LUDLUM MODEL 54 SERIES
54, 54A, 54R, 54R-1, & 54R-11
ARTICLE MONITORS

OPERATOR'S MANUAL

March 2021

Version 1.1.4 / 54001N03

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

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

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

REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	6/6/11	CMC

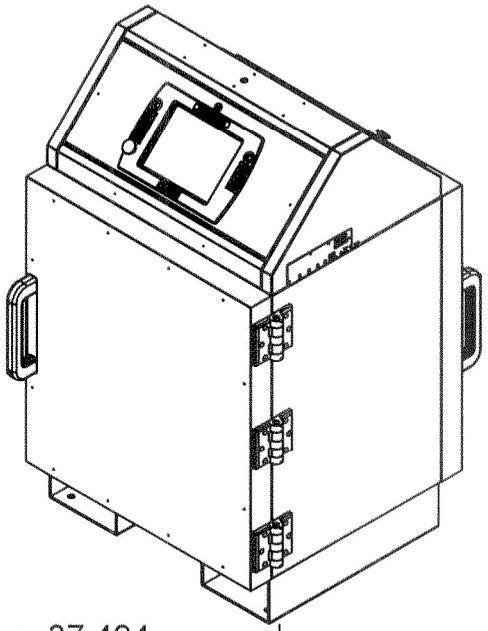
SPECIFICATIONS:

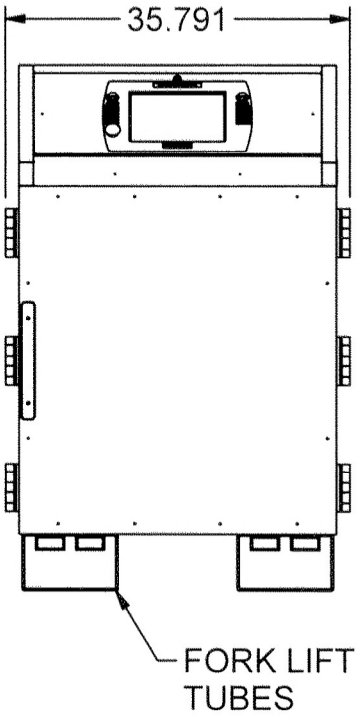
CHAMBER:
INTERNAL DIMENSIONS 20.0(50.8cm) X 20.0(50.8cm) X 20.0(50.8cm)
MAT'L: 0.031 STAINLESS STEEL (OTHER MAT'L OPTION)

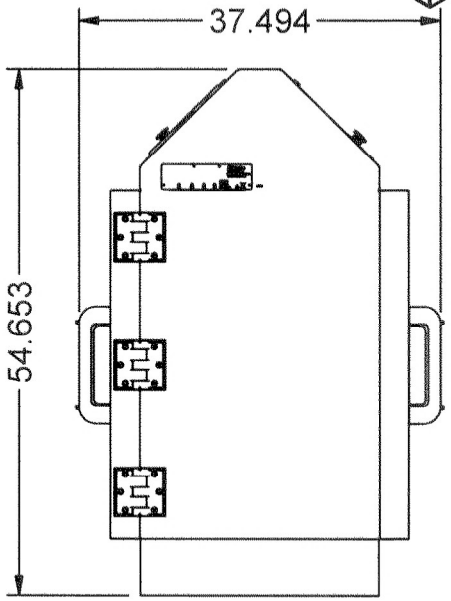
SCINTILLATOR SIZE = 19.0(48.26cm) X 19.0(48.26cm) X 2.0(5.08cm)

WEIGHT:
NO LEAD = APPROXIMATELY 1200 LBS
1" OF LEAD = APPROXIMATELY 2900 LBS
2" OF LEAD = APPROXIMATELY 4600 LBS

DOOR SWING IS REVERSIBLE







DWN	DATE	CHK	DATE	APP	DATE
ABM	01/03/20			JGW	1-3-20

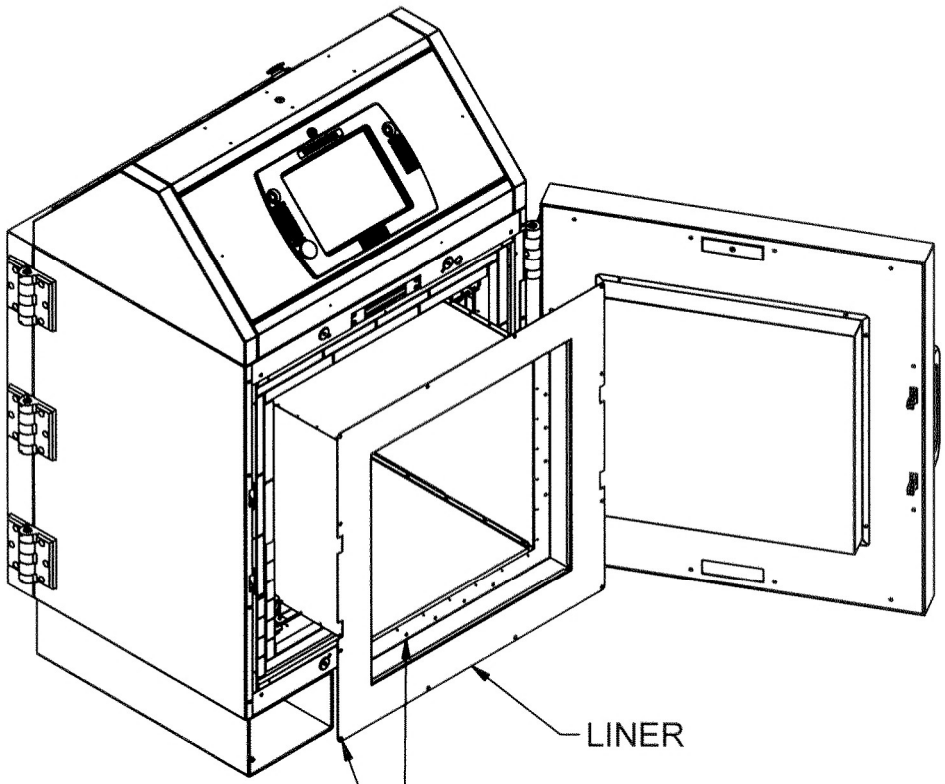
DWG NUM: 4540-004 SCALE: 1/2

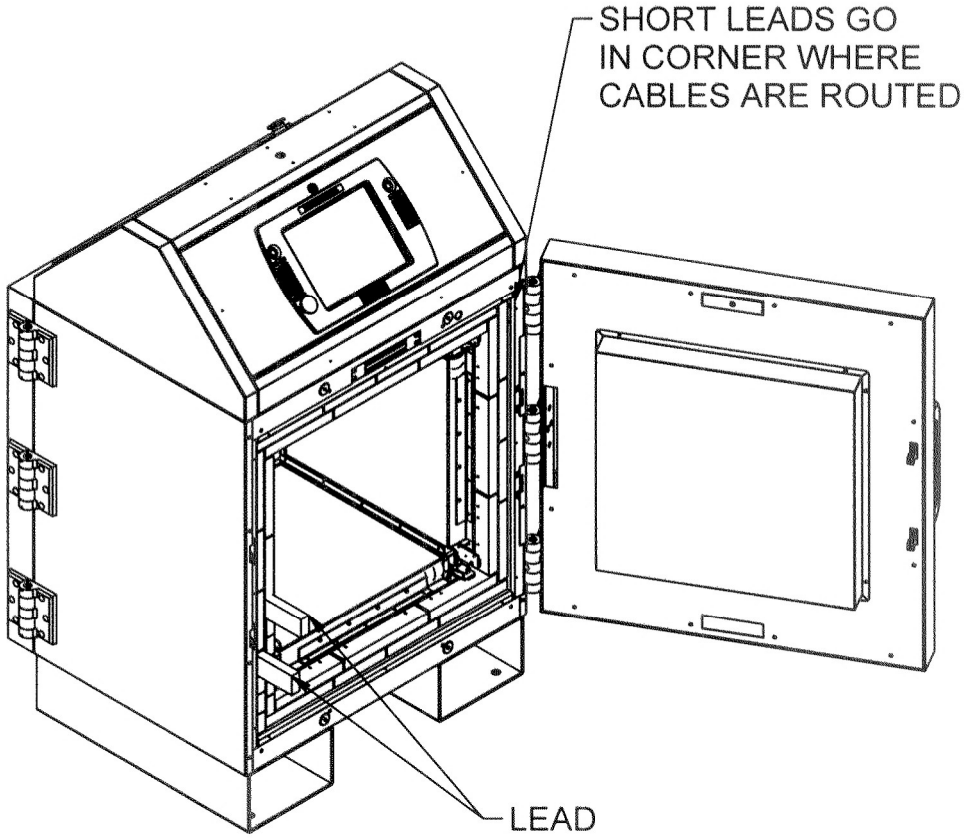
TITLE M 54 OVERALL DIMENSIONS

LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES 540 SHEET 4

REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	6/6/11	CMC





TO LOAD LEAD REMOVE THE OUTER
AND INNER SCREWS TO ACCESS
THE LEAD HOLDING AREA.

NOTE:
LOAD LEAD INTO
CABINET BEFORE
LOADING LEAD INTO DOORS

DWN	DATE	CHK	DATE	APP	DATE
ABM	01/03/20			JGW	1-3-20

DWG NUM: 4540-004 | SCALE:

TITLE M 54 LEAD LOADING CABINET

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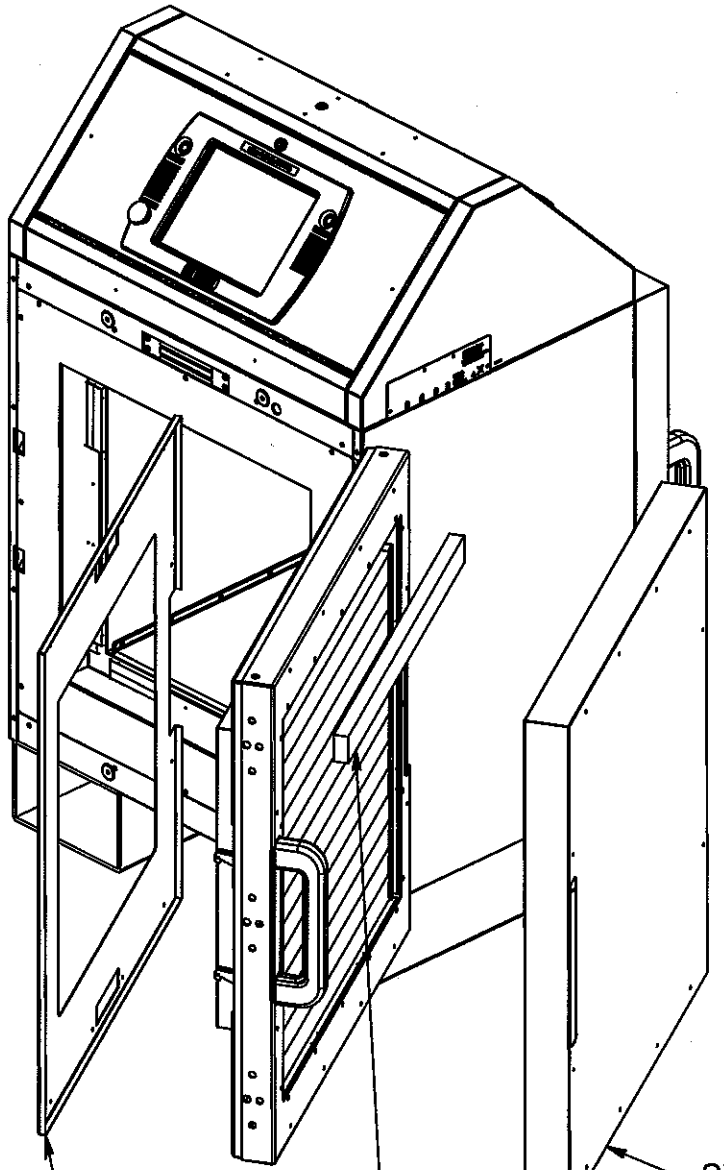
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES	SHEET
540	4A

REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	6/6/11	CMC



STEP 1
REMOVE INNER
COVER

STEP 3
PLACE LEAD
INTO SLOTS

STEP 2
REMOVE OUTER
COVER

NOTE:
LOAD LEAD INTO
CABINET BEFORE
LOADING LEAD INTO DOORS

DWN	DATE	CHK	DATE	APP	DATE
CMC	6-6-11			WBW	6-6-11

DWG NUM: 4540-004 SCALE: 1:1

TITLE M 54 LEAD LOADING-DOOR

LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES 540

SHEET 4B

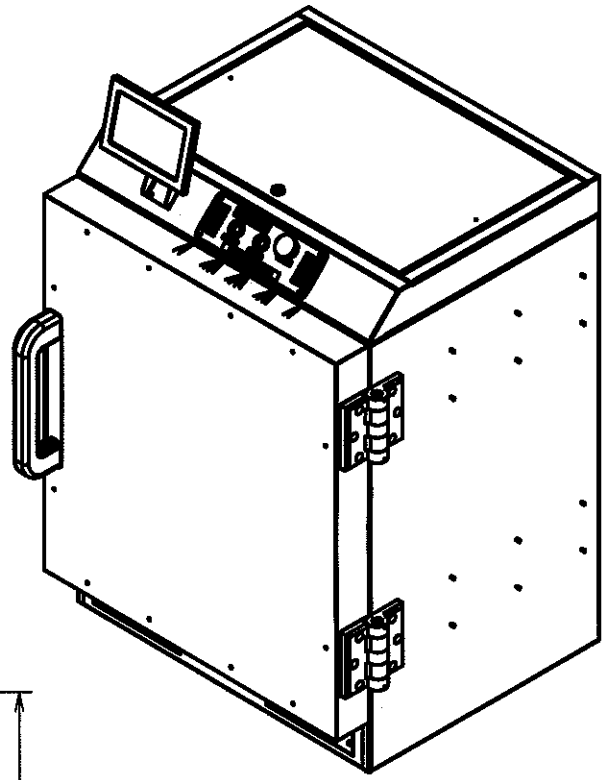
SPECIFICATIONS:

