IN PART, SOFTWARE OR DOCUMENTATION; MODIFY THE SOFTWARE; REVERSE COMPILE OR REVERSE ASSEMBLE ALL OR ANY PORTION OF THE SOFTWARE; OR RENT, LEASE, DISTRIBUTE, SELL, OR CREATE DERIVATIVE WORKS OF THE SOFTWARE.

Customer agrees that aspects of the licensed materials, including the specific design and structure of individual programs, constitute trade secrets and/or copyrighted material of Ludlum. Customer agrees not to disclose, provide, or otherwise make available such trade secrets or copyrighted material in any form to any third party without the prior written consent of Ludlum. Customer agrees to implement reasonable security measures to protect such trade secrets and copyrighted material. Title to Software and documentation shall remain solely with Ludlum.

LIMITED WARRANTY. Ludlum warrants that for a period of ninety (90) days from the date of shipment from Ludlum: (i) the media on which the Software is furnished will be free of defects in materials and workmanship under normal use; and (ii) the Software substantially conforms to its published specifications. Except for the foregoing, the Software is provided AS IS. This limited warranty extends only to Customer as the original licensee. Customer's exclusive remedy and the entire liability of Ludlum and its suppliers under this limited warranty will be, at Ludlum or its service center's option, repair, replacement, or refund of the Software if reported (or, upon request, returned) to the party supplying the Software to Customer. In no event does Ludlum warrant that the Software is error free or that Customer will be able to operate the Software without problems or interruptions.

This warranty does not apply if the software (a) has been altered, except by Ludlum, (b) has not been installed, operated, repaired, or maintained in accordance with instructions supplied by Ludlum, (c) has been subjected to abnormal physical or electrical stress, misuse, negligence, or accident, or (d) is used in ultra hazardous activities.

DISCLAIMER. EXCEPT AS SPECIFIED IN THIS WARRANTY, ALL EXPRESS OR IMPLIED

CONDITIONS, REPRESENTATIONS, AND WARRANTIES INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NONINFRINGEMENT OR ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE, ARE HEREBY EXCLUDED TO THE EXTENT ALLOWED BY APPLICABLE LAW. IN NO EVENT WILL LUDLUM OR ITS SUPPLIERS BE LIABLE FOR ANY LOST REVENUE, PROFIT, OR DATA, OR FOR SPECIAL, INDIRECT, CONSEQUENTIAL, INCIDENTAL, OR PUNITIVE DAMAGES HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY ARISING OUT OF THE USE OF OR INABILITY TO USE THE SOFTWARE EVEN IF LUDLUM OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH.

DAMAGES. In no event shall Ludlum's or its suppliers' liability to Customer, whether in contract, tort (including negligence), or otherwise, exceed the price paid by Customer. The foregoing limitations shall apply even if the above-stated warranty fails of its essential purpose. **SOME STATES DO NOT ALLOW LIMITATION OR EXCLUSION OF LIABILITY FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES**.

The above warranty DOES NOT apply to any beta software, any software made available for testing or demonstration purposes, any temporary software modules or any software for which Ludlum does not receive a license fee. All such software products are provided AS IS without any warranty whatsoever.

This License is effective until terminated. Customer may terminate this License at any time by destroying all copies of Software including any documentation. This License will terminate immediately without notice from Ludlum if Customer fails to comply with any provision of this License. Upon termination, Customer must destroy all copies of Software.

Software, including technical data, is subject to U.S. export control laws, including the U.S. Export Administration Act and its associated regulations, and may be subject to export or import regulations in other countries. Customer agrees to comply strictly with all such regulations and acknowledges that it has the responsibility to obtain licenses to export, re-export, or import Software.

This License shall be governed by and construed in accordance with the laws of the State of Texas, United States of America, as if performed wholly within the state and without giving effect to the principles of conflict of law. If any portion hereof is found to be void or unenforceable, the remaining provisions of this License shall remain in full force and effect. This License constitutes the entire License between the parties with respect to the use of the Software.

Restricted Rights - Ludlum's software is provided to non-DOD agencies with RESTRICTED RIGHTS and its supporting documentation is provided with LIMITED RIGHTS. Use, duplication, or disclosure by the Government is subject to the restrictions as set forth in subparagraph "C" of the Commercial Computer Software - Restricted Rights clause at FAR 52.227-19. In the event the sale is to a DOD agency, the government's rights in software, supporting documentation, and technical data are governed by the restrictions in the Technical Data Commercial Items clause at DFARS 252.227-7015 and DFARS 227.7202. Manufacturer is Ludlum Measurements, Inc. 501 Oak Street Sweetwater, Texas 79556.

Section
4

Safety Considerations

Environmental Conditions for Normal Use

Indoor use only

No maximum altitude

Temperature range of -40 to 50 °C (-40 to 122 °F)

Maximum relative humidity of less than 95% (non-condensing)

Mains supply voltage range 100-240 Vac, 50-60 Hz single phase (less than 1A) to desktop power supply, supplies DC voltage to instrument

Replacement of Fuses

Warning!

For continued protection against risk of fire, replace only with fuses of the specified type and current rating!

Cleaning Precautions

The Model 2100 is ruggedly designed and requires very little maintenance. The only routine maintenance item is the periodic cleaning of the LCD touch screen. Cleaning of the LCD touch screen should be done using a soft cloth and water only.

Section	Operation
5	

Controls and Functions

The following is a description of the controls and functions on the sample counter.

LCD Touch screen: 20.3 cm (8 in.) color Liquid Crystal Display (LCD) with integrated touch screen.

Audio: Loud continuous tone on alarm or failure status. Volume can be adjusted by rotating the provided shutter on the device.

Relay Out: 3-pin connector on back chassis to activate external devices such as a horn or strobe on alarm

> Pin 1 = Normally Open (white wire on pigtail)
>
> Pin 2 = Common (black wire on pigtail)
>
> Pin 3 = Normally Closed (green wire on pigtail)

Ethernet: standard RJ-45 connection for 10BaseT Ethernet connection

USB-1, USB-2, USB-3: three connections for Universal Serial Bus devices

Model 2100 Conveyor: 5.1 cm (2 in.) width conveyor with 1/20 hp motor feeds sample into chamber, and feeds sample off end of conveyor if "CLEAN."

Model 2100-1 Sample Tray: Chrome-plated brass sample tray capable of holding a 6.5 cm (2.5 in.) diameter sample up to 1.3 cm (0.5 in.) thick.

Infrareds (Model 2100 Only): Two thru-beam infrared sensors, located at the input side of the conveyor and at the chamber, are used to start and stop the conveyor in order to feed the sample into the chamber.

Power on Self Test (POST)

When the Sample Counter is first powered up, all relays, lights, and audio devices are momentarily activated. This POST is done in order to give the

user an opportunity to ensure that all applicable devices are working. The test lasts for about three seconds. Approximately one minute later the system should be finished booting, and the initializing screen will be displayed.

After POST, the system will establish the level of background radiation. The system then begins updating background radiation levels every second.

Powering the Model 2100 On

1. Connect the AC adapter to a 120-volt electrical outlet.

2. Press the POWER/RESET switch. The power switch is located on the back of the instrument.

3. The Model 2100 will take approximately two minutes to boot.

4. The Model 2100 software will start, and the display will show a countdown screen as it starts a mandatory background measurement. If all the diagnostic tests and measurements are passed, the unit displays a READY status.

Powering the Model 2100 Off

1. Tap the EXIT button on the main screen and enter the Level 1 or 2 password.

2. Tap the **Shutdown Sample Counter** button.

3. It will take approximately one minute for the computer to shut down and turn power off.

Note: Do not turn off the Model 2100 without first shutting down the computer.

Normal Operation (Model 2100)

1. If the status is READY, place the sample on the input side of the conveyor.

2. When the infrared sensor on the input side is blocked, the conveyor will start, feeding the sample into the chamber. The status will change to COUNTING.

3. After the count time has expired, the status will change to CLEAN or ALARM. If CLEAN, the conveyor will automatically feed the sample off the output end of the conveyor.

4. If an alarm occurred, the alarm relay will activate, and the screen status will change to red.

5. In an ALARM condition, the user may choose to either press the RECOUNT button or to press the FEED button. The FEED button merely clears the alarm condition and feeds the sample out of the chamber. The RECOUNT button, when pressed, clears the alarm and starts a new count.

Normal Operation (Model 2100-1)

1. If the status is READY, open the tray and place the sample in the sample tray and close the tray.

2. Press the COUNT button. The status will change to COUNTING. If it is not pressed after 10 seconds, the instrument will return to READY.

3. After the count time has expired, the status will change to CLEAN or ALARM. If CLEAN, open the sample tray and remove the sample.

4. If an alarm occurred, the alarm relay will activate, and the screen status will change to red.

5. In an ALARM condition, the user may choose to either press the RECOUNT button or remove the sample. The RECOUNT button, when pressed, clears the alarm and starts a new count.

Status Colors

The Sample Counter uses color to identify the status of the instrument at any given time. The status box in the upper left-hand side of the main screen and the detector map change colors depending on the various states of the Sample Counter and detectors. The colors are:

☢ Green – Indicates the Sample Counter is ready to scan samples.

☢ Yellow – Indicates the Sample Counter has a failure.

☢ Red – Indicates the Sample Counter has a radiation alarm.

☢ White – Indicates the Sample Counter is scanning a sample.

☢ Blue – Indicates the Sample Counter is initializing or updating background.

The lights and audio on the light stack operate as follows:

☢ Red – Indicates the Sample Counter has a radiation alarm. In addition to the voice audible alert, there will be a fast, beeping audible alarm.

☢ Yellow – Indicates the Sample Counter is in a fail condition or is not ready to scan samples. If a fail condition is present, there will be a slow, beeping audible alarm. While in any setup screens, when the Sample Counter is forcing a background update or when the Supervisor application is not running, the yellow light will be ON.

☢ Green – Indicates the Sample Counter is ready to scan samples.

Instrument Failure

There are several conditions that cause system failure:

1.   LOW BACKGROUND - The instrument continually checks the detector for abnormally low readings as defined by the low-background alarm set points. When this condition is detected, the status will change to FAILURE. This condition normally signals a failure of either the detector or its associated preamp electronics.

2.   HIGH BACKGROUND - The instrument continually checks the detectors for abnormally high readings as defined by the high-background alarm set points. When this condition is detected, the status will change to FAILURE. This condition normally signals a failure of either the detector or its associated preamp electronics, but can also warn of some nearby strong source of radiation. The possibility of such a nearby strong source of radiation warrants further investigation.

.

Section
6

Supervisor

The Model 2100 Sample Counter is controlled by the Supervisor application. The Supervisor is started automatically when the Sample Counter is booted. If the Supervisor is not running, it can be started from the Model 2100 Sample Counter icon on the desktop. When the Supervisor is not running, the yellow light on the light stack will be lit to indicate that the Sample Counter is not in service.

Touchscreen Operation

For normal operation, the Supervisor requires little to no interaction. When interaction is required, the Supervisor can be controlled using the LCD touchscreen or through an external USB keyboard and mouse. Simply tap on the screen to "click" on buttons. Each screen in the Supervisor has a button at the top right, which will open an on-screen keyboard. Numeric fields have up and down arrows, which provide a means to quickly increment or decrement the value. By tapping directly in a numeric field, an onscreen keypad is displayed for quick data entry.

Operate Screen

The Operate screen is the main display of the Sample Counter and contains the following items:

Title Bar – Displays the user-definable site, location, customer ID, and LMI serial number of the Sample Counter along the top of the screen.

Status Display – Displays the current status of the sample counter. The status can be one of the following:

- ☢ Ready

- ☢ Clean

- ☢ Counting

- ☢ Alarm

- ☢ Failure

☢ Updating Background

☢ Extending Background

☢ Initializing

Status Text Box– Displays information about the current status.

Clock/Timer – Displays the current time when not counting and a countdown timer when the Sample counter is counting or initializing a new background.

Detector Status Display – Graphical representation of the detectors with color-coded status display. Tapping on a detector brings up the detector detail screen.

Test Button - Performs a normal count with the exception of logging the sample count as a "Test."

Exit Button – Allows the user to exit the Supervisor application, restart the Sample Counter, or shut down the Sample Counter. This is password protected.

Setup Button – Allows access to the various setup screens. This is password protected.

Version – The software version and host board firmware version are displayed next to the LMI logo in the bottom, left-hand corner of the screen.
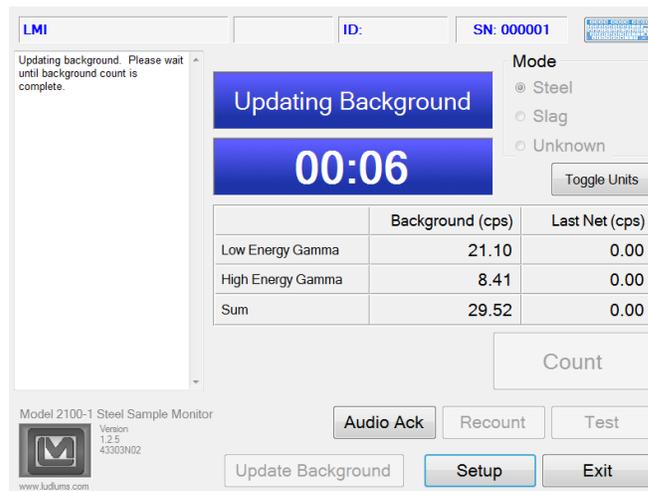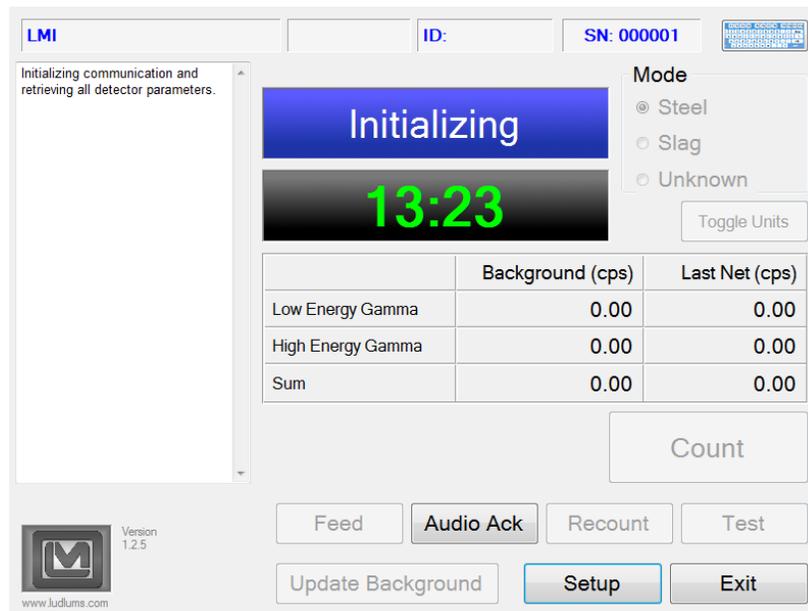
Shutdown Menu

The Shutdown menu provides access to restart or shut down the Sample Counter or to exit the Supervisor application. It is accessed through the Exit button on the Operate screen. The level 1 or 2 password is required before accessing this screen. Always shut down the Sample Counter properly through software before disconnecting the power cord. Otherwise, data corruption may occur.

Exit Supervisor – Closes the Supervisor application and provides access to the Windows XP Embedded environment. This is necessary for performing software updates, configuring Windows settings such as printing or networking, or to provide access to the data files. A confirmation window will be displayed before the Supervisor application is closed.

Restart Sample Counter – This function performs a restart of the Sample Counter's single board computer. A confirmation window will be displayed before the Sample Counter is restarted.

Shutdown Sample Counter – This function shuts down the operating system in preparation for powering off the Sample Counter. This option should always be used before powering off the Sample Counter to prevent data corruption.

Setup Screen

The Setup button on the Operate screen provides access to the various setup and calibration functions of the Sample Counter. The Level 2 password provides full acess to all setup screens. The Level 1 password only provides access to the following screens:

- ☢ Save Setup Report
- ☢ Update Background
- ☢ Source Check
- ☢ Buttons/Relays
- ☢ Scaler
- ☢ Reset Host
- ☢ View Log

If the Sample Counter is in a failure state, only the following setup screens are available regardless of of the password level:

- ☢ Radiological Setup
- ☢ Operational Setup
- ☢ Detectors
- ☢ Save Setup Report
- ☢ Scaler
- ☢ Reset Host
- ☢ View Log
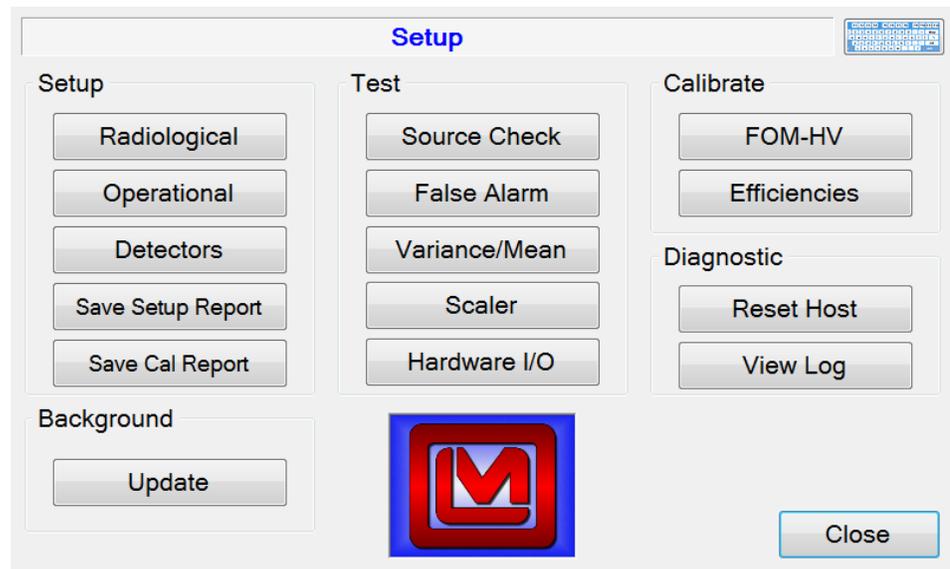
Radiological – Set up the counting mode and its parameters, isotopic mix, and unit of measurements.

Operational – Set up passwords, user-definable information, and options that control how the Supervisor application operates and displays information.