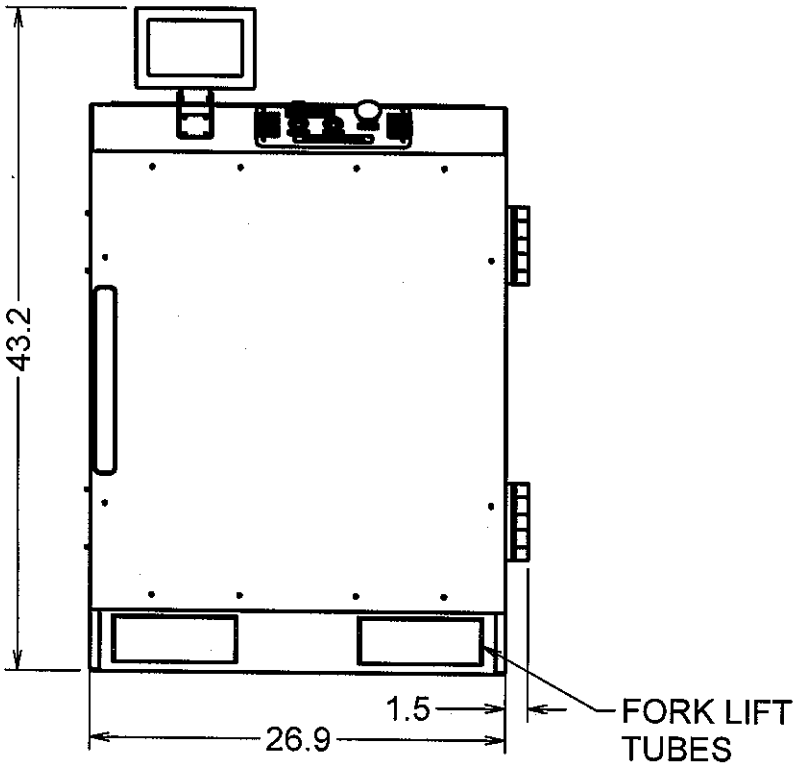
CHAMBER:
INTERNAL DIMENSIONS 14.0"(35.6cm) X 14.0"(35.6cm) X 14.0"(35.6cm)
LINER MAT'L: .031 STAINLESS STEEL (OTHER MATERIALS AVAILABLE)

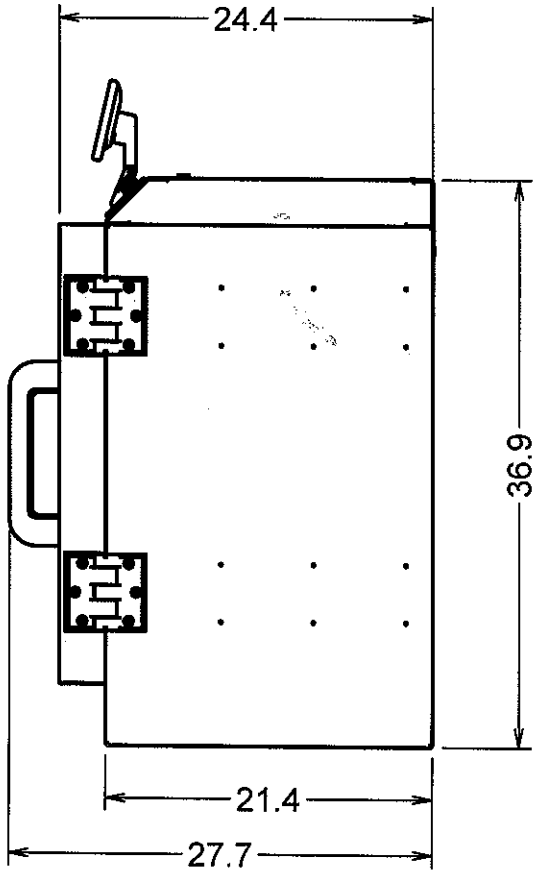
SCINTILLATOR SIZE = 13.0"(33.0cm) X 13.0"(33.0cm) X 2.0"(5.08cm)

WEIGHT :
WITHOUT LEAD = APPROXIMATELY 700 LBS
WITH 1" OF LEAD = APPROXIMATELY 1700 LBS
WITH 2" OF LEAD = APPROXIMATELY 2750 LBS

DOOR SWING IS REVERSIBLE







DWN	DATE	CHK	DATE	APP	DATE
ZCH	5-19-11			MBW	5-19-11

DWG NUM: 4540-358 SCALE: 1:1

TITLE M 54A OVERALL VIEW

LUDLUM MEASUREMENTS, INC.
501 OAK STREET
SWEETWATER, TEXAS 79556

SERIES	SHEET
540	358

Table of Contents

Section 1

Introduction

The Model 54 Article Monitor is used to detect gamma radiation in or on small articles, tools, and equipment. The interior volume of the chamber is 50.8 x 50.8 x 50.8 cm (20 x 20 x 20 in.). The chamber is shielded with lead, making it fairly massive.

The Model 54A is a smaller version of the Model 54 with internal dimensions of 35.6 x 35.6 x 35.6 cm (14 x 14 x 14 in.). This version provides an option for monitoring smaller articles. Although a smaller size, the Model 54A exhibits the same features and operates in the same way as the Model 54.

The Model 54R, 54R-1, and 54R-11 are retrofit options that allow customers to use an existing article monitor from another manufacturer, but with the Ludlum Model 54 electronics. Existing detectors can also be replaced with Ludlum detectors if needed.

The Model 54R-11, is a specific set of electronics designed to fit an existing Thermo SAM-11 article monitor.

- For the remainder of this manual, references to the Model 54 will include the Model 54A and retrofit options unless otherwise noted.

The Model 54 is designed to be user-friendly. Users press only a single COUNT button in normal operation and see status clearly on the 30.7 cm (12.1 in.) color liquid crystal display (LCD). Instrument technicians have password-protected access to advanced automated routines to calibrate or verify operation. The Model 54 Article Monitor can be configured with several different options including:

- 2.5 or 5.1 cm (1 or 2 in.) thick lead shielding
- left or right-door swing
- optional second LCD display

There are three counting modes to maximize throughput, sensitivity, or to fix the count time. Several parameters can be modified to adjust the alarm set point, including the false alarm probability, detection probability, background sigma coefficient, and the composite sigma coefficient. Fast alarm and clean options provide the ability to determine if an article is contaminated or clean before the count cycle has ended.

The model number identifies the configuration of the Article Monitor. The first number is the basic series number. The second number is the number of detectors. The third number indicates the thickness of the lead shielding. The fourth number indicates the number of displays. So a Model 54-6-1-1 has the following configuration:

- 6 detectors
- 2.5 cm (1 in.) lead shielding
- 1 LCD display

Section 2

Features

- True 4π counting geometry for optimized homogeneous efficiency.
- Fast Alarm/Fast Clean counting technology for shorter counting cycles.
- Large 30.7 cm (12.1 in.) color LCD with touch screen interface.
- Three counting modes to maximize throughput, sensitivity, or fix the count time.
- Automatic background updating.
- Contaminated detector check.
- Individual detector and sum channel alarms.
- Two levels of password security.
- Door locks to control single or dual door operation.
- 5.1 cm (2 in.) thick lead shielding (option for 2.5 cm {1 in.}).
- Rugged, easy-swing hinges.
- Count, Background Update, and Alarm Acknowledge buttons.
- **Model 54:** 50.8 x 50.8 x 50.8 cm (20 x 20 x 20 in.) inside dimensions **Model 54A:** 35.6 x 35.6 x 35.6 cm (14 x 14 x 14 in.) inside dimensions
- Single Board Computer (SBC) running a Windows Operating System (Windows 7 at the time of this writing.)

Section 3 Specifications

CHAMBER

Internal Dimensions: **Model 54:** 50.8 x 50.8 x 50.8 cm (20 x 20 x 20 in.) (H x W x L)
Model 54A: 35.6 x 35.6 x 35.6 cm (14 x 14 x 14 in.) (H x W x L)

Detection Volume: **Model 54:** 130 L (4.6 ft^3)
Model 54A: 45 L (1.6 ft^3) for the Model 54A

Liner Material: 0.79 mm (0.031 in.) thick, stainless steel

Note: For the Model 54R or 54R-1, this depends on the customer's existing system.

DETECTORS

Four or six detector configurations available

Scintillator: EJ-200 plastic

Size: **Model 54:** 48.3 x 48.3 x 5.1 cm (19 x 19 x 2 in.) (H x W x D)
Model 54A: 33.0 x 33.0 x 5.1 cm (13.0 x 13.0 x 2.0 in.) (H x W x D)
Model 54R-1 (4 each): 30.5 x 89 x 5.1 cm (12 x 35 x 2 in) (H x W x D)
Model 54R-1 (2 each): 30.5 x 61 x 5.1 cm (12 x 24 x 2 in) (H x W x D)

DOORS

Reversible door swing

Door hinges are heavy-duty rated, incorporating ball bearings for smooth operation

Door locks to control single (or dual) door operation

MECHANICAL

Dimensions: **Model 54:** 139 x 90.9 x 95.3 cm (54.7 x 35.8 x 37.5 in.) (H x W x D)
Model 54A: 94.0 x 68.6 x 80.0 cm (37.0 x 27.0 x 31.5 in.) (H x W x D)

Note: For the Model 54R or 54R-1, this depends on the customer's existing system.

Weight:	0 cm (0 in.) of lead:	**Model 54** is approximately 544 kg (1200 lb) **Model 54A** is approximately 318 kg (700 lb)
	2.5 cm (1 in.) of lead:	**Model 54** is approximately 1315 kg (2900 lb) **Model 54A** is approximately 771 kg (1700 lb)
	5.1 cm (2 in.) of lead:	**Model 54** is approximately 2087 kg (4600 lb) **Model 54A** is approximately 1247 kg (2750 lb)

Lead is shipped separately and installed on site.

Model 54R: depends on the customer's existing system.
Model 54R-1: weight of system without lead is approximately 137 kg (303 lb)

ENVIRONMENTAL

Temperature: 0 to 50 °C (32 to 122 °F)

COUNTING

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

Alarms available for sum channels, sum zones, and individual detectors

Automatic background updating

Contaminated detector checking

False alarm control

Logs each use, operational test, and calibration

PERFORMANCE

Detects 2.2 nCi mixed $^{60}Co/^{137}Cs$ source in under 5 seconds

Section 4

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Section 5

Safety Considerations

Environmental Conditions for Normal Use

Indoor use only

No maximum altitude

Temperature range of 0 to 50 °C (32 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 54 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.

Lead Shielded Doors

The doors are shielded with lead, which makes them very heavy. Use caution when opening and closing the doors.

Electrical Safety Precautions

When installing the unit:

- Do not expose electronics to rain or an environment where they may be splashed by water or other liquids, as doing so may result in fire or electric shock.

- Use the unit only with the voltage specified. Using a voltage higher than that which is specified may result in fire or electric shock.

- Do not cut, kink, otherwise damage nor modify the power supply cord. In addition, avoid using the power cord in close proximity to heaters, and never place heavy objects – including the unit itself – on the power cord, as doing so may result in fire or electric shock.

- Avoid installing or mounting the unit or its power supply in unstable locations, such as on a rickety table or a slanted surface. Doing so may result in the unit falling down and causing personal injury and/or property damage.

Section 6

Operation

Controls and Functions

The following is a description of the controls and functions on the article monitor.

LCD Touch Screen: 30.7 cm (12.1 in.) color liquid crystal display (LCD) with integrated touch screen. An optional touch screen display may be mounted on the egress side, which mirrors the main display.

Count Buttons: green count buttons mounted on both the ingress and egress sides. Press this button after placing an article in the monitor to start the count.

Update Button(s): blue background update button mounted on the ingress side. An optional update button may also be mounted on the egress side.

Acknowledge Button(s): red alarm acknowledge button mounted on the ingress side. An optional update button may also be mounted on the egress side. Press button once to acknowledge the audio and again to clear the alarm.

Top Panel Doors: locking top-panel doors provide internal access to the power button and main electronics.

Light Stack with Audio: three color (Red, Yellow, and Green) lights indicate the article monitor status.

Front Door: ingress door secured by latch integrated into the door handle and magnetic lock.

Rear Door: egress door secured by latch integrated into the door handle and a magnetic lock.

Power on Self Test (POST)

When the Article Monitor 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 two minutes 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 54 On

1. Using the supplied key, unlock and open either top panel.
2. Connect the AC adapter to a 120 volt electrical outlet.
3. Turn the power switch on. The power switch is located on the circuit board mounted on the side. All relays and lights will be activated for approximately three seconds.
4. Close and lock the panel.
5. The Model 54 will take approximately two minutes to boot.

Powering the Model 54 Off

1. Tap the Exit button on the main screen and enter the level 1 or 2 password.
2. Tap the Shutdown Article Monitor button.
3. Wait until the message, "It is now safe to turn off your computer," is displayed.
4. Using the supplied key, unlock and open either door.
5. Turn the power switch off. The power switch is located on the circuit board mounted on the side.
6. Close and lock the panel.

Note: Do not turn off the Model 54 without first shutting down the computer.

Normal Operation

1. Open door.
2. Place article(s) to be monitored into chamber.
3. Close door.
4. Press count button.
5. After count has expired, remove the article. The door that is not opened automatically locks.
6. If an alarm occurred and contamination checks are enabled, the article monitor will start a count when the door is closed to check if the chamber has been contaminated.

Status Colors

The Article Monitor uses color to identify the status of the instrument at any given time. The status box in the upper left of the main screen and the detector map change colors depending on the various states of the article monitor and detectors. The colors are:

- Green – indicates the Article Monitor is ready to scan articles.
- Yellow – indicates the Article Monitor has a failure.
- Red – indicates the Article Monitor has a radiation alarm.
- White – indicates the Article Monitor is scanning an article.
- Blue – indicates the Article Monitor is initializing or updating background.

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

- Red – indicates the Article Monitor has a radiation alarm. In addition to the voice audible alert, there will be a fast beeping audible alarm.
- Yellow – indicates the Article Monitor is in a fail condition or is not ready to scan articles. If a fail condition, is present there will be a slow beeping audible alarm. While in any setup screens, when the Article Monitor is forcing a background update or when the Supervisor application is not running, the yellow light will be ON.
- Green – indicates the Article Monitor is ready to scan articles.

Instrument Failure

There are several conditions that cause system failure:

1. LOW BACKGROUND - The instrument continually checks the detectors for abnormally low readings as defined by the low background alarm set points. When this condition is detected, the detector map on the main screen will indicate which detector failed. 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 detector map on the main screen will indicate which detector failed. 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. At any rate, the possibility of such a nearby strong source of radiation warrants further investigation.

Sum Channels

The Model 54 can be set to the article monitor physical detectors, which are grouped into various sum zones composed of two and three detector combinations. The sum zones are defined as:

- Left + Top
- Top + Right
- Right + Bottom
- Bottom + Left
- Left + Front Door
- Top + Front Door
- Right + Front Door
- Bottom + Front Door
- Left + Rear Door
- Top + Rear Door
- Right + Rear Door
- Bottom + Rear Door
- Left + Top + Front Door
- Top + Right + Front Door
- Right + Bottom + Front Door
- Bottom + Left + Front Door
- Left + Top + Rear Door
- Top + Right + Rear Door
- Right + Bottom + Rear Door
- Bottom + Left + Rear Door
- Sum Channel (All Detectors)

Sum Zone Alarm Priority

Alarm priority is dependent on the number of detectors. A two-detector sum alarm will not be posted if either of its constituent detectors have alarmed. A three-detector sum alarm will not be posted if any of its single detectors or two-detector sum zones have alarmed. The sum channel will only alarm if no other detector or sum zone alarmed.