Detectors – Set up the detector high voltage (HV), lower-level discriminator (THR 1), and upper-level discriminator (THR 2). A calibration wizard is available to calibrate the various voltages and calibration constants.

Save Setup Report – Save a report that contains the current hardware and software configuration.

Save Cal Report – Save a calibration report that contains all the calibration and setup information. The report covers the counting parameters, source information, detector settings, FOM data, and application settings. After saving the file, the report can be copied from the Sample Counter and printed if necessary. Open the file in WordPad and change all the margins to 0.5 inches and the font size from 10 points to 9.

Update – Start a new background initialization.

Source Check – Perform a source check to verify all detectors are operating correctly.

False Alarm – Perform a false alarm test with a specified number of counting cycles for each detector.

Buttons/Relays – Test the input and output, including buttons, door locks, lights, and relays.

Variance/Mean – Calculate the variance and mean for each detector.

Scaler – Perform a scaler count for a user-definable count time. Also used to clear fail or contaminated conditions.

FOM – Find the optimum HV set point for each detector by running a high-voltage plateau and calculating the Figure of Merit.

Efficiencies – Calculate the efficiencies for each detector.

Reset Host – Reset the internal host board. The host board is responsible for collecting the count data and passing it to the SBC though a USB serial port.

View Log – View the log and report files. System, background, and scan logs are created automatically. Other screens provide the ability to save a report, which can be viewed here.

Section 7

Radiological Setup
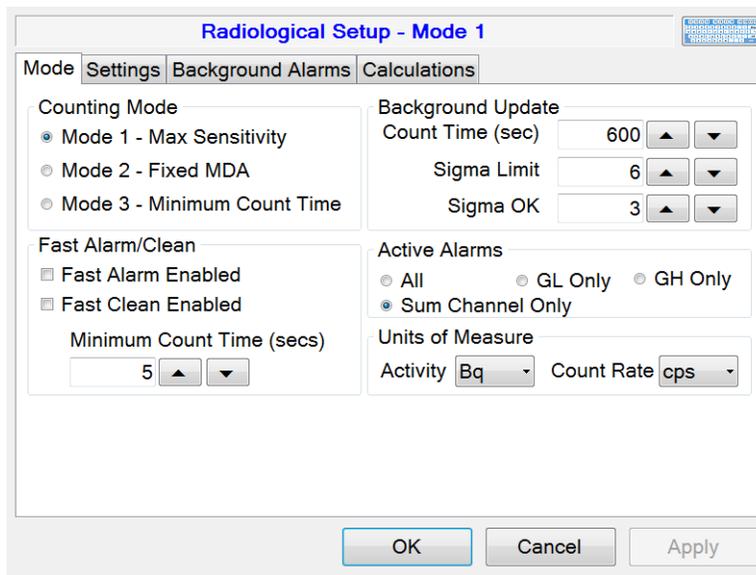
The Radiological Setup screen provides access to the various parameters and options that control the counting modes, isotopic mix, background alarm set points, and units of measure. The title indicates the current counting mode.

After making a change, press the Apply button to save the changes immediately. Press the OK button to save the changes and exit the Radiological Setup screen. Press the Close button to exit the screen without saving any changes.

Counting Modes

There are three counting modes available.

Mode 1 – Maximum Sensitivity

The alarm set point is computed at the minimum allowable value that is determined by the background count rate and acceptable false alarm probability.

Note: Alarm set points are computed as background-subtracted (net) count rates.

$$R_{A(min)} = K_B \sqrt{\frac{R_B}{T} + \frac{R_B}{T_B}}$$

Where:

$R_{A(min)}$ = Alarm set point in cps.

K_B = Background sigma coefficient, which determines the false alarm probability.

R_B = Average background count rate in cps for the detector.

T = Count time in seconds.

T_B = Background count time in seconds.

After calculating the alarm set point, a check is made to see if the computed MDA exceeds the maximum MDA. If it does, then a high-background alarm is posted.

$$MDA = \frac{R_{A(min)} + K_{S+B} \sqrt{\frac{MDA \times Eff + R_B}{T} + \frac{R_B}{T_B}}}{Eff}$$

Where:

$R_{A(min)}$ = Alarm set point in cps.

K_{S+B} = Composite sigma coefficient for controlling the false alarm probability.

MDA = Minimum Detectable Activity.

Eff = Detector efficiency.

R_B = Average background count rate in cps for the detector.

T = Count time in seconds.

T_B = Background count time in seconds.

Mode 2 – Fixed MDA

The alarm set point is calculated on the basis of the maximum allowable as determined by the MDA and its associated detection probability.

$$R_{A(\max)} = MDA \times Eff - K_{S+B}\sqrt{\frac{MDA \times Eff + R_B}{T} + \frac{R_B}{T_B}}$$

Where:

$R_{A(max)}$ = Alarm set point in cps.

K_{S+B} = Composite sigma coefficient for controlling the false alarm probability.

MDA = Minimum Detectable Activity.

Eff = Detector efficiency.

R_B = Average background count rate in cps for the detector.

T = Count time in seconds.

T_B = Background count time in seconds.

If the value of $R_{A(max)}$ is less than $R_{A(min)}$ as is computed using the Mode 1 equation, a high-background alarm is posted.

Mode 3 – Minimum Count Time

The minimum count time is calculated based on the user-defined MDA and is rounded up. If the resulting count time is greater than the user-defined maximum count time, then a high-background alarm is posted.

$$T_{MIN} = \left[\frac{K_B\sqrt{2R_B} + K_{S+B}\sqrt{MDA \times Eff \times 2R_B}}{MDA \times Eff} \right]^2$$

If the computed value for the minimum count time exceeds the background update time, then the background update time will be extended to match the minimum count time. When this occurs, the status will change to Extending Background.

The minimum count time is calculated as follows:

1. Calculate T_{MIN} using the equation above. If the calculated value of T_{MIN} exceeds the background update time, extend the background to match.

2. If T_{MIN} is less than or equal to the background update time, then the equation below is used to iteratively compute the minimum count time.

$$T_{MIN} = \cfrac{R_B}{\left[\cfrac{MDA \times Eff - K_{S+B}\sqrt{\cfrac{MDA \times Eff + R_B}{T_{MIN}} + \cfrac{R_B}{T_B}}}{K_B}\right]^2 - \cfrac{R_B}{T_B}}$$

Where:

T_{min} = Computed minimum count time.

K_{S+B} = Composite sigma coefficient for controlling the false alarm probability.

K_B = Background sigma coefficient for controlling the false alarm probability.

MDA = Minimum Detectable Activity.

Eff = Detector efficiency.

R_B = Average background count rate in cps for the detector.

T_B = Background count time in seconds.

3. The iteration is complete when the resulting T_{MIN} is greater than or equal to the T_{MIN} used on the right side of the equation.

4. If the calculated count time is greater that the user-defined maximum count time, a high-background alarm is posted.

5. The Mode 3 alarm set point is calculated using the $R_{A(MIN)}$ formula for Count Mode 1.

Count Mode Settings

The Settings tab allows the various parameters that affect the operation of the count modes to be modified. After changing a setting, press the Apply button to save the changes immediately.

NOTE: Only the settings that apply to the current count mode are shown.
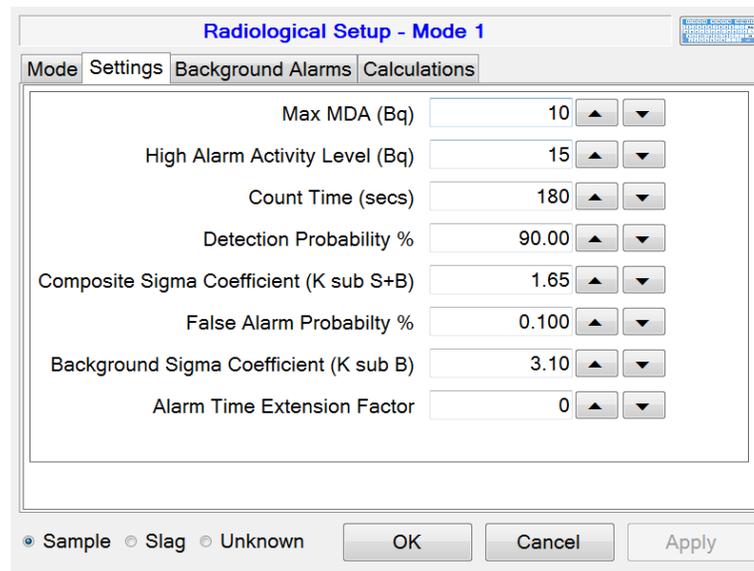
Max MDA – Sets the Mode 1 maximum MDA value. If the calculated MDA is greater than this value, a high background is posted. This value is set in specified activity units and is automatically converted when changed. The default value is 675 Bq.

High Alarm Activity Level – If an alarm exceeds this value, it is considered to be a high alarm. A high alarm displays a different message than a low-level alarm.

MDA – Sets the minimum detectable activity used in Mode 2 and 3. This value is set in specified activity units and is automatically converted when changed. The default value is 675 Bq.

Count Time – Specifies the count time in seconds for Mode 1 and 2. The count time is adjustable from 6 to 1000 seconds. The default value is 10 seconds.