Section 7

Supervisor

The Model 54 Article Monitor is controlled by the Supervisor application. The supervisor is started automatically when the article monitor is booted. If the supervisor is not running, it can be started from the Model 54 Article Monitor icon on the desktop. When the supervisor is not running, the yellow light on the light stack will be lit to indicate that the article monitor is not in service.

Touch Screen Operation

For normal operation, the supervisor requires little to no interaction. When interaction is required, the supervisor can be controlled using the LCD touch screen 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, a numeric keypad is displayed to allow values to be changed easily.

Operate Screen

The Operate screen in normal operation of the article monitor contains the following:

Title Bar – displays the user-definable site, location, customer ID and LMI serial number of the article monitor.

Status Display – displays the current status of the article monitor. The status can be one of the following:

- Ready
- Door Open
- Clean
- Counting
- Alarm
- Failure
- Updating Background

- Initializing
- Contamination Check
- Contaminated

Status Text – displays information about the current status.

Clock/Timer – displays the current time when not counting and a countdown timer when the article monitor 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.

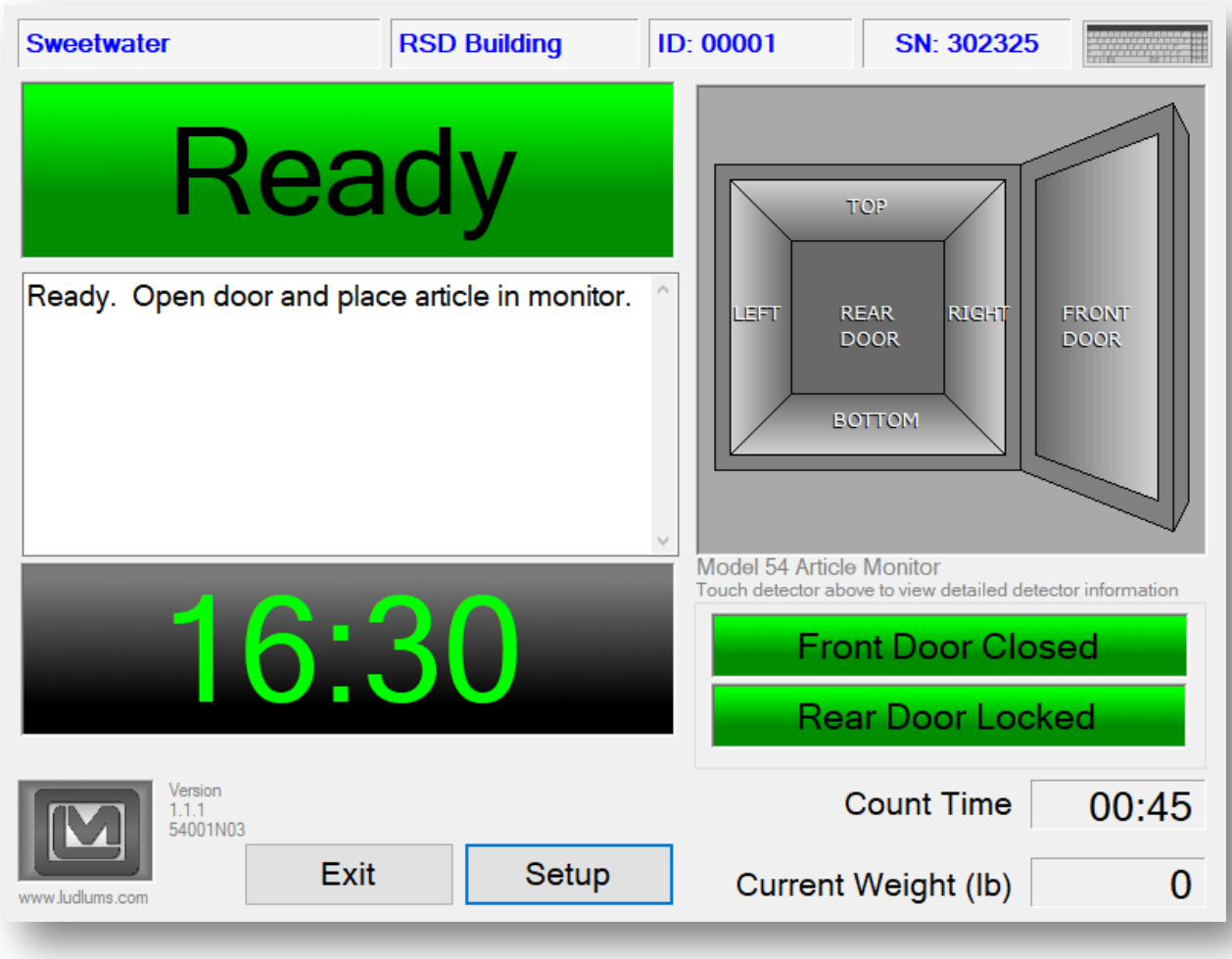
Door Indicators – indicate if a door is open, closed, or locked.

Alarm Activity – current alarm activity shown when only the sum channel option is enabled.

Exit Button – allows the user to exit the Supervisor application, restart the article Monitor, or shut down the article monitor. It is password protected.

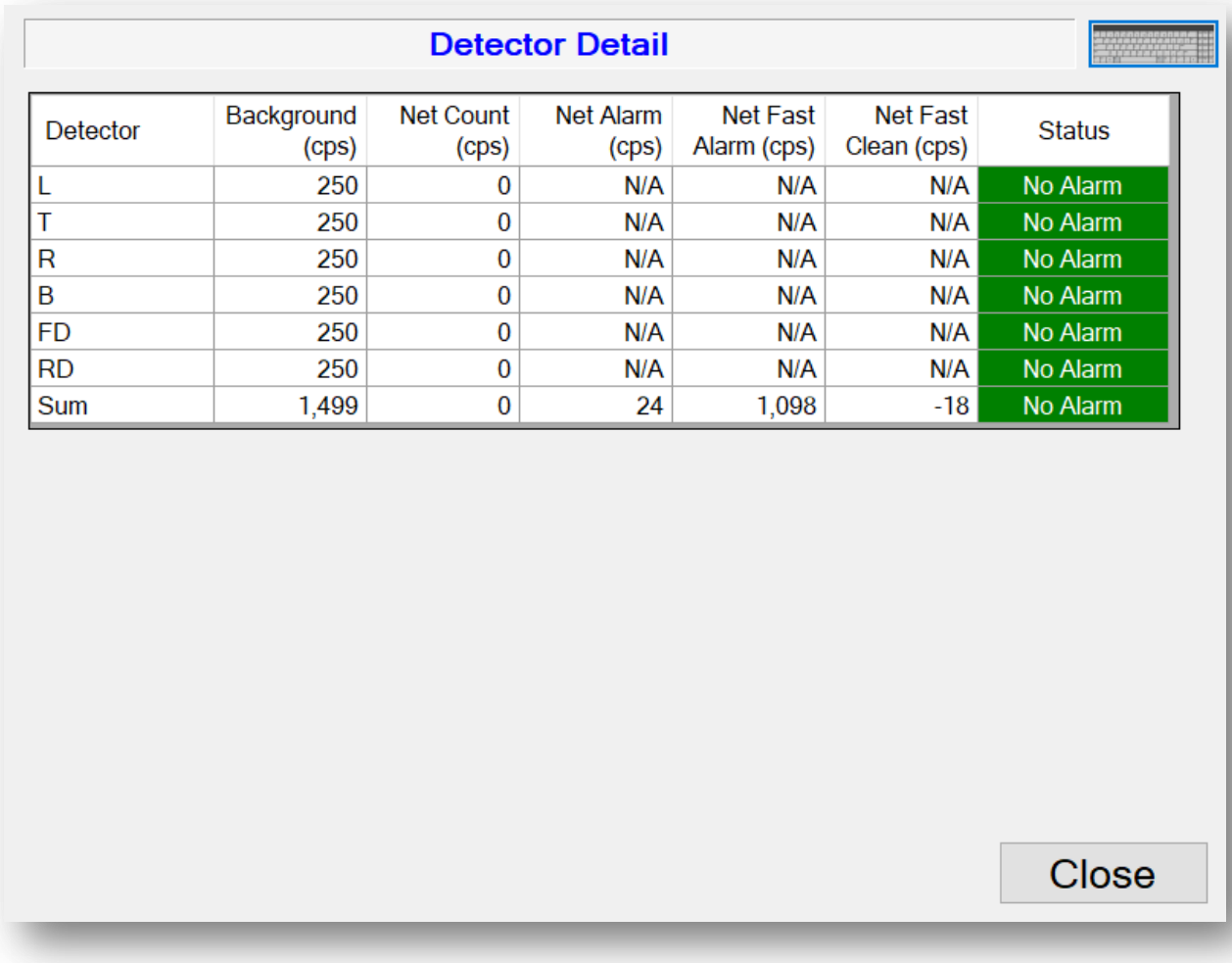
Setup Button – allows access to the various setup screens. It is password protected.

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



Detector Detail Screen

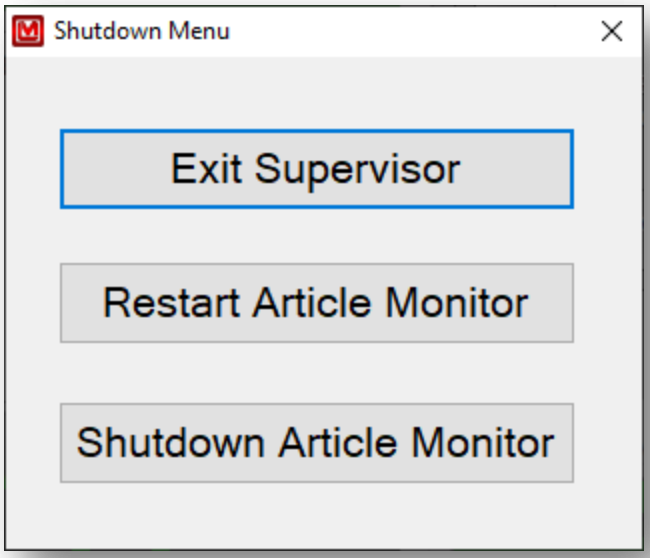
A detail screen for a detector can be displayed by tapping on the detector in the graphical display. The detail screen provides the background count, net count (if a count is in progress), alarm set point, and status. Also displayed are the values for each sum zone that the detector is included in. In Sum Channel Only mode, tapping on any detector will display all individual detectors plus the sum channel. When individual detectors are enabled, tapping on a detector will bring up that detector plus all sum zones that include the detector.



Detector	Background (cps)	Net Count (cps)	Net Alarm (cps)	Net Fast Alarm (cps)	Net Fast Clean (cps)	Status
L	250	0	N/A	N/A	N/A	No Alarm
T	250	0	N/A	N/A	N/A	No Alarm
R	250	0	N/A	N/A	N/A	No Alarm
B	250	0	N/A	N/A	N/A	No Alarm
FD	250	0	N/A	N/A	N/A	No Alarm
RD	250	0	N/A	N/A	N/A	No Alarm
Sum	1,499	0	24	1,098	-18	No Alarm

Shutdown Menu

The Shutdown menu provides access to restart or shut down the article monitor 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 article monitor properly through software before powering off; otherwise data corruption may occur.



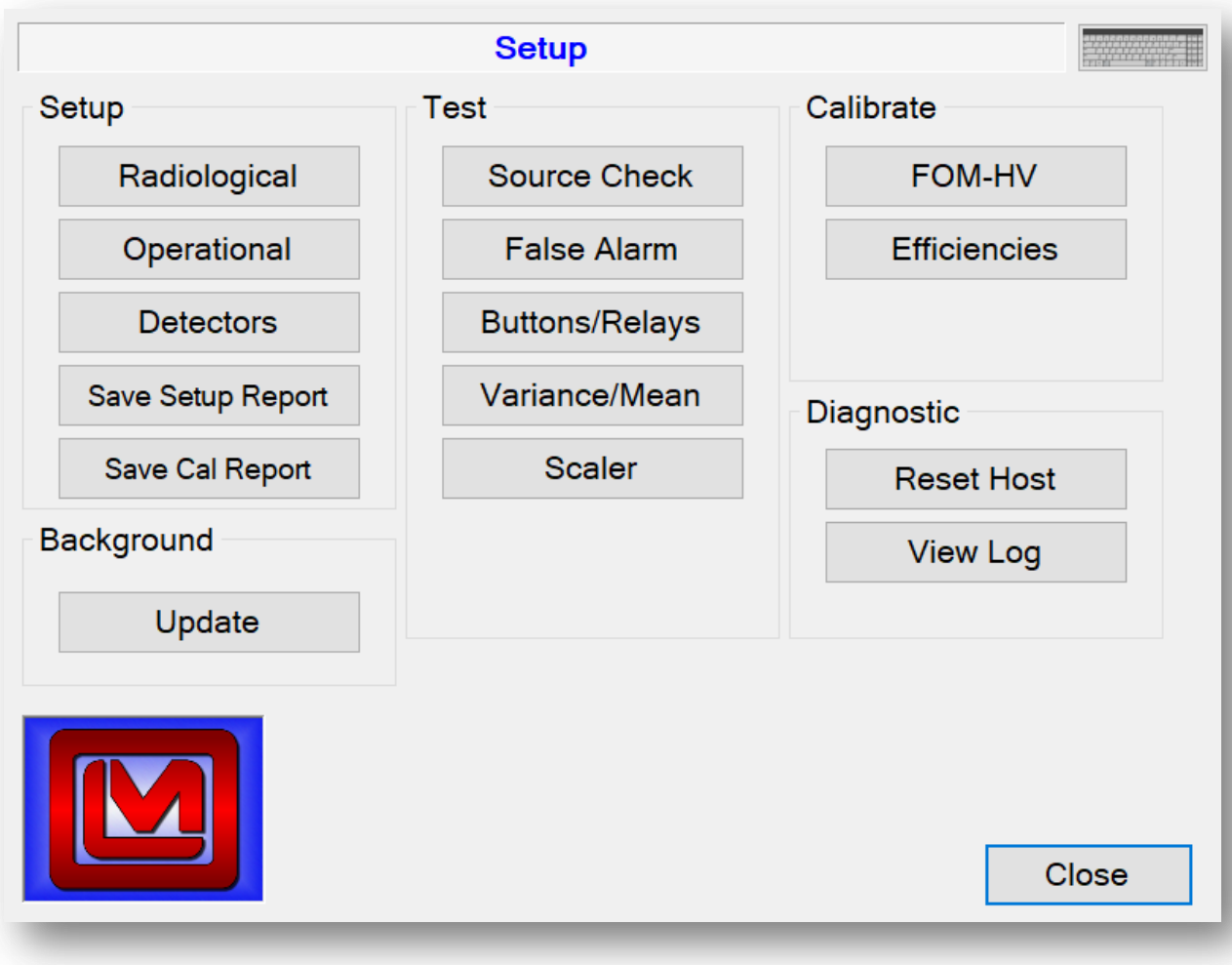
Exit Supervisor – Closes the Supervisor application and provides access to the operating system environment. This is necessary for performing software updates, configuring Windows settings such as printing or networking, or to provide access to the data files. A confirmation window will be displayed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

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

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

Setup Screen

The Setup button on the Operate screen provides access to the various setup and calibration functions of the article monitor. The level 1 or 2 password is required to access the Setup screen. The level 1 password does not provide full access to all setup functions. Radiological, Operational, FOM, Variance/Mean, and False Alarm screens are not available using the level 1 password.