Max Count Time – Specifies the maximum allowed count time in seconds for Mode 3. If the computed count time is greater than this value, a high background is posted. The count time is adjustable from 6 to 1000 seconds. The default value is 60 seconds.

Minimum Count Time – Specifies the minimum count time allowed in seconds for Mode 3. The computed count time will not be allowed to be less than this value. The count time is adjustable from 6 to 1000 seconds. The default value is 6 seconds.

Detection Probability % - Sets the detection probability percentage for all counting modes. Changing this value updates the K_{S+B} parameter. The detection probability is adjustable from 0 to 100 %. The default value is 95%.

K_{S+B} – Sets the composite sigma coefficient for all counting modes. Changing this value updates the Detection Probability % parameter. The detection probability is adjustable from 0 to 100. The default value is 1.65.

False Alarm Probability % - Sets the false alarm probability for all counting modes. Changing this value updates the K_B parameter. The false alarm probability is adjustable from 0 to 100 %. The default value is 0.10%.

K_B – Sets the background sigma coefficient for all counting modes. Changing this value updates the False Alarm Probability % parameter. The detection probability is adjustable from 0 to 100. The default value is 4.00.

Alarm Time Extension Factor – Sets a multiplier of elapsed time that is used whenever an alarm condition is detected. The alarm time extension factor is adjustable from 0 to 1000. The default value is 0.

Fast Clean

The Fast Clean option provides the ability to determine if a sample is clean before the count time has completed. If enabled, the accumulated count rate is evaluated at the end of each one-second interval throughout the countering cycle. If the count rate is statistically shown to have a very high probability of being free of contamination, an early clean condition will be posted immediately after the minimum count time has elapsed. The Fast Clean option only applies to the individual detectors and the Sum Channel. The following equation is used:

Individual Detectors Enabled

$$\frac{Accumulated\ Counts}{T_E} < R_B + MDA \times Eff - K_{S+B} \sqrt{\frac{MDA \times Eff + R_B}{T_E} + \frac{R_B}{T_B}}$$

Only Sum Channel Enabled

$$\frac{Accumulated\ Counts}{T_E} < R_B + MDA \times Eff - K_B \sqrt{\frac{MDA \times Eff + R_B}{T_E} + \frac{R_B}{T_B}}$$

Where:

T_{min} = Computed minimum count time.

K_{S+B} = Composite sigma coefficient for controlling the false alarm probability.

K_B = The background sigma coefficient.

MDA = Minimum Detectable Activity.

Eff = Detector efficiency.

R_B = Average background count rate in cps for the detector.

T_B = Background count time in seconds.

T_E = Elapsed count time since the start of the countering cycle.

If all single-detector channels and/or the sum channel are found to satisfy this test, then a clean condition is posted immediately.

Fast Alarm

The Fast Alarm option provides the ability to determine if a sample is contaminated before the count time has completed. If enabled, the counts required for an alarm condition are calculated at the end of each one-second interval and compared to the accumulated counts. A Fast Alarm will only be posted after the minimum count time has elapsed. The following equation is used:

$$\frac{Accumulated\ Counts}{T_E} > R_B + K_B \sqrt{\frac{R_B}{T_E} + \frac{R_B}{T_B}}$$

Where:

R_B = Average background count rate in cps for the detector.

K_B = Background sigma coefficient.

T_B = Background count time in seconds.

T_E = Elapsed count time since the start of the countering cycle.

Sum zone alarm conditions are not processed using the Fast Alarm algorithm.

Individual Alarms

Alarms can be enabled for individual detectors or for the sum channel only. When the individual detectors are enabled, then the sum zones and the sum channel are also active. When the individual detectors are disabled, then only the sum channel is enabled.

Units of Measure

The activity units of measure are used where a value is displayed as an activity. When changing the activity unit, the activity is automatically converted into the new unit of measure. The following units of measure are supported:

- dpm
- pCi
- nCi
- μci
- mCi
- Ci
- Bq
- kBq
- MBq

The count rate units are used where a value is displayed as a count rate. The following units of measure are supported:

- cps
- cpm

Updating Background

A new background is taken after the Supervisor application is started. The background count time is set here and is valid from 30 to 600 seconds. The default value is 120 seconds. A background update is forced when returning to the Operate screen from the Setup menu or when the Update button is pressed. During this time the Sample counter is considered not ready for use. Once a new background update is complete, the background is updated once every second.

The Sigma Limit and Sigma OK parameters are used to detect sudden increases or decreases in the background. If the sigma for the current one-second count is greater than the last one-second count, a tentative background update is started. If after 10 seconds the background falls to within the Sigma OK parameters, the background is restored and normal operation continues. If after 10 seconds background is greater than the Sigma OK parameter, a background alarm is posted.

Background Update Method

The background update method involves using a simple "sliding window" for computing an average. A FIFO buffer the size of the number of seconds in the background update count time is created. After the full background update, this buffer will be filled with readings in cps. As additional counts are collected, the oldest count will be replaced with the newest count, and an average will be calculated using the equation:

$$Avg_{New} = Avg_{Old} + \frac{x_{Newest} - x_{Oldest}}{N}$$

Where:

Avg_{New} = New background average in cps. This is the new value for R_B used in other equations.

Avg_{Old} = Old background average in cps.

x_{Newest} = Newest one-second count in FIFO buffer.

x_{Oldest} = Oldest one-second count in FIFO buffer.

N = Number of samples in the FIFO buffer.

To determine when a new background update is required, the following equation is used:

$$\sigma = \frac{x_{Newest} - (Avg_{Old})}{\sqrt{Avg_{Old}}}$$

If the sigma is greater than or equal to Sigma Limit parameter, a tentative 10-second background update is started. If the count rate returns to within the sigma value set by the Sigma OK parameter of the old average rate at the end, the old background average is kept. If it has not, then a background fail is posted.

Background Alarms

Each detector has a low and high background alarm set point, which is used to identify a detector that is failing. If the background drops below the low set point or goes above the high set point, a detector failure will occur. A low or high background alarm normally signals a failure of either the detector or its associated preamp electronics. A high-background alarm can also warn of some nearby strong source of radiation.
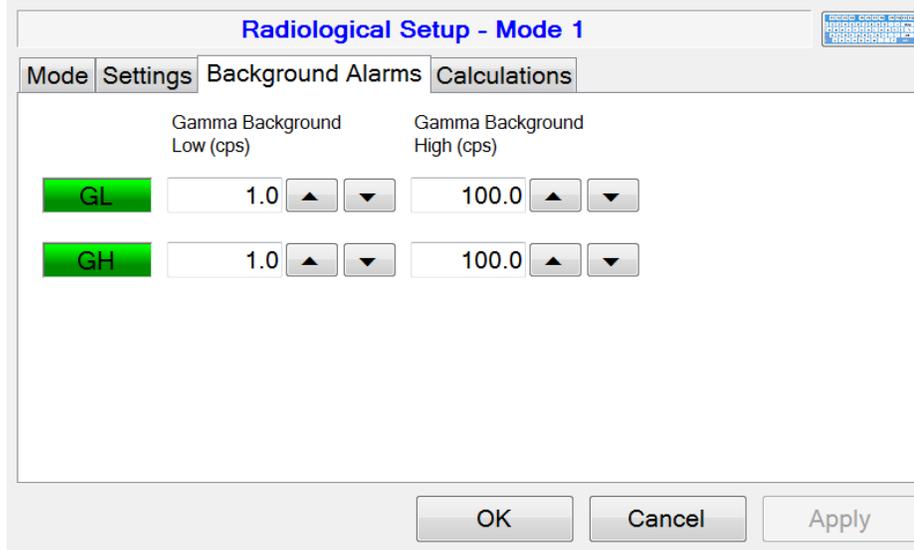
Calculations

The Calculations tab shows the current alarm set point and other values relating to the counting mode for all detectors, sum zones, and sum channel. These values are updated once per second. In the far right column, Mode 1 and 3 show the sensitivity, and Mode 2 shows the false alarm probability.

The background is displayed in cpm or cps, depending on the units selected along with the background and alarm set point adjusted for the current count time. The composite efficiency for each detector, sum zone, and sum channel is displayed.
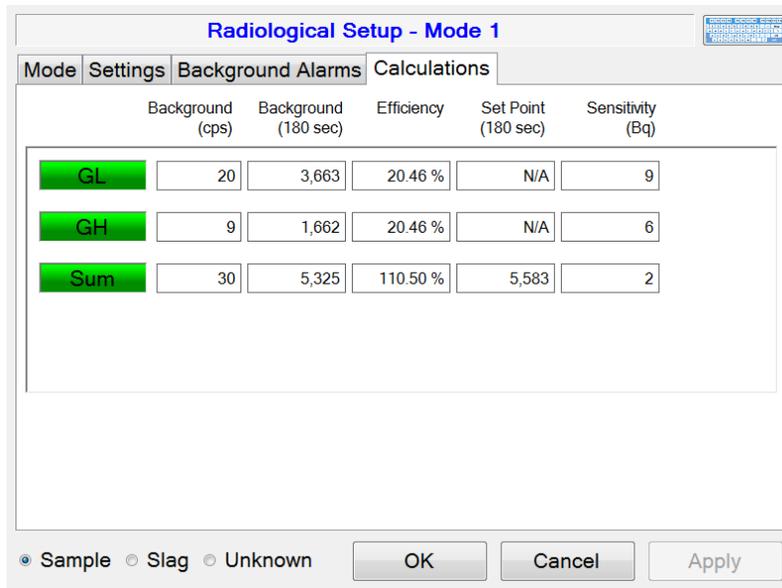
Section
8

Operational Setup

The Operational Setup screen is used to configure the various options that define how the Supervisor software operates.

General

Serial Number
Set the serial number of the Sample Counter. This is displayed on the title bar of the Operate screen. The serial number is also stamped onto a plate mounted on the top inside corner of the Sample Counter.

Site
User-defined field 20 characters in length. The Site is displayed in the title bar of the Operate screen.

Location
User-defined field 15 characters in length. The Location is displayed in the title bar of the Operate screen.

Customer ID

User-defined field 10 characters in length. The Customer ID is displayed in the title bar of the Operate screen.

Password

Two-level numeric password. A Level 1 password does not allow access to the following setup screens: Radiological, Operational, FOM, Variance/Mean, and False Alarm. A password is required to access the setup menu and to exit/reboot/shut down the application.

User-defined Sample Names

Name 1, 2 and 3 are user-defined text fields used to designate between the three different types of samples. Default is "Steel", "Slag", and "Unknown".

Model Number

Configure the software for the correct model number. The Model 2100 has a conveyer, and the 2100-1 uses a sample tray.

Alarm Hold

Sets the number of seconds before the alarm will automatically clear. When the alarm hold time is set to zero, pressing the Acknowledge button once within six seconds of the alarm will silence the audio, and pressing it again after six seconds will clear the alarm. When the alarm hold time is greater than zero, pressing once will silence the audio, and pressing again will have no effect.

Conveyor Timeout (s)

This parameter, in seconds, defines how long the conveyor will run when the input infrared sensor detects an object, but the chamber infrared sensor does not sense the object entering the chamber. This does not apply to the Model 2100-1.

Conveyor Cal (100ms)

This parameter adjusts the calibration of the conveyor speed in 100 ms increments. This does not apply to the Model 2100-1.

Conveyor Feed Out (s)

This parameter adjusts the time in seconds that the conveyor will run to remove the sample from the chamber. This does not apply to the Model 2100-1.

Options

Require Sample ID to Start Count

When enabled, the user must enter in a Sample ID before a counting cycle can be started. The Sample ID is logged in the scan log.

Require Password to Clear Alarms

When enabled, the Level 1 or 2 password is required before the alarm can be cleared.

Show Alarm Result

When enabled, this option will display as a percentage of how much over the alarm set point the reading was.

Read sample ID from c:\sample.txt

When enabled, this sample ID is read from C:\sample.txt. The sample ID must be the first line in the file.

Print Sample Report

When enabled, a sample report is sent to the default printer showing the results of the last sample count.

Require Sample ID Validation

When enabled, the Sample ID must fit the pattern set in the Sample ID tab.

Log Scan Record to CSV File

When enabled, each sample is recorded in a comma delimited file. The file contains the date, time, status, sample id, and sum channel activity. This file is stored in a CSV folder under the data folder.

Language

Operational Setup

General | Options | Language | Logging | Com | Network | Sample ID

Select Language   English

OK   Cancel   Apply
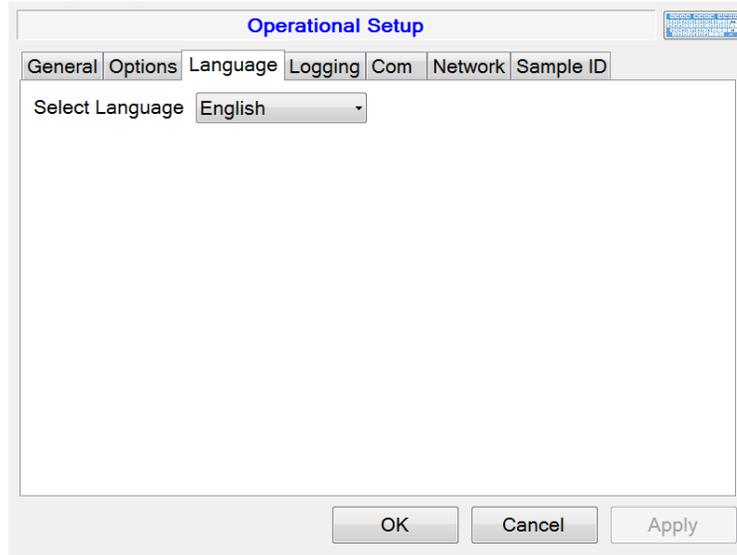
The language tab allows other languages, if available, to be implemented throughout the software screens.

Logging

Operational Setup

General | Options | Language | Logging | Com | Network | Sample ID

Enabled
○ Yes
○ No

Background Logging
Minute(s)   5

Data Directory
C:\Program Files\Ludlum Measurements, Inc\Model 2100   Browse

OK   Cancel   Apply
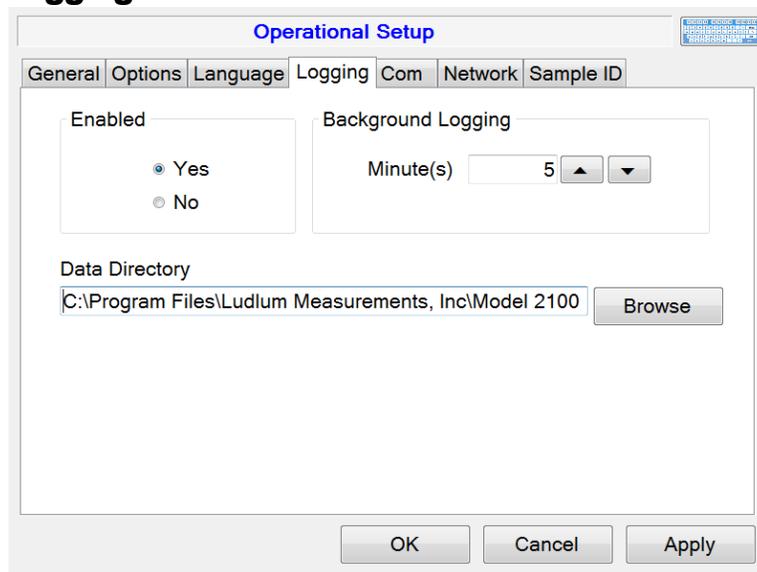
The Logging screen is used to set whether data logging is enabled, the directory where the data will be logged, and how often to log the background readings. When logging is disabled, no data will be saved to the scan, background, and system event logs.

Com
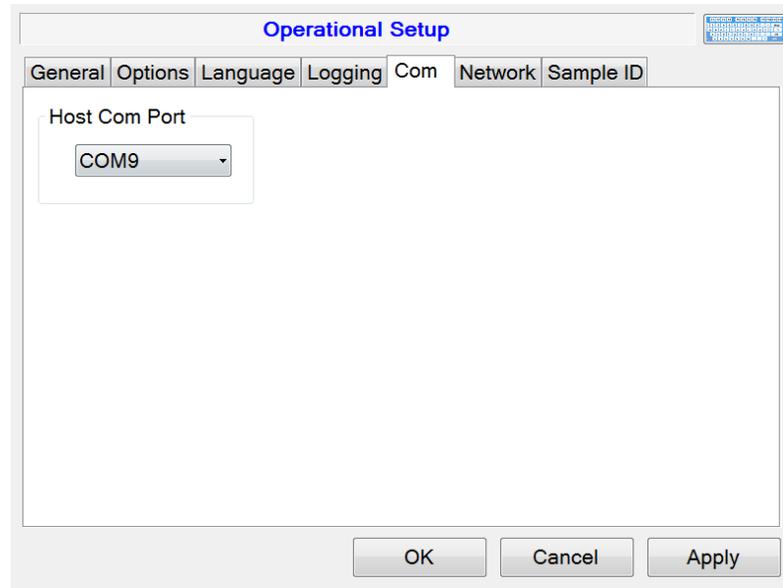
The Com screen is used to select the RS-232 communication port used by the onboard computer to the host board. This is set at the factory, and normally should not need to be changed.

Network

The Network screen is used to configure the Model 2100 Sample Counter to communicate over the Ethernet network. The first configuration, the Universal Configuration, enables the LMI data collection service, which provides web-based access to view the data. The second configuration defines the communication to the optional Model 272E remote viewer.

Overall operation on an Ethernet network can be described as the Model 2100 pushing or serving data to the two connections shown above. The Model 2100's own IP address is defined in the operating system's Network Properties screen, and can either by dynamically or statically defined. It is probably best, though not mandatory, that the Universal server and Model 272E Remote be given static IP addresses. If they were dynamically reassigned a new IP address, then the link would be lost until the parameters on this screen were also changed.