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 (LLD), and upper level discriminator (ULD). A calibration wizard is available to calibrate the various voltages and calibration constants.

Save Setup Report – save a report, which contains the current hardware and software configuration.

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.

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

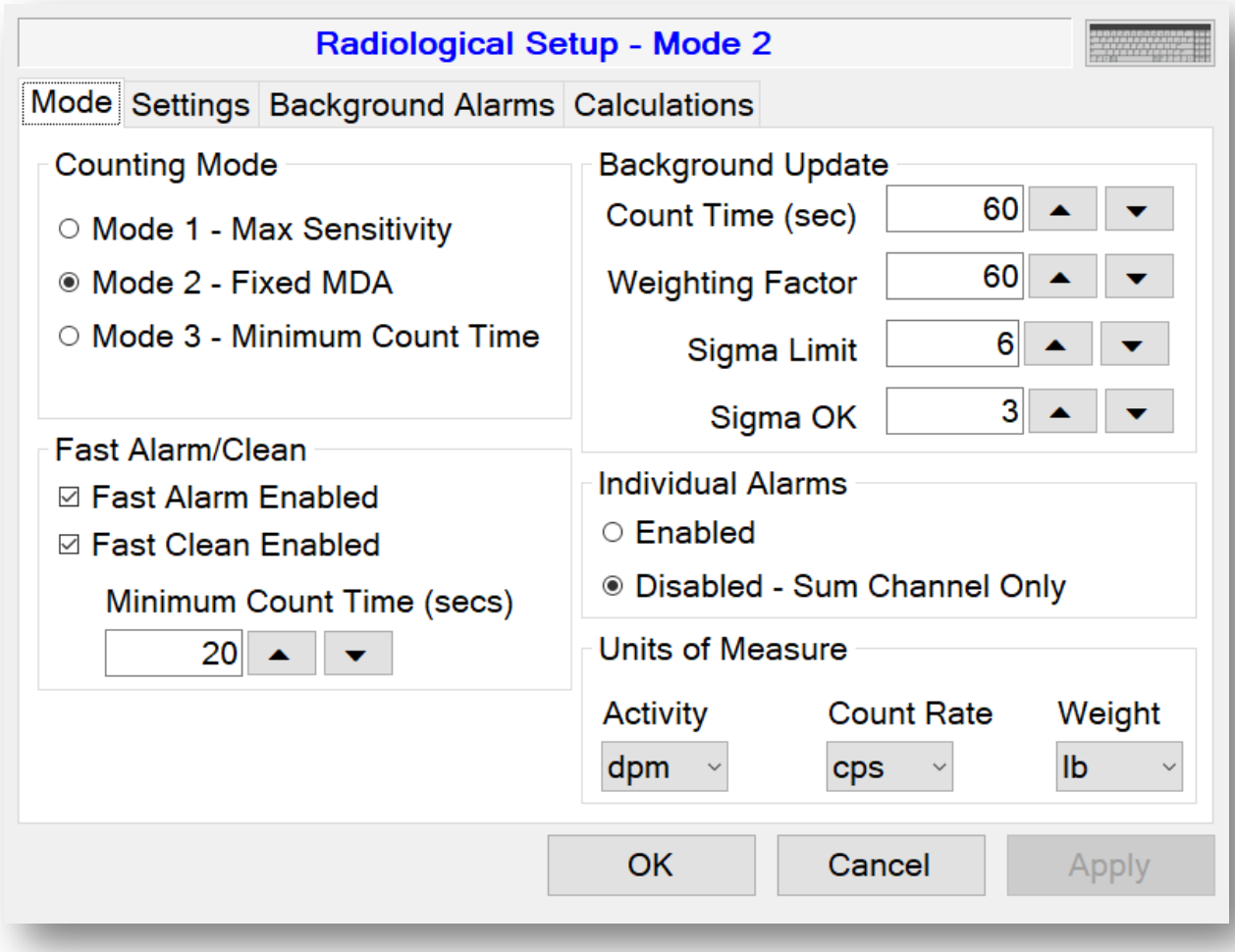
Efficiencies – calculate the efficiencies for each detector.

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 8

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. To set the changes immediately, press the Apply button.

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.

$$T = \left[\frac{K_B\sqrt{R_B} + K_{S+B}\sqrt{MDA \times Eff \times R_B}}{MDA \times Eff}\right]^{\frac{1}{2}}$$

The minimum count time is calculated as follows:

1. Calculate $R_{A(min)}$ and MDA using the Mode 1 equations.

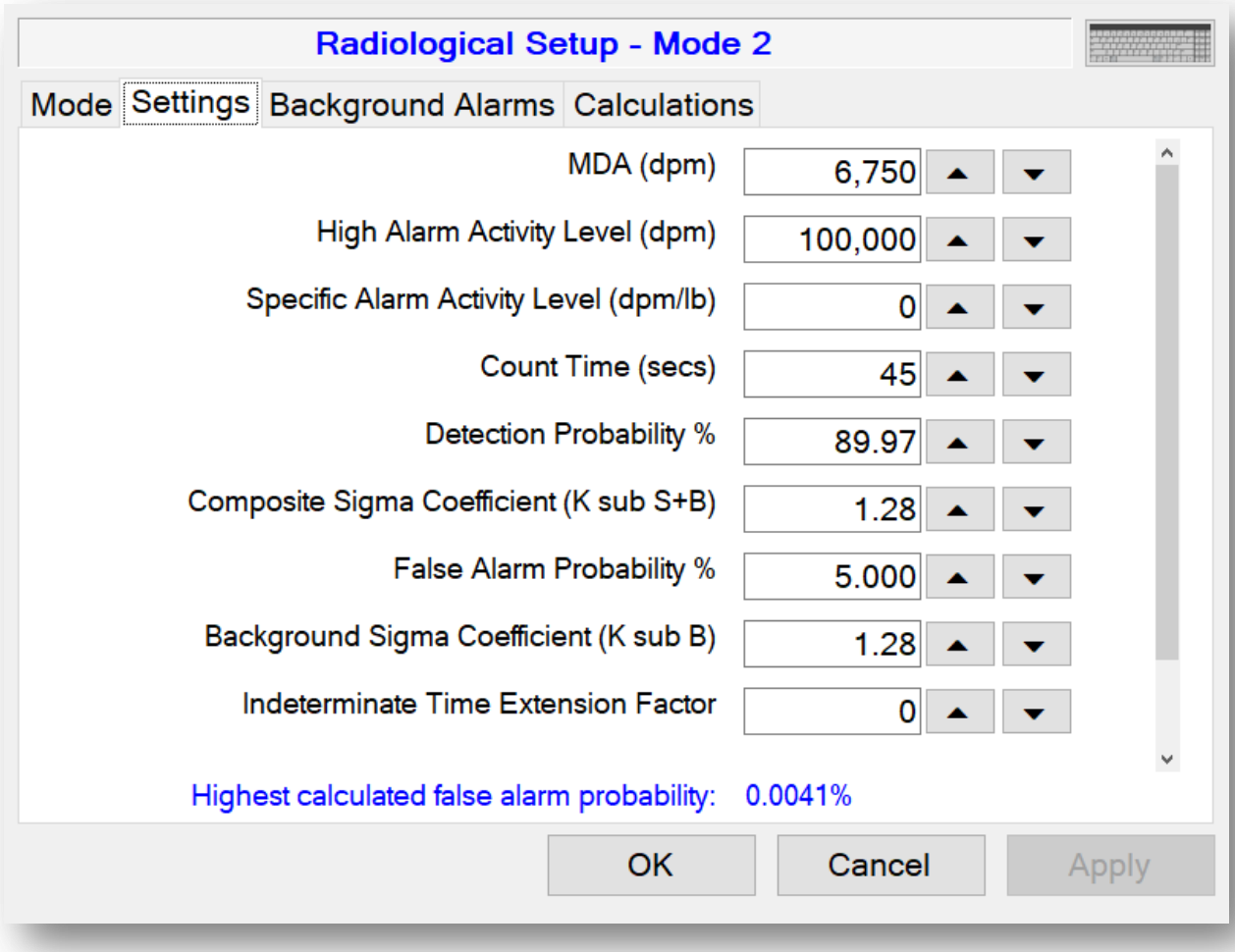
2. If the calculated MDA is less than or equal to the user-defined MDA, proceed to the next step, otherwise increment the count time by one second and return to step 1.

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

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.

MDA – wets 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 percent. 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 percent. 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.

Indeterminate Time Extension Factor – sets a multiplier of elapsed time that is used whenever an indeterminate condition is detected. At the end of a count, if the readings are below the alarm set point and above the fast clean set point (even if fast clean is disabled) the count time is extended. The extended count continues until the system alarms, the counts drop below the fast clean set point or the extended count time expires. The indeterminate 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 an article 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 monitoring 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. If Sum Channel Only is enabled, then only the sum channel must pass the test

otherwise all individual detectors plus the sum channel must pass. The following equation is used:

$$\frac{Accumulated\ Counts}{T_E} < R_B - 3.1\sqrt{\frac{R_B}{T_E}}$$

Where:

R_C = Count rate required to deem the article to be clean and computed as the total counts accumulated divided by the elapsed time.

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

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

If all single-detector channels 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 an article 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. The following equation is used:

$$N_A = (R_B + R_A) \times T$$

Where:

R_A = Alarm set point in cps for the detector.

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

T = Count time in seconds.

Sum zones alarm conditions are not processed using the fast alarm algorithm. If the Sum Channel Only option is selected, then only the Sum Channel is checked for a fast alarm otherwise all individual channels and the sum channel are tested.

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

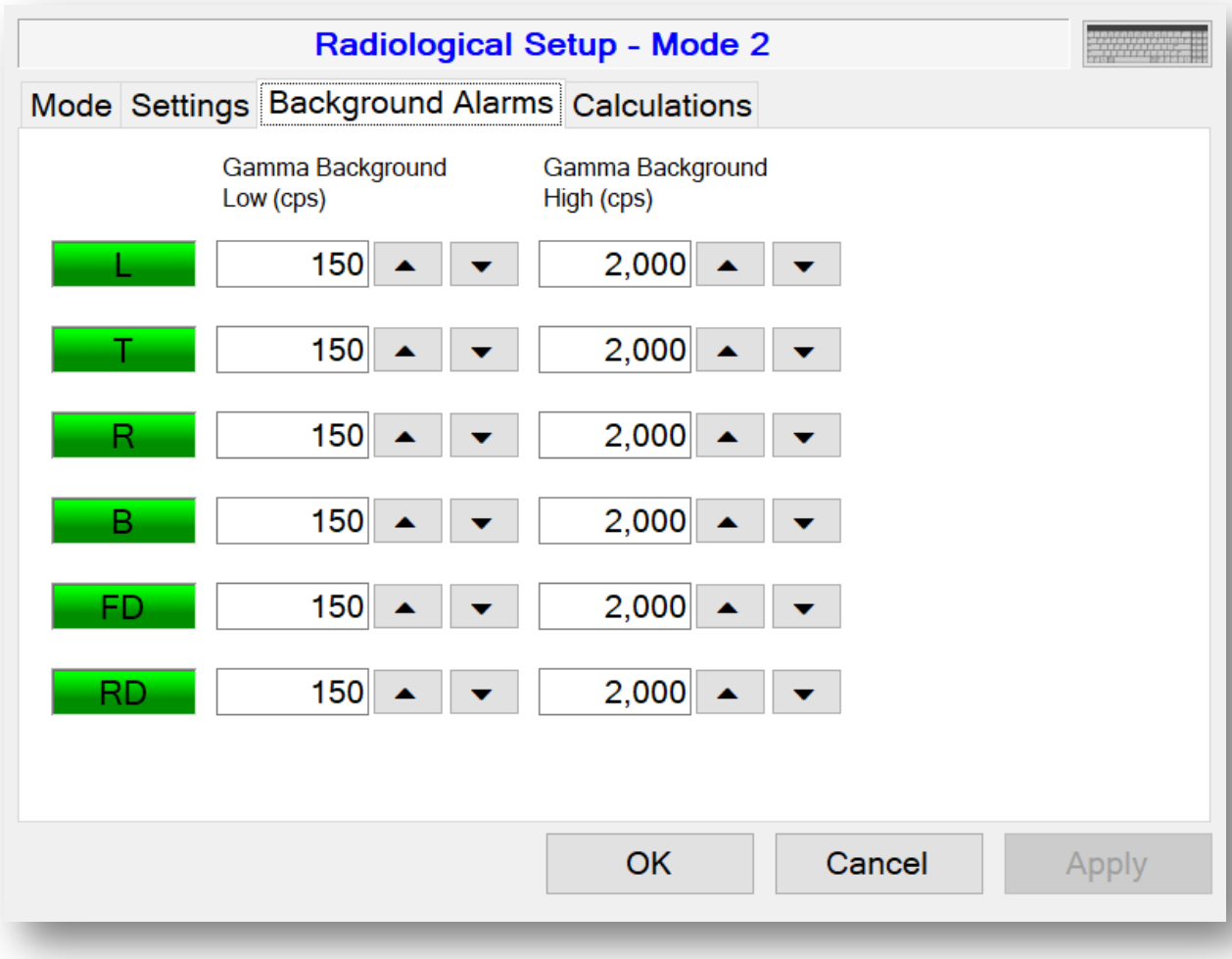
Updating Background

A new background is taken after the Supervisor application is started. The background count time is set here and is valid from 1 (default) to 10 minutes. 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 Article monitor is considered not ready for use. Once a new background update is complete, the background is updated once every second.

If the new one second count is higher than the sigma limit, a tentative 10 second background count is taken. If the background is within the sigma okay parameter, the background is restored and normal operation resumes otherwise a high background is posted.

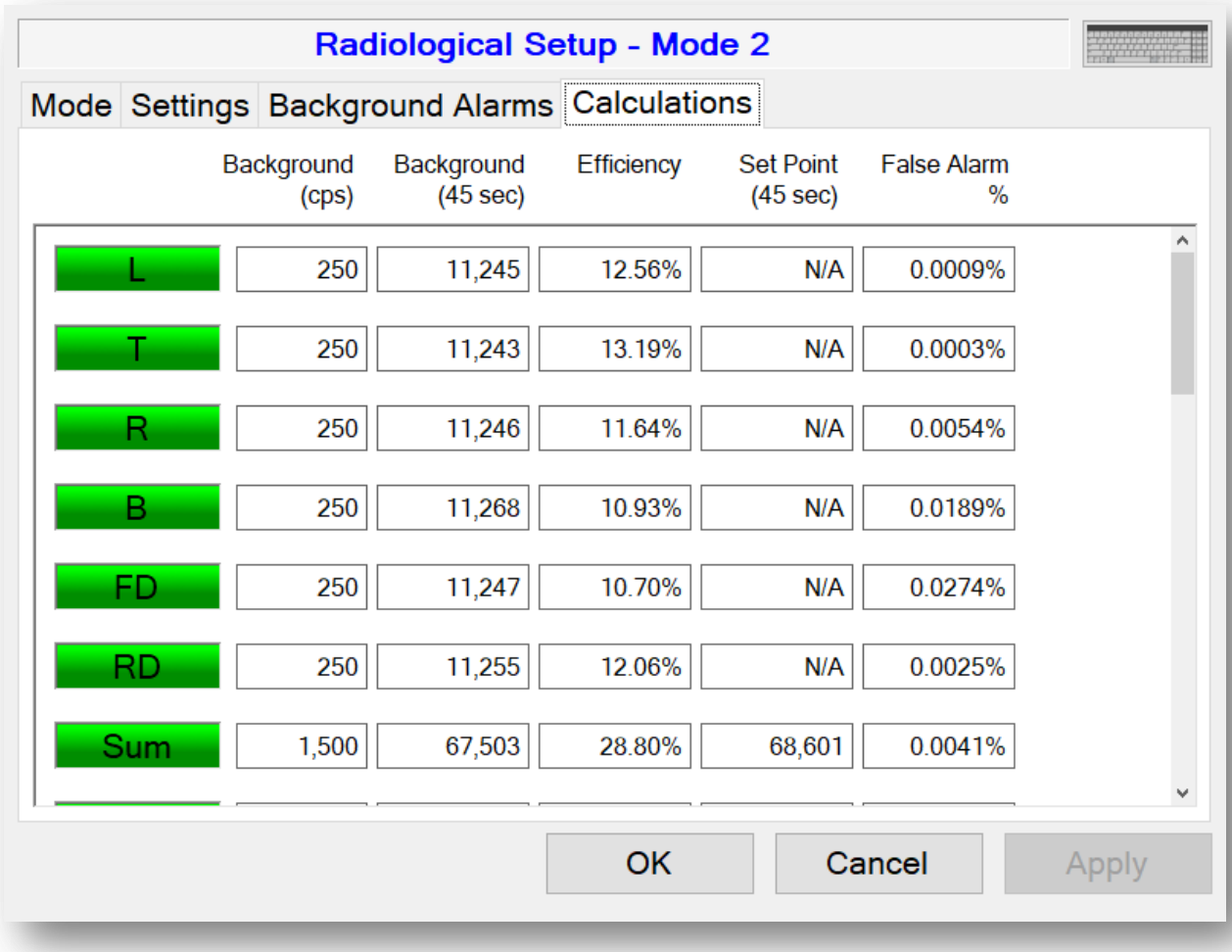
Background Alarms

Each detector has a low and high background alarm set point that 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

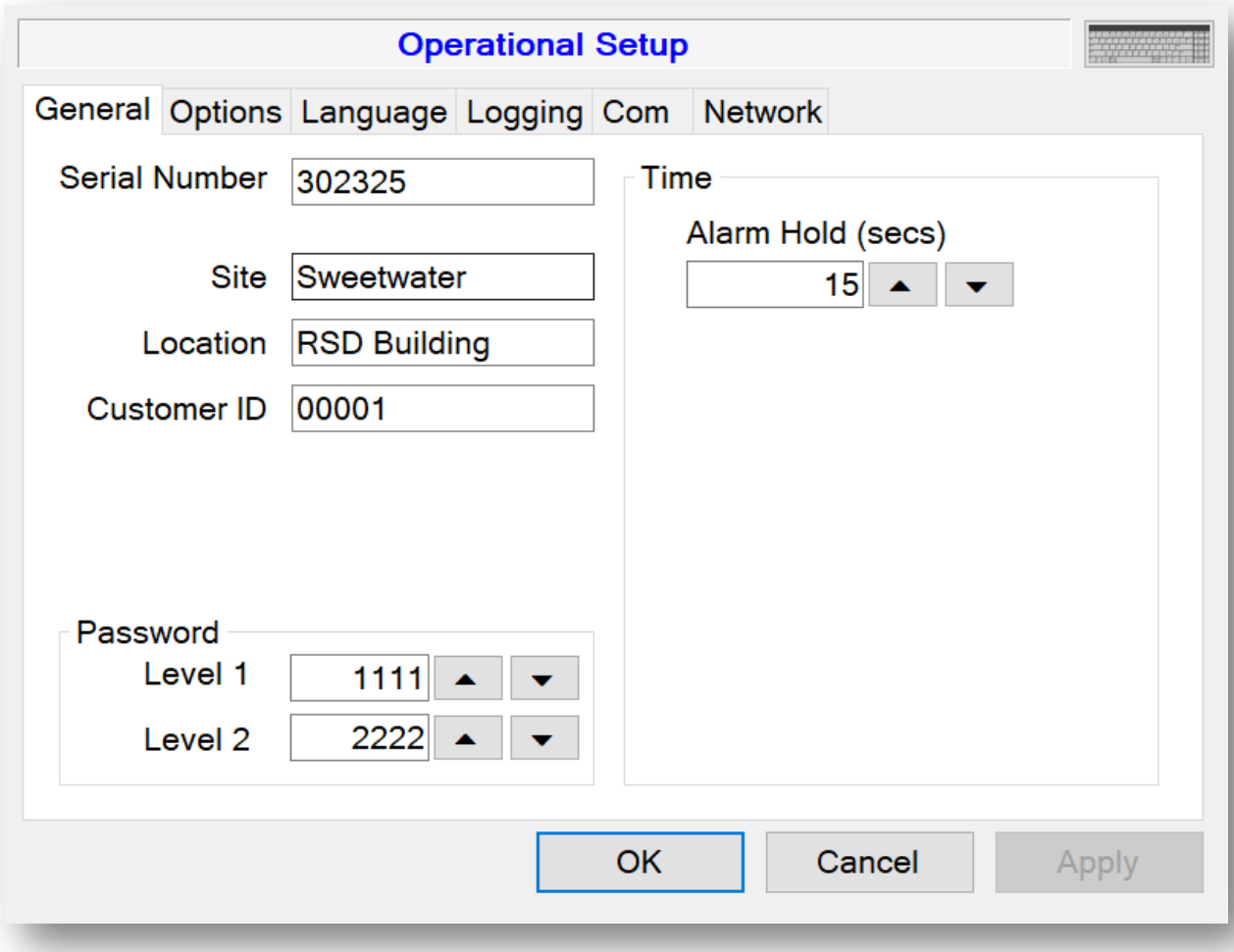
The Calculations tab shows the current alarm set point and other values relating to the counting mode. In the far right column, Mode 1 and 3 show the sensitivity, and Mode 2 shows the false alarm probability. These values are updated once per second and show all detectors, including sum zones and the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


Radiological Setup - Mode 2
Mode
Settings
Background Alarms
Calculations
Background (cps)
Background (45 sec)
Efficiency
Set Point (45 sec)
False Alarm %
L 250 11,245 12.56% N/A 0.0009%
T 250 11,243 13.19% N/A 0.0003%
R 250 11,246 11.64% N/A 0.0054%
B 250 11,268 10.93% N/A 0.0189%
FD 250 11,247 10.70% N/A 0.0274%
RD 250 11,255 12.06% N/A 0.0025%
Sum 1,500 67,503 28.80% 68,601 0.0041%
OK
Cancel
Apply

Section 9

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 article monitor. 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 article monitor.

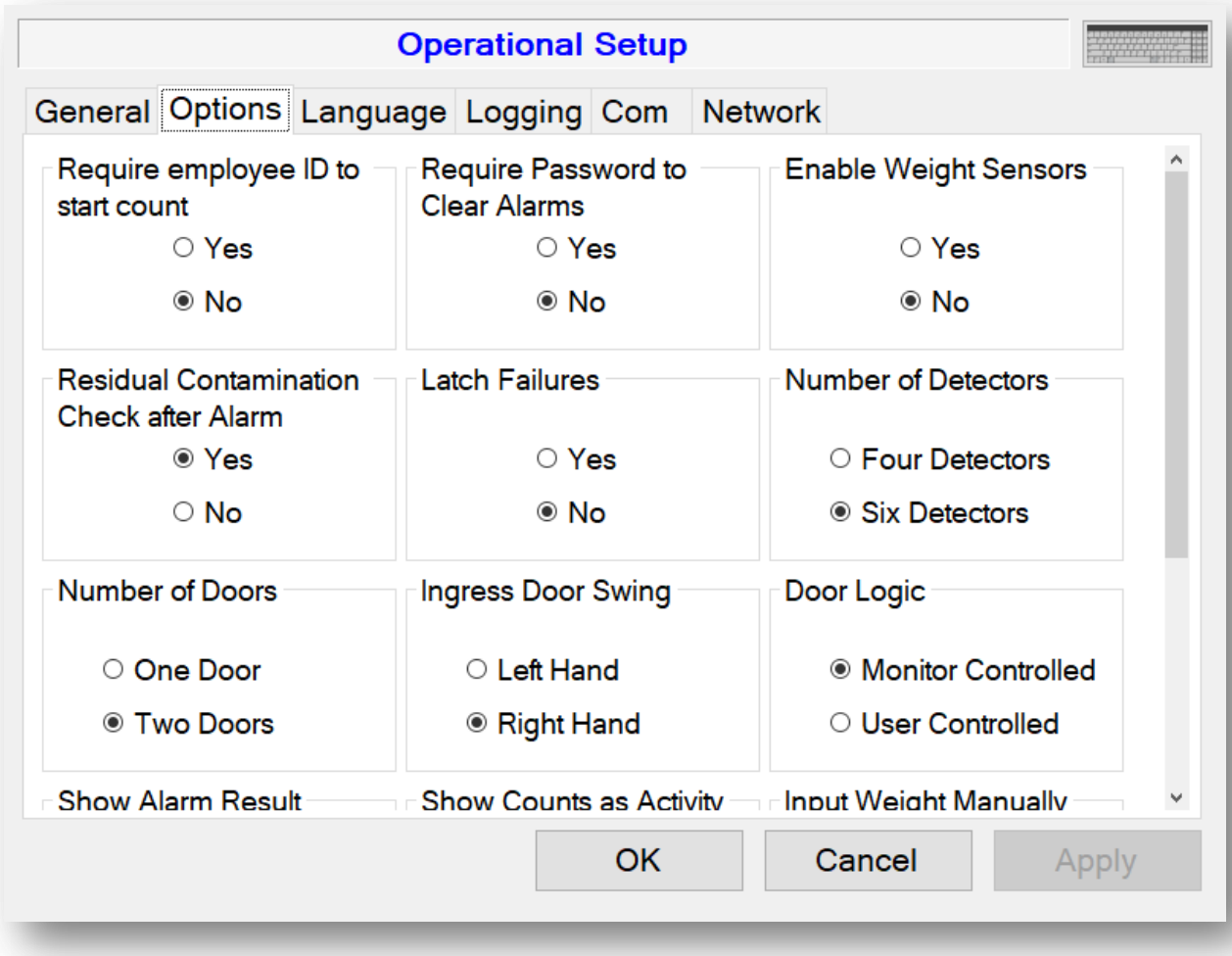
Site
User-defined field 20 characters in length. The Site is displayed in the title bar of the Operate screen.

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.

Alarm Hold
Sets the number of seconds before the alarm will automatically clear. When the alarm hold time is set to 0, 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 0, pressing once will silence the audio and pressing again will have no effect.



Options

Require Employee ID to Start Count

When enabled, the user must enter in an Employee ID before a monitoring cycle can be started. The employee 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.

Enable Weight Sensors (CURRENTLY NOT IMPLEMENTED)

When enabled, allows the weight of the article and specific activity to be determined.

Residual Contamination Check

Enable a residual contamination check after an alarm to verify that the chamber is not contaminated.

Latch Failures

When enabled all detector failures must be cleared manually. When disabled, detector failures will automatically recover once the readings fall back into acceptable limits.

Number of Detectors

The Model 54 Article Monitor may be configured with four or six detectors. A four-door configuration only has the left, top, right, and bottom detectors.

Number of Doors

The Model 54 Article Monitor may be configured with either one or two doors.

Ingress Door Swing

The door swing may be configured at the factory for either left or right-hand operation. This option changes the display of the Article Monitor on the Operate screen.

Door Logic

The door locks can be set to either monitor or user controlled. When using monitor control, the doors are locked to provide a single path through the system. Typically the front door is unlocked with the rear door locked. Once counting is complete, the rear door is unlocked and the front door is locked. If the count results in an alarm, the rear door is locked to prevent the material from leaving and must be taken out through the front door. User control, locks the door opposite of the open door so if a user opens the front door, the rear door is locked and vice versa.

Show Alarm Result

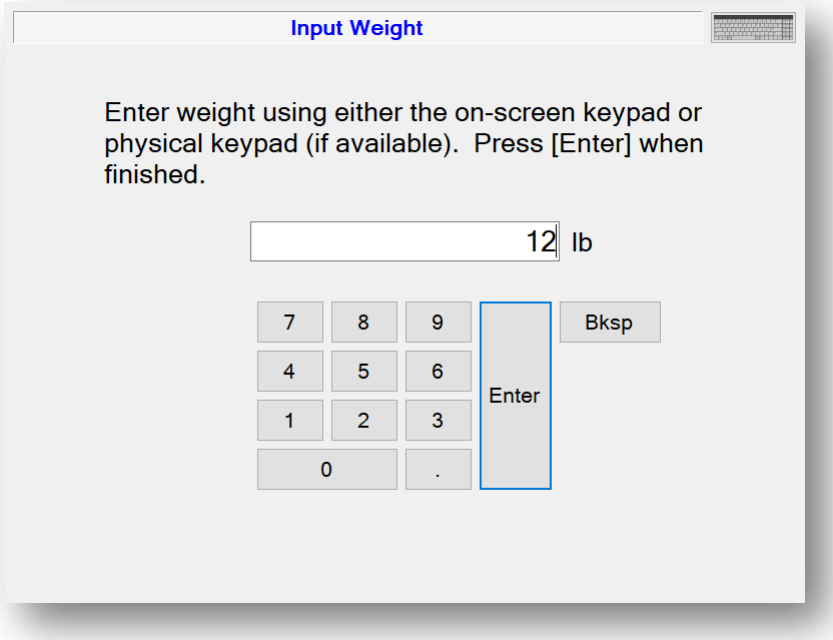
If enabled, the alarm will be displayed as a percentage above the alarm set point.

Show Counts as Activity

When enabled, the scan log will show the count data as activity rather than total counts.

Input Weight Manually

When enabled, a window will appear after pressing the count button to allow for a weight to be entered. The Specific Alarm Activity Level on the Radiological Setup screen sets an alarm based on the activity/weight.