Sample ID

By setting the options here, the sample ID can be validated to meet a specific format. Each sample type has its own ID format that can be set including a sub ID.
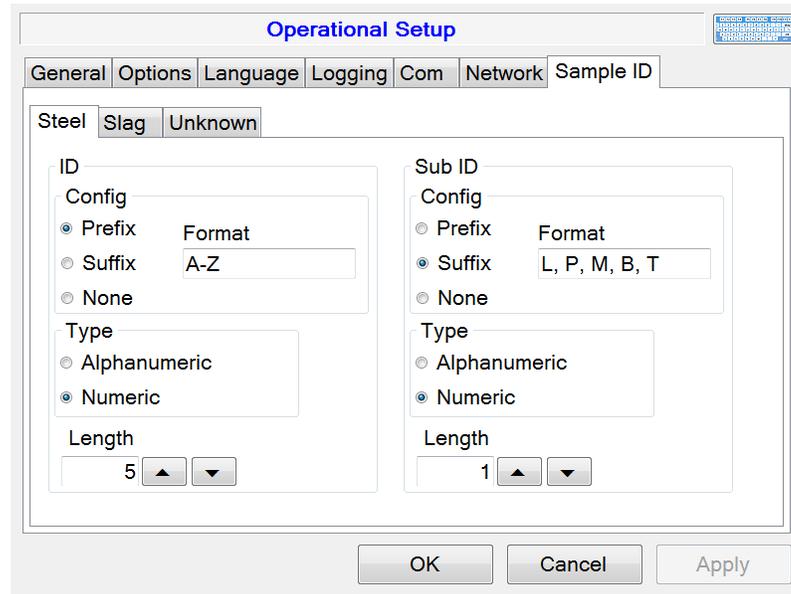
The sample id is comprised of two sections: ID and a Sub ID. Each can be configured individually. Each section can have a prefix or suffix and can take a specified length of numeric or alphanumeric characters.

The Format field accepts a list of comma separated values, the value "A-Z" and a dash "-" character. The values can be single or groups of alphanumeric characters. Valid values are: A-Z, AB, AC, A1, B2, -. Using the format of A-Z means that it can be any letter A though Z. The sample ID much match the pattern set here for it to be considered valid.

Examples:

Prefix of one letter followed by five numbers with a sub ID of one number with a suffix of the following: L, P, M, B, T.

ID Prefix:	Selected
ID Format:	A-Z
ID Type:	Numeric
ID Length:	5
Sub ID Prefix:	Selected
Sub ID: Format:	L, P, M, B, T, -
Sub ID Type:	Numeric
Sub ID Length:	1

A valid sample ID is: A12345L1, B12345M2, C12345-3

An invalid sample ID is: 612345M1, B12345P2, 61234533

Prefix of one letter followed by five numbers with a sub ID of one number with a suffix of the following: LF, LS.

ID Prefix:	Selected
ID Format:	A-Z
ID Type:	Numeric
ID Length:	5
Sub ID Suffix:	Selected
Sub ID: Format:	LF, LS
Sub ID Type:	Numeric
Sub ID Length:	0

A valid sample ID is: A12345LF, B12345LS, C12345LF

An invalid sample ID is: 612345FS, B12345P2, 61234533

ID is a 25 digit alphanumeric value.

ID Non:	Selected
ID Format:	
ID Type:	Alphanumeric
ID Length:	25
Sub ID Suffix:	None
Sub ID: Format:	
Sub ID Type:	Numeric
Sub ID Length:	0

A valid sample id is any combination of letters and numbers up to 25 characters long.

Section
9

Detectors

The Detectors screen is used to view and set the detector's high voltage, lower-level discriminator, and upper-level discriminator. The calibration constants can be set through an easy-to-use wizard, which guides the user through the process. The current background readings can also be viewed here.

Background
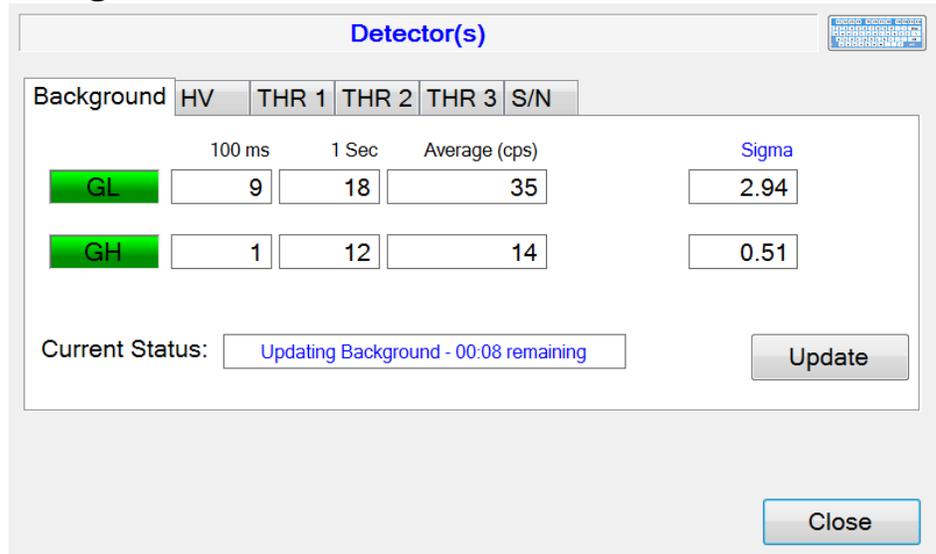
The background screen shows the current background detail for each detector. Status for each detector is displayed using the background color of the detector indicators. Count data is received from the host board every 100 ms. These 100 ms counts are accumulated together every one second. The Average count is the current background average. The Sigma is the standard deviation from the old background average and the new one-second count.

These values only update when the background is updating. The detector indicators will change color to indicate the detector's status with green for OK, yellow for fail, and red for alarm. The current Sample Counter status is displayed at the bottom. Press the Update button to start a new background update cycle.

High Voltage (HV)

The HV screen displays the current high-voltage set point and calibration constants for each detector. High voltage is typically set using the FOM-HV screen. Read-back voltage is the value from the A/D converter. There are two calibration constants associated with the high voltage. The Actual calibration constant is used to calibrate the high-voltage output while the read-back calibration constant is used to calibrate the read-back value from the A/D converter. The high voltage is adjustable from 0 to 2500 V, and the calibration constants are adjustable from -9.9 to +9.9. Click the Refresh button to reload the parameters from all detector boards. After changing the high-voltage set point, click the Save button to apply the changes. The calibration constants can only be changed from the Voltage Calibration Wizard.
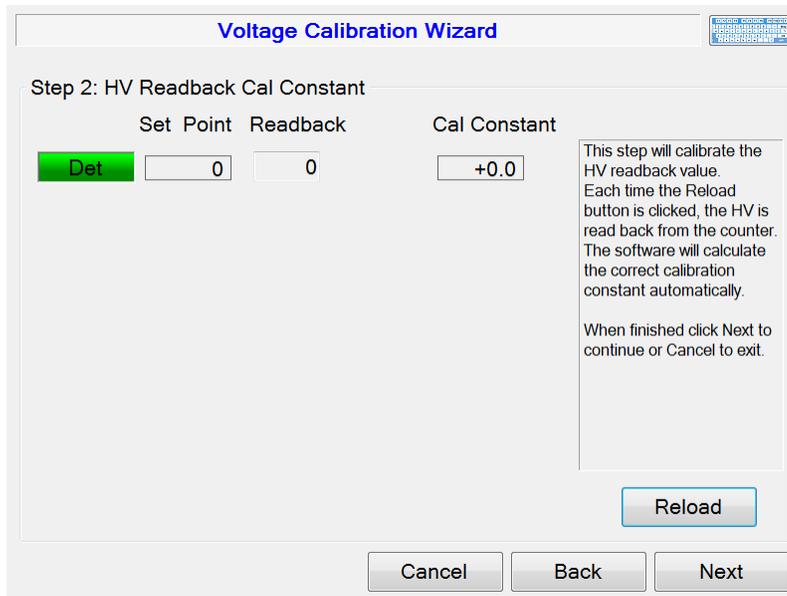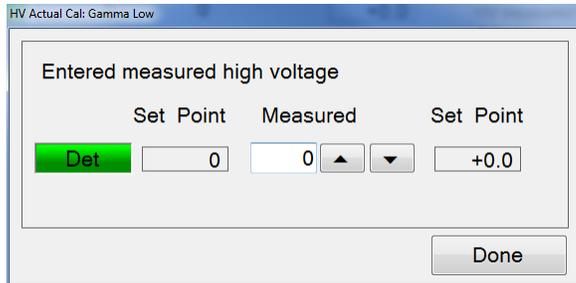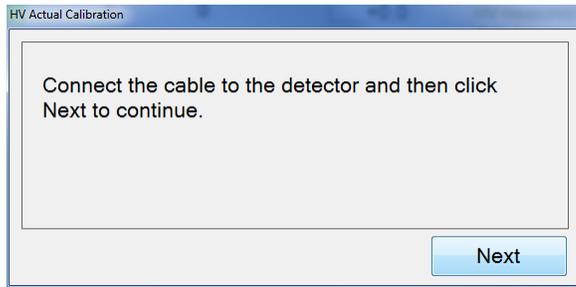
Voltage Cal