Invert Door Sensors (SAM-11)

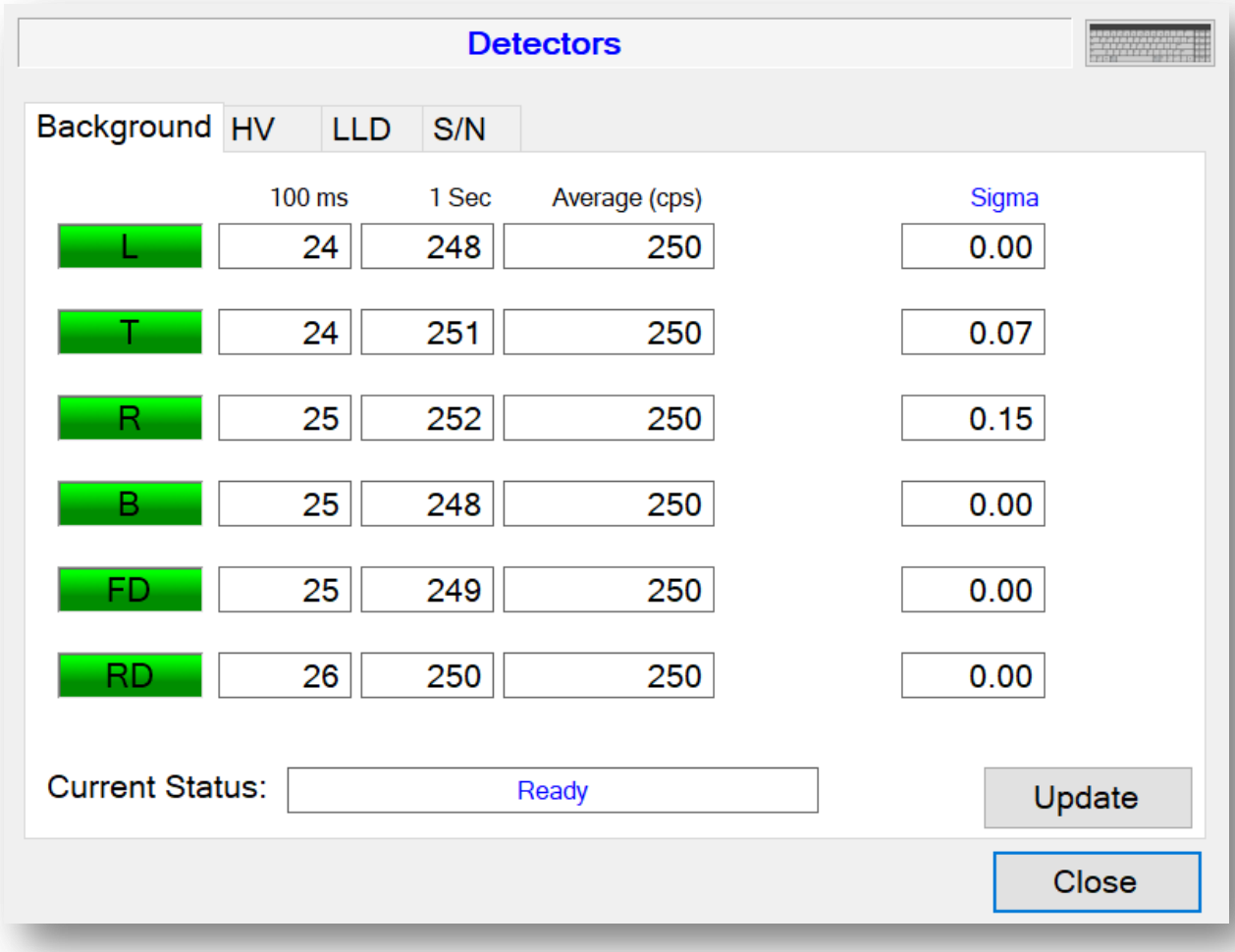
The SAM-11 uses inverted logic to determine if the door is open compared to the Model 54 series. This needs to be enabled to correct the door sensor logic.

Section 10

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.

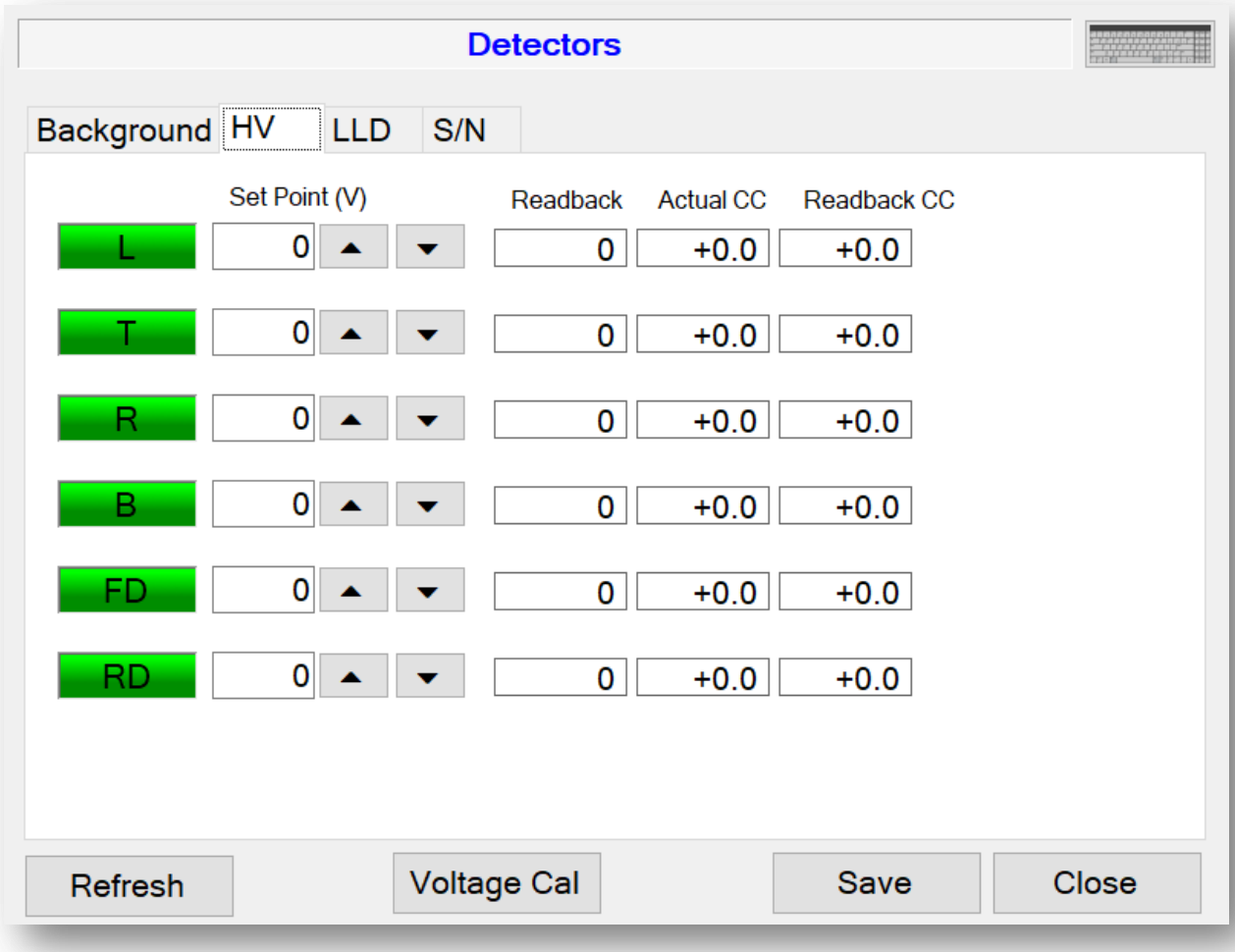
Background



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-milisecond 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 Article Monitor status is displayed at the bottom. Press the Update button to start a new background update cycle.

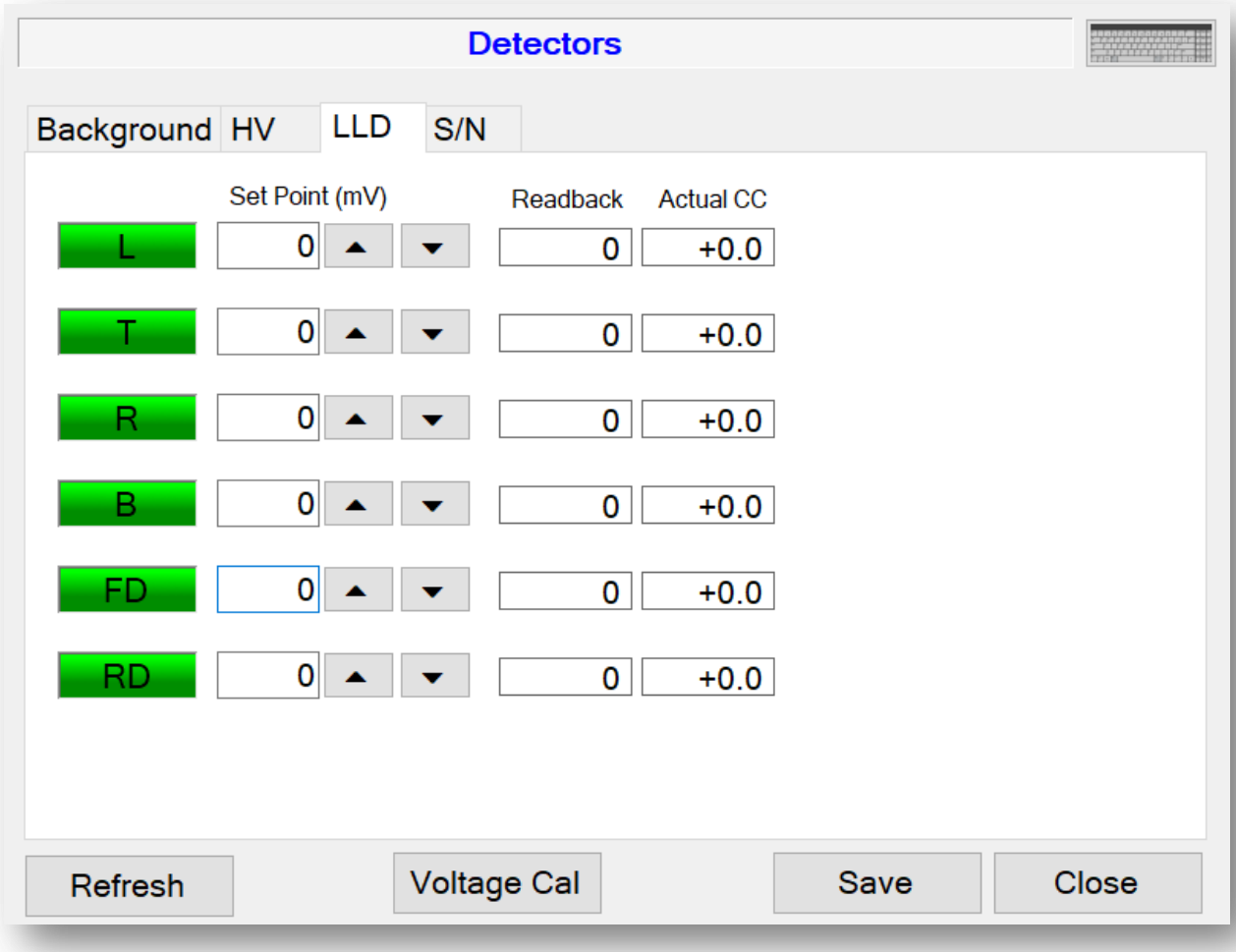
High Voltage (HV)



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 volts, 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. See below for more information on the Voltage Cal button.

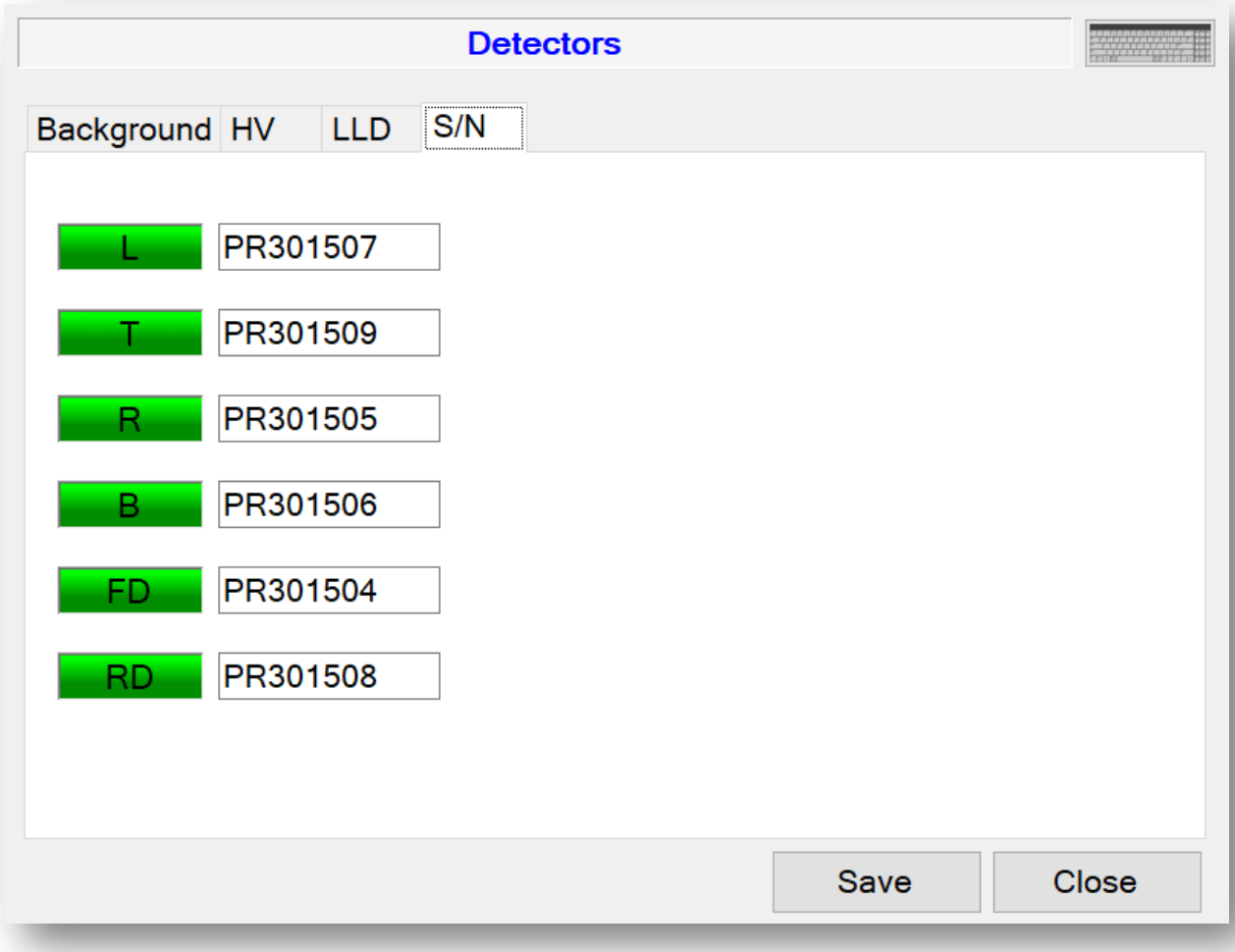
Lower Level Discriminator (LLD)



The LLD 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 LLD output. The LLD 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 LLD 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.

S/N



The S/N screen displays the serial numbers for each detector.

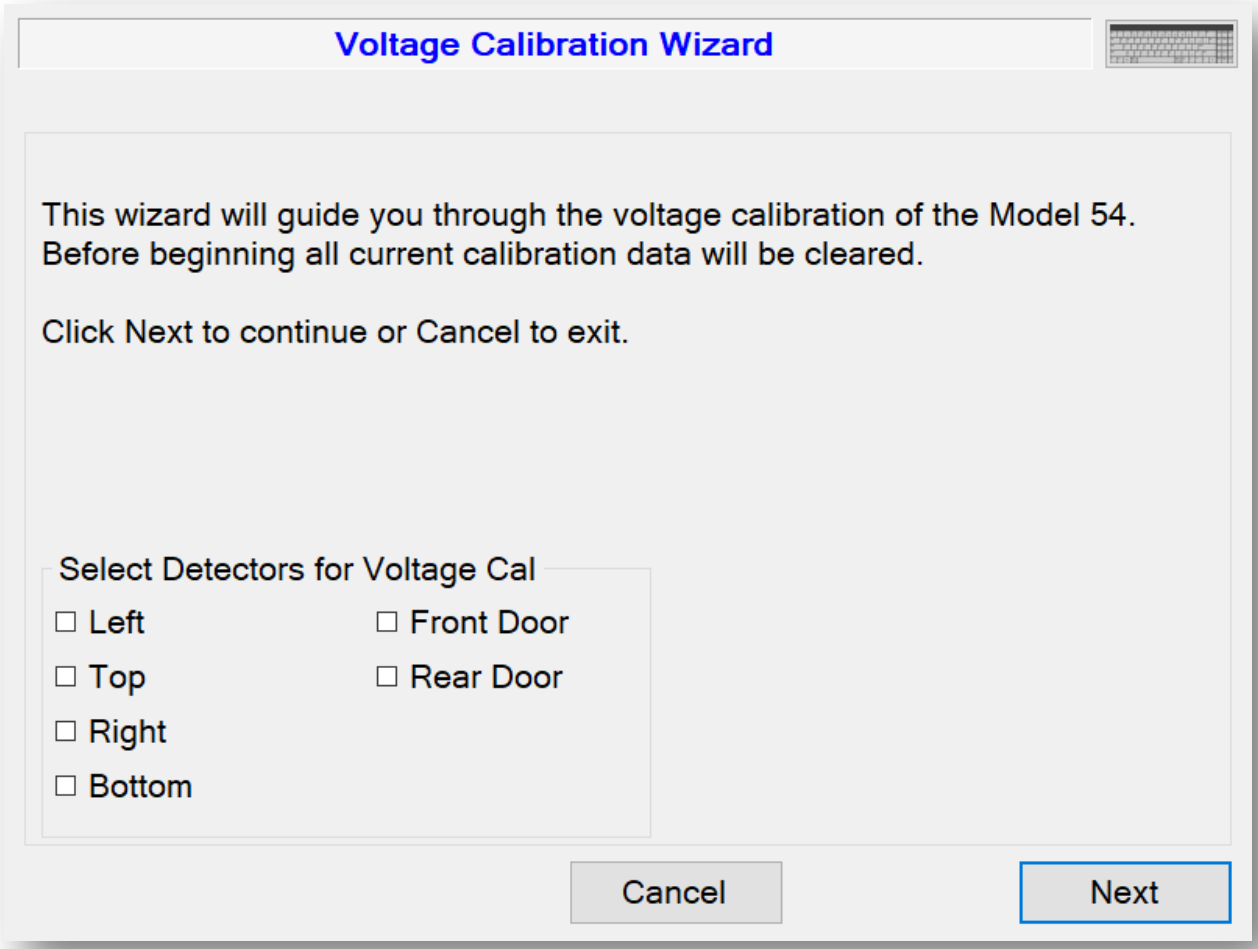
Voltage Calibration

The Voltage Calibration Wizard is accessed through the Voltage Cal button. The wizard guides the user through the process of setting the calibration constants for each detector. The following parameters will be set by the wizard:

- HV Actual Calibration Constant
- HV Read Back Calibration Constant
- LLD Actual Calibration Constant

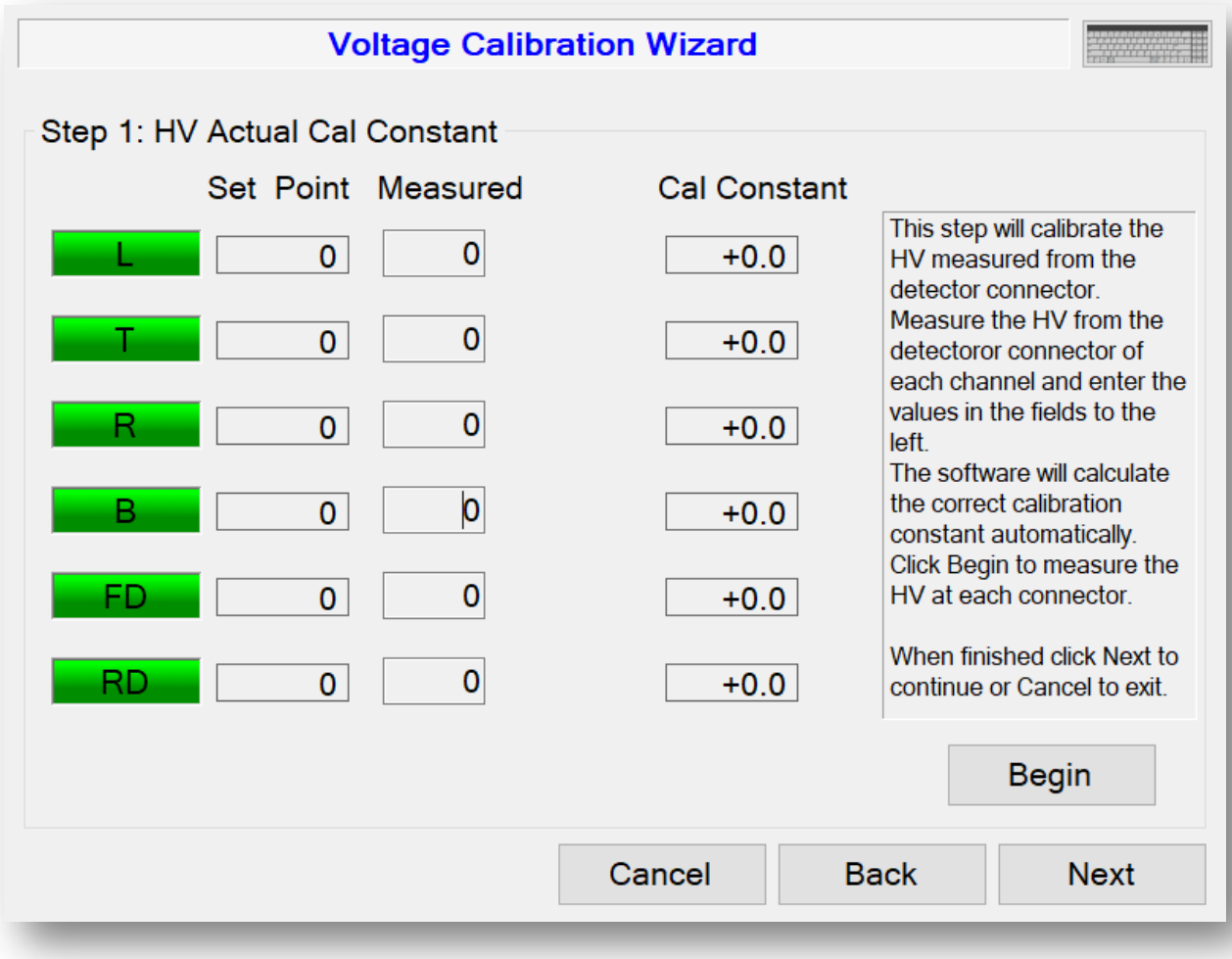
- ULD Actual Calibration Constant

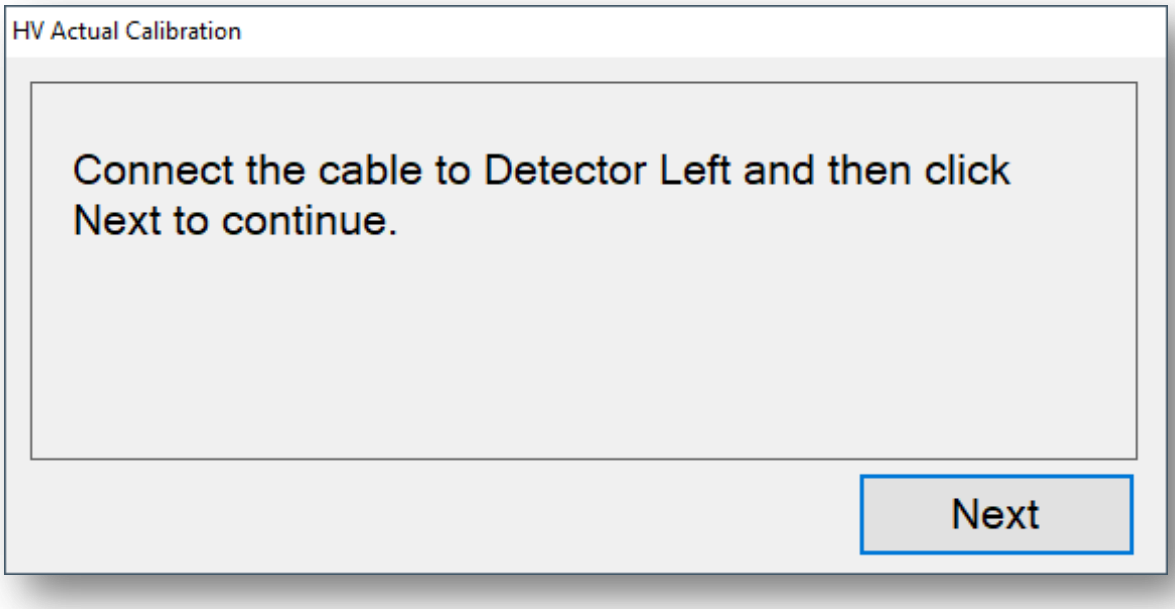
The wizard automatically calculates the calibration constant based on the measurements entered for each detector. All calibration constants are zeroed out at the beginning for the selected detectors. Calibration requires a Model 500 Pulser with high-voltage readout or a high-impedance voltmeter with at least 1000 a megohm meter input resistance. Click the Next button to begin the calibration.



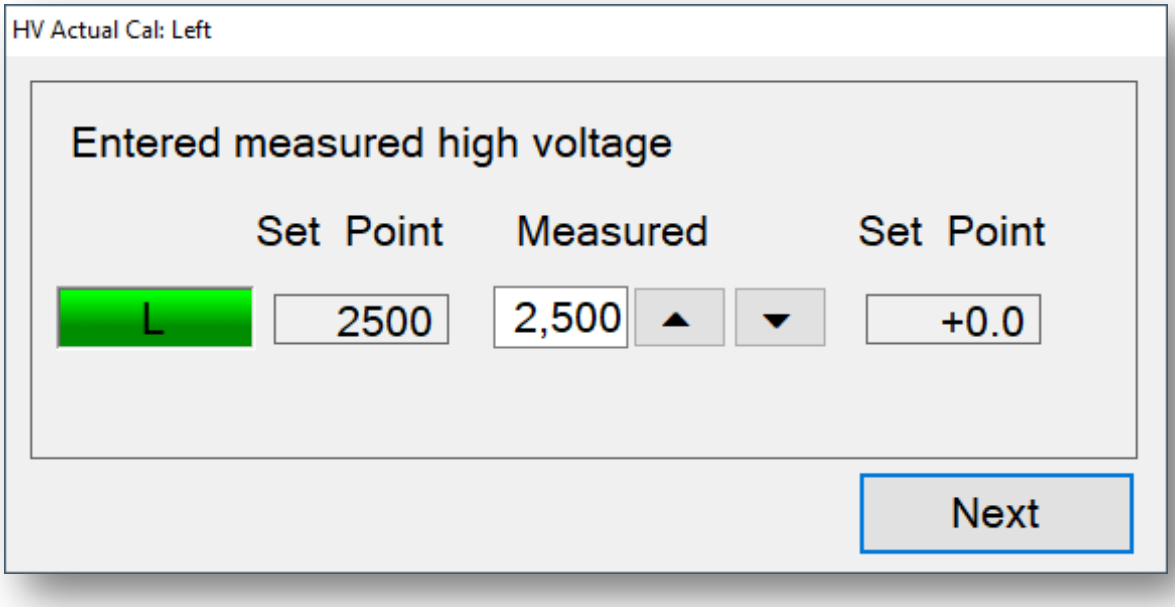
HV Actual Calibration Constant

Click the Begin button to start the process of calibrating the HV Actual Calibration Constant. The calibration constant is calculated automatically by entering the high voltage measured at the detector connector. The wizard will set the high voltage of all detectors to 0 and then prompt for the cable to be connected to the first detector. The detector order is: Left, Top, Right, Bottom, Front Door, and Rear Door.