The Voltage Cal button appears on the HV, THR 1, THR 2, and THR 3 tabs. Clicking this button on any of the tabs will start the Voltage Calibration Wizard. Voltage calibration consists of measuring the voltage at test points and setting a calibration constant for each voltage.
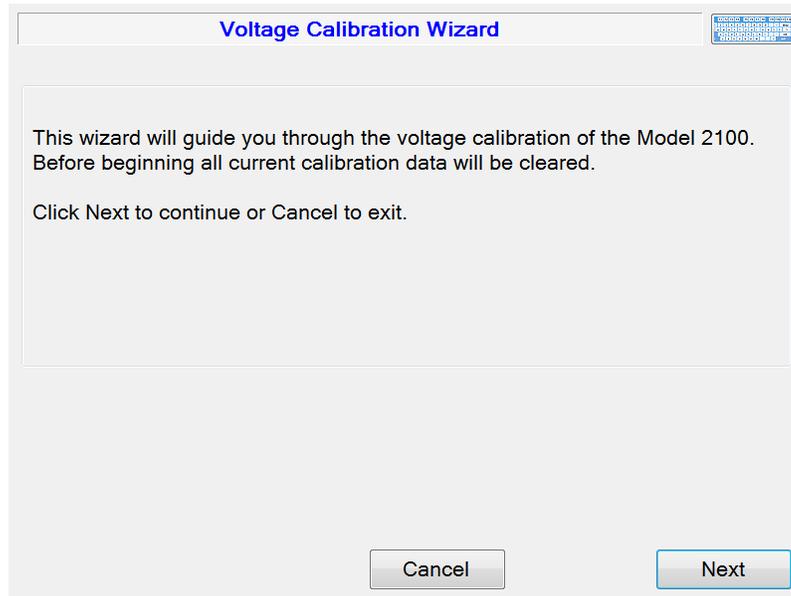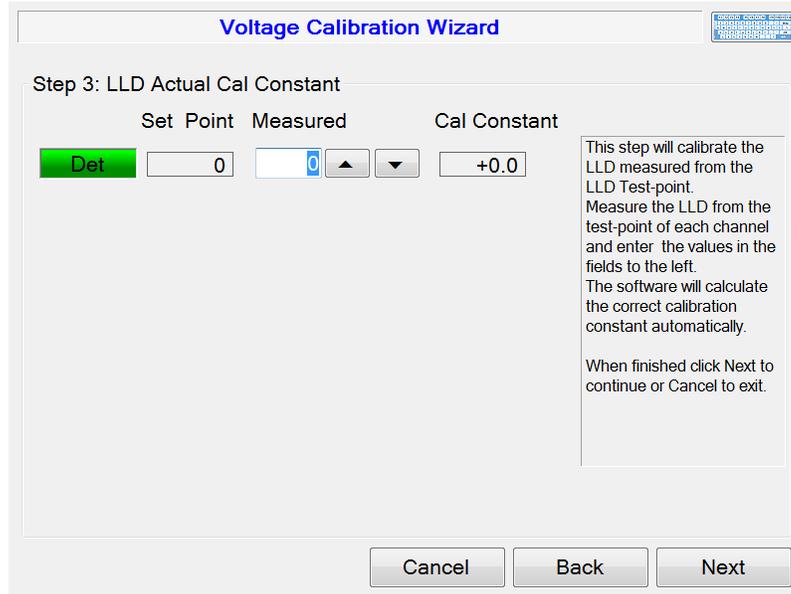
Click Next to reset all calibration data and start the wizard. Follow the on-screen prompts to set all calibration constants.
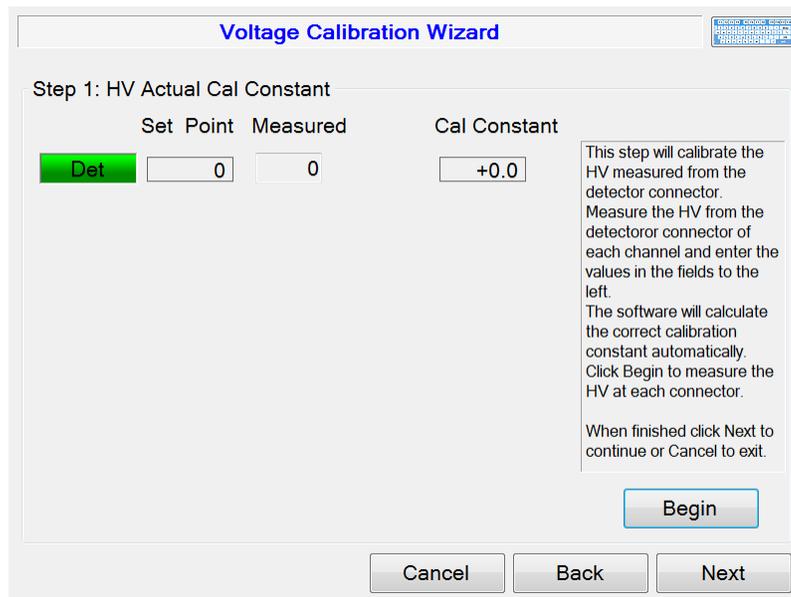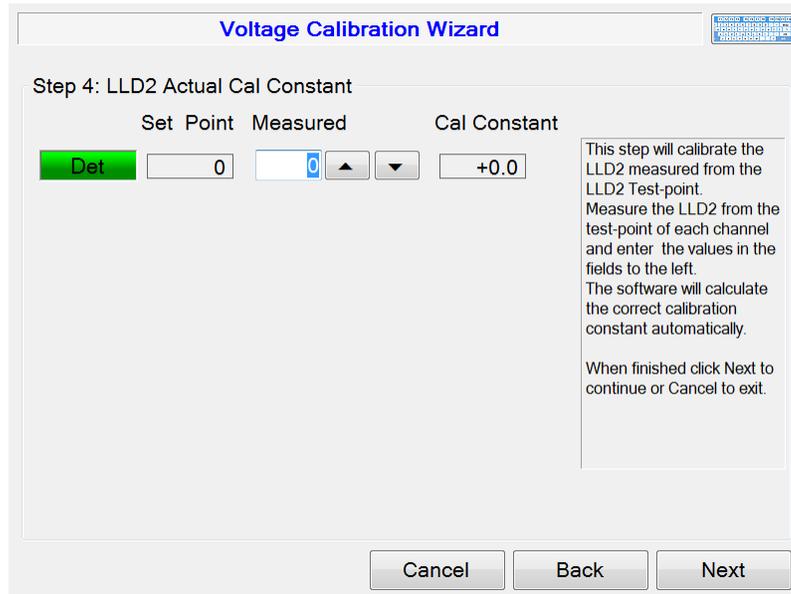

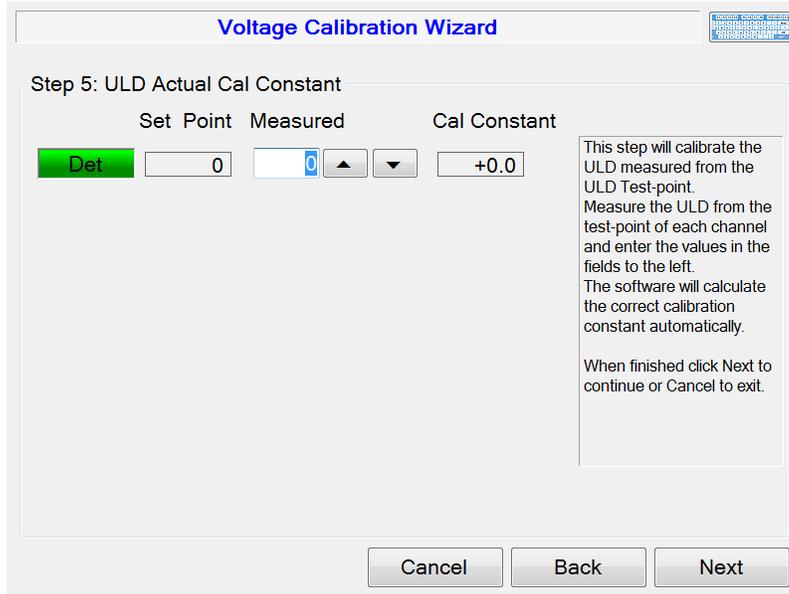**HV Actual Calibration Constant**

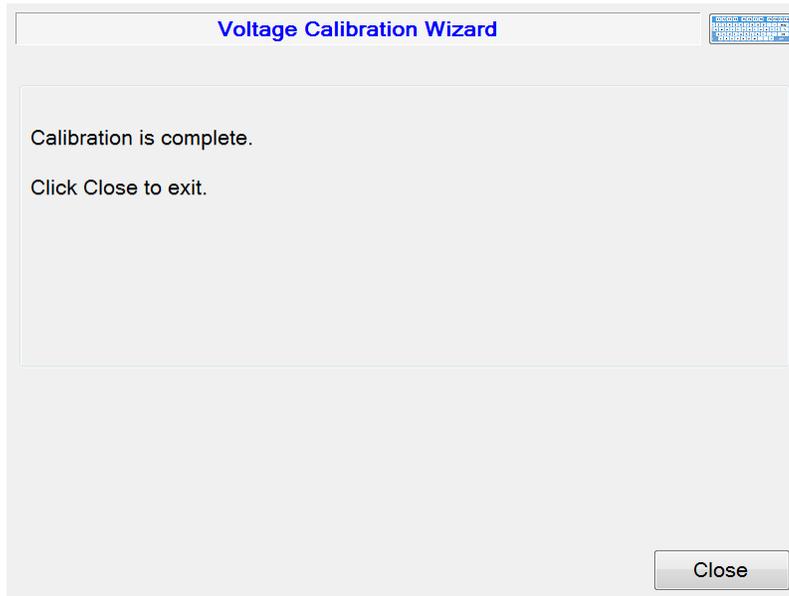**HV Readback Calibration Constant**

LLD (THR 1) Actual Calibration Constant

LLD2 (THR 2) Actual Calibration Constant

ULD (THR 3) Actual Calibration Constant

Click Close to exit the Voltage calibration Wizard.

THR 1 (Threshold 1)

The THR 1 screen displays the current lower-level set point and calibration constant for each detector. Read-back is the value from the A/D converter and should be close to the set point. The Actual calibration constant is used to calibrate the THR 1 output. The THR 1 is adjustable from 0 to 3300 mV, and the calibration constant is adjustable from -9.9 to +9.9. Click the Refresh button to reload the parameters from all detector boards. After changing the THR 1 set point, click the Save button to apply the changes. The calibration constant can only be changed from the Voltage Calibration Wizard. See below for more information on the Voltage Cal button.

THR 2 (Threshold 2)

The THR 2 screen displays the current upper-level set point and calibration constant for each detector. Read-back is the value from the A/D converter and should be close to the set point. The Actual calibration constant is used to calibrate the THR 2 output. The THR 2 is adjustable from 0 to 3300 mV, and the calibration constant is adjustable from -9.9 to +9.9. To enable the THR 2, check the detector's check box, and to disable the THR 2, uncheck the check box. Click the Refresh button to reload the parameters from all detector boards. After changing the THR 2 set point, click the Save button to apply the changes.

THR 3 (Threshold 3)

The THR 3 screen displays the current upper-level set point and calibration constant for each detector. Read-back is the value from the A/D converter and should be close to the set point. The Actual calibration constant is used to calibrate the THR 3 output. The THR 3 is adjustable from 0 to 3300 mV, and the calibration constant is adjustable from -9.9 to +9.9. To enable the THR 3, check the detector's check box. To disable the THR 3, uncheck the check box. Click the Refresh button to reload the parameters from all detector boards. After changing the THR 3 set point, click the Save button to apply the changes.

S/N (Detector Serial Number)
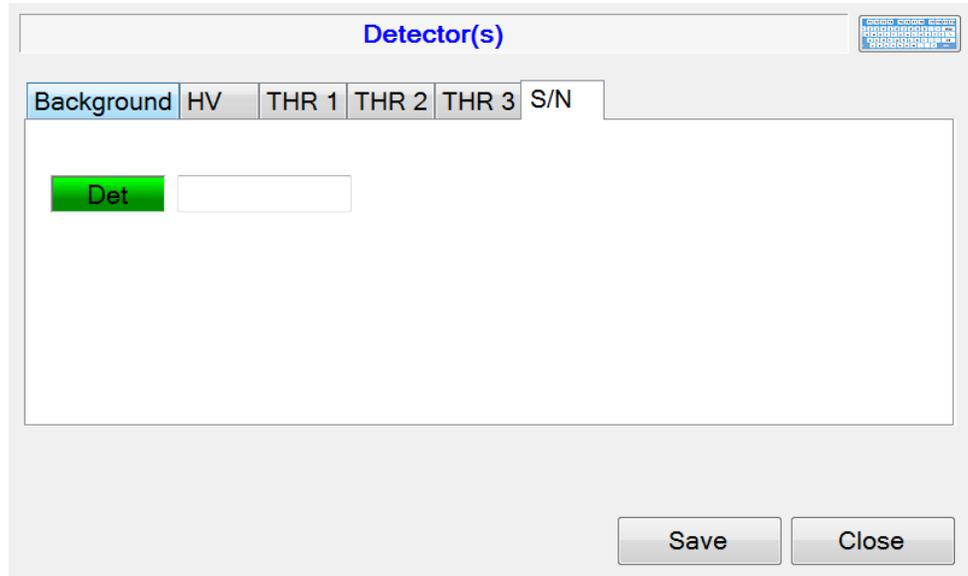
The Detector S/N screen has a single user-defined entry for the detector serial number, which is saved onto data records produced by the software.

Section

16

Efficiencies

The Efficiency screen is used to configure the efficiencies for each detector. These efficiencies are used in calculating alarm points and determining the activity of the unknown source.

Configuration

The Configuration tab is where the count times and detectors are selected. In addition to the individual detectors, the sum channel can also be selected. The count times are adjustable from 1 to 300 seconds.

The Sources tab is used to configure up to five sources that will be used in determining the efficiencies.

Sources

Up to five sources can be used in determining the efficiency. For each source, the half-life, certification date, and activity can be set. The current activity is automatically determined based on the data entered for the source.

To edit a source, select it from the list. The default names for the sources are Source-1, Source-2, Source-3, Source-4, and Source-5. After selecting a source, its parameters can be changed. After changing the parameters, click the Save button to save the changes.

The current activity is calculated using the following equation:

$$A_F = A_o e^{-KT}$$

Where:

A_F = Current activity

A_O = Original activity

K = 0.693 / half-life in days

T = Elapsed time in days from certification date

Click on the Efficiencies tab to view efficiencies for the detectors.

Isotopic Mix

The isotopic mix is used to create a weighted average efficiency during countering cycles. Up to five isotopes may be used, which are defined in the Sources tab. The percentages must add up to 100%. The isotope names default to Source-1, Source-2, Source-3, Source-4, and Source-5, but will be updated to reflect the isotope names defined in the Sources tab.

Efficiencies

A grid displays the count and efficiency data for all detectors. Each detector and the Sum channel have efficiency data calculated on the selected combination of

detector(s), isotope, and configuration. After selecting the detectors, isotope and configuration, click the Start button to begin. A background will be taken for all selected detectors. After the background count is complete, place the source in the appropriate location on the conveyor. The efficiency will be calculated after the source count is taken and is the net count divided by the source size.

Section

17

View Logs

The View Log screen is used to view various log files and reports. Log files and reports are saved in the Data Directory specified in the Logging tab of the Operational screen. The Sample Counter creates several log files automatically. These are:

- System Log

- Background Log

- Scan Log

Log files are named with a prefix of the date and time in the format of YYYYMMDD and have a file extension of .log. These files are ASCII text files and are viewable in any program that can read text files. New log files are created for each day.

The system log file records events relating to the status of the Sample Counter such as:

- Starting and stopping the Supervisor application

- Commands sent to the host board

- Current status

- Door and push-button events

- Alarms and failures

The background log file records the current background and detector status at an interval specified in the logging tab of the Operational screen.

The scan log file records information about the results of the countering of a sample including:

- Date/Time

⚛ Sample ID, if required

⚛ Status and which detector alarmed, if any

⚛ Count time

⚛ Detector readings

Most setup screens have an option to save a report. These reports can be viewed here as well.

Section

18

Changes

Software-Firmware Compatibility
Version 1.0.0 –54003n01

Version 1.0.1 - 54003n01
"Sample" and "Slag" now user-defineable.
Fixed issue that caused host communication error.

Version 1.2.0 - 54003n02
Added support for the Model 2100-1.

Version 1.2.1 - 54003n02
Added support for two Universal connections.
Fixed issues with Universal connection.
Made changes for smoother barcode operation.

Version 1.2.2
Changed references for LLD, LLD2, and ULD to Threshold 1, Threshold 2, and Threshold 3. Changed order of thresholds on detector window to make better sense.

Version 1.2.3
Changed so when barcode is scanned, the count is started automatically.

Version 1.2.4
Fixed issue with Gamma Low alarm always alarming.
Added option to read sample ID from c:\sample.txt.

Version 1.2.5
Changed scan reports to show readings to match mains screen.
Added Sample ID format verification
Added sample report
Added third sample type, default name is "Unknown"
Updated default values.
Misc. bug fixes

Version 1.2.6
Updated sample ID format to allow a dash "-" character.

Version 1.2.7
Added option to disable sample ID verification.
Fixed issue where sum channel was incorrectly shown as an alarm in the Universal software.

Version 1.2.8
Added option to save samples individually into a .CSV file.

Version 1.2.9
Fixed issue where a full background update was being run after a tentative background update.

Version 1.3.0
Fixes issue with HV calibration.

Section

19

Recycling

Ludlum Measurements, Inc. supports the recycling of the electronics products it produces for the purpose of protecting the environment and to comply with all regional, national, and international agencies that promote economically and environmentally sustainable recycling systems. To this end, Ludlum Measurements, Inc. strives to supply the consumer of its goods with information regarding reuse and recycling of the many different types of materials used in its products. With many different agencies – public and private – involved in this pursuit, it becomes evident that a myriad of methods can be used in the process of recycling. Therefore, Ludlum Measurements, Inc. does not suggest one particular method over another, but simply desires to inform its consumers of the range of recyclable materials present in its products, so that the user will have flexibility in following all local and federal laws.

The following types of recyclable materials are present in Ludlum Measurements, Inc. electronic products, and should be recycled separately. The list is not all inclusive, nor does it suggest that all materials are present in each piece of equipment:

- Batteries
- Glass
- Aluminum and Stainless Steel
- Circuit Boards
- Plastics
- Liquid Crystal Display (LCD)

Ludlum Measurements, Inc. products, which have been placed on the market after August 13, 2005, have been labeled with a symbol recognized internationally as the "crossed-out wheelie bin." This notifies the consumer that the product is not to be mixed with unsorted municipal waste when discarding; each material must be separated. The symbol will be placed near the AC

receptacle, except for portable equipment where it will be placed on the battery lid.