Voltage Calibration Wizard
Step 1: HV Actual Cal Constant
Set Point
Measured
Cal Constant
L
0
0
+0.0
T
0
0
+0.0
R
0
0
+0.0
B
0
0
+0.0
FD
0
0
+0.0
RD
0
0
+0.0
This step will calibrate the HV measured from the detector connector.
Measure the HV from the detectoror connector of each channel and enter the values in the fields to the left.
The software will calculate the correct calibration constant automatically.
Click Begin to measure the HV at each connector.
When finished click Next to continue or Cancel to exit.
Begin
Cancel
Back
Next

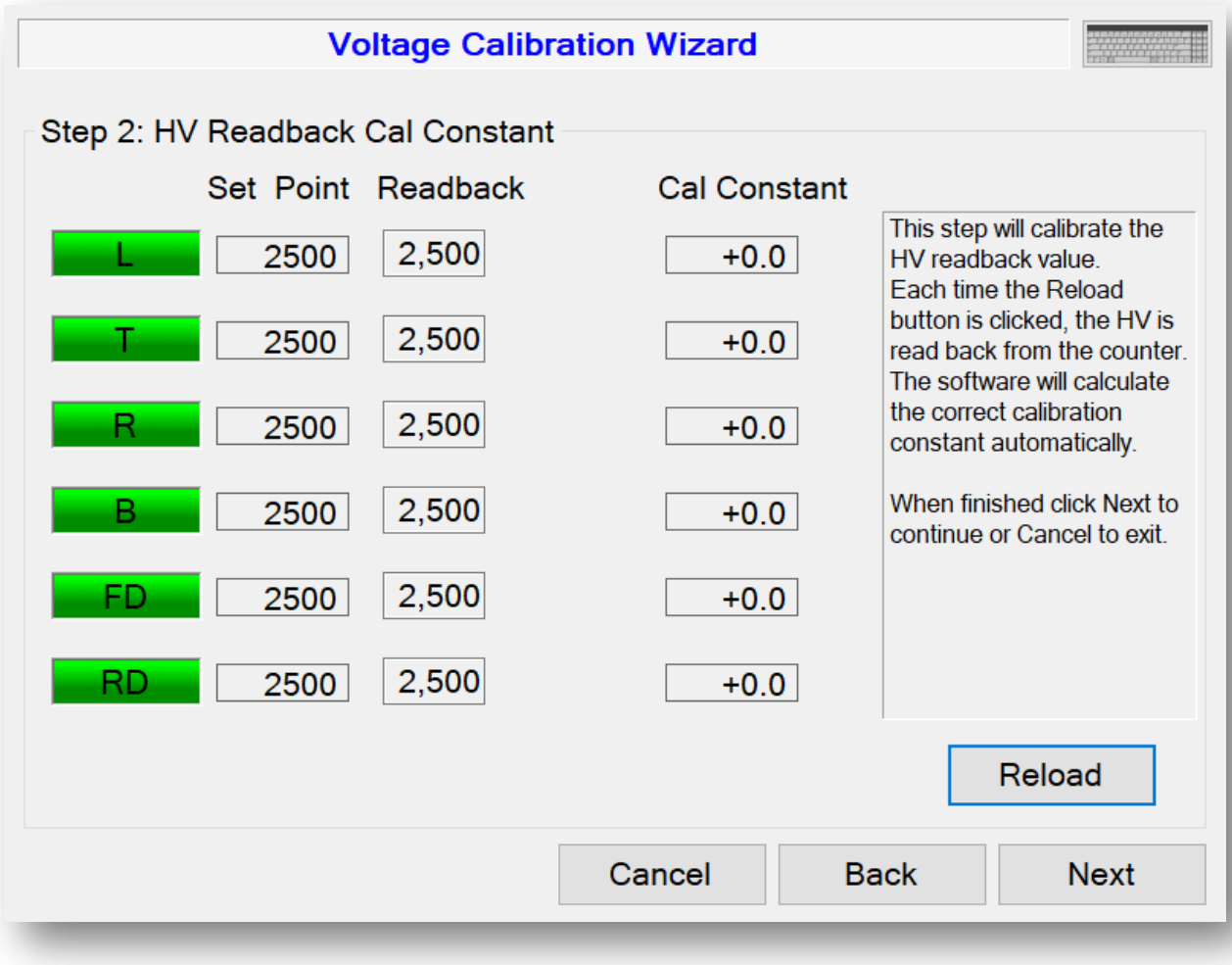


After connecting the cable and clicking the Next button, the high voltage will be restored to the set point. Enter the measured high voltage and click Next. Continue repeating this process until all detectors are completed.



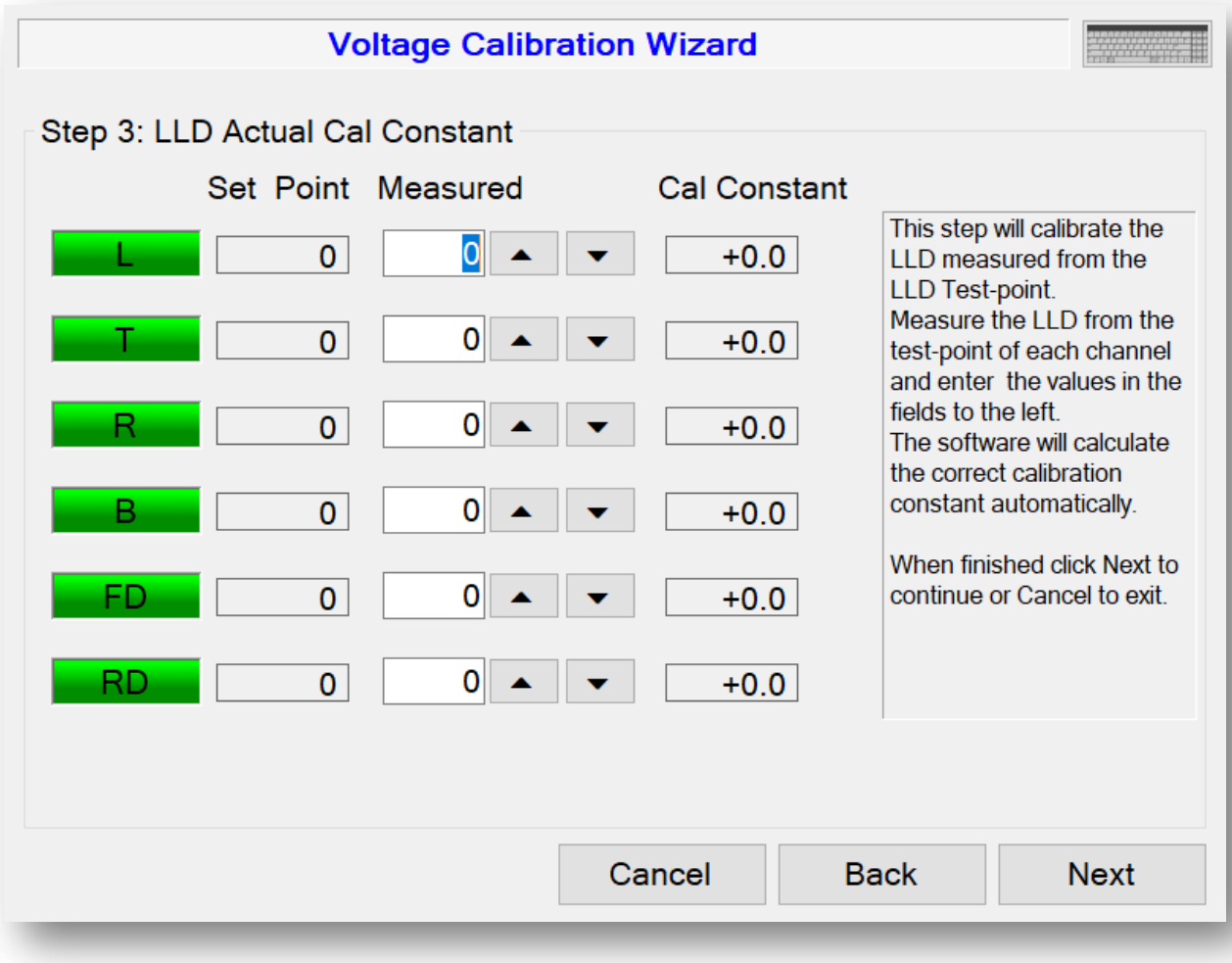
HV Read Back Calibration Constant

The calibration of the Read Back value is automatic. The wizard will automatically calculate a new calibration constant each time the Reload button is clicked. If the values returned are consistent, click the Next button.



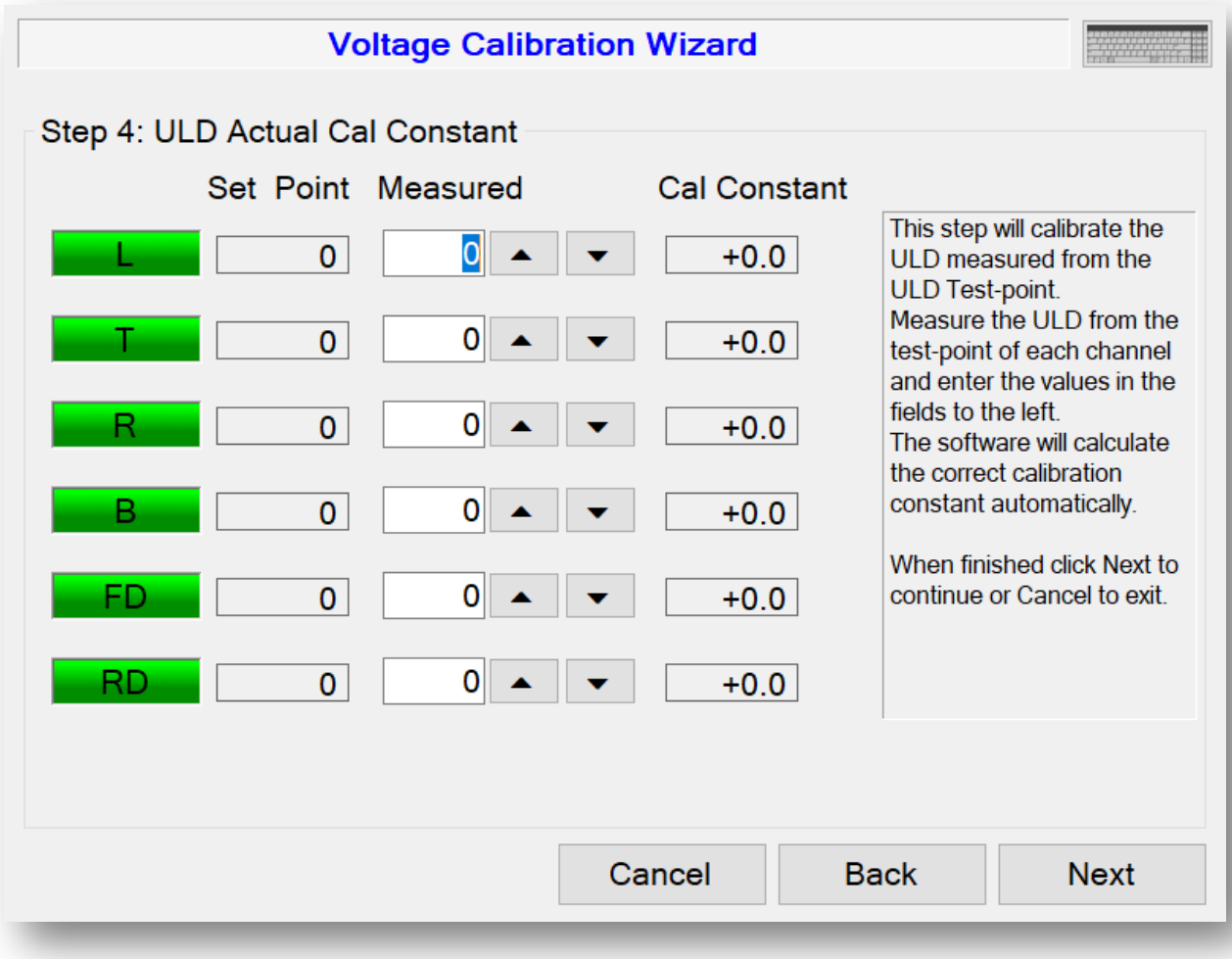
LLD Actual Calibration Constant

The LLD actual calibration constant is obtained by measuring the LLD from the test point on each detector and entering the measured reading in the appropriate field. The calibration constant is automatically calculated. Click the Next button when finished.



ULD Actual Calibration Constant

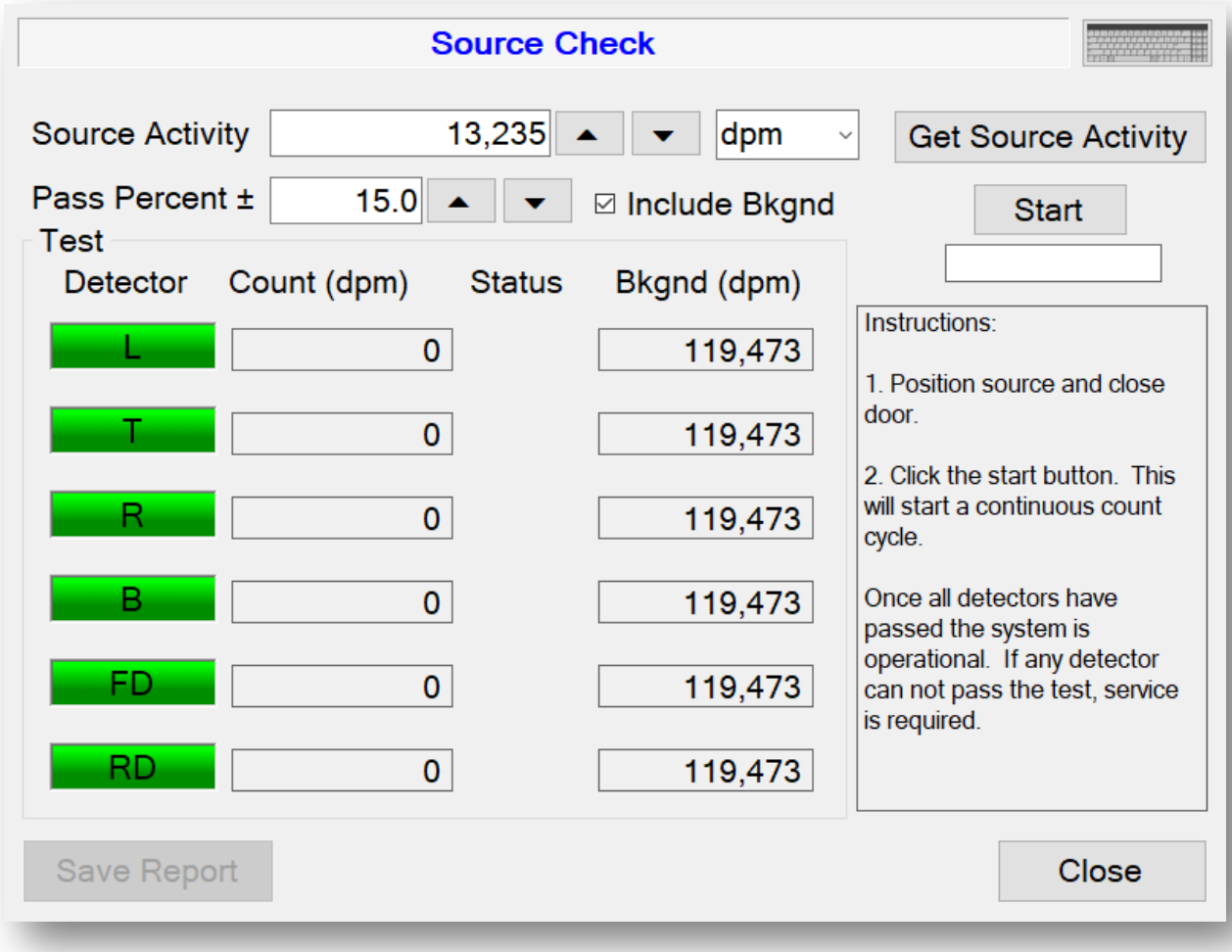
The ULD actual calibration constant is obtained by measuring the ULD from the test point on each channel and entering the measured reading in the appropriate fields. When complete, click the Next button.


Voltage Calibration Wizard
Step 4: ULD Actual Cal Constant
Set Point
Measured
Cal Constant
L
0
0
+0.0
T
0
0
+0.0
R
0
0
+0.0
B
0
0
+0.0
FD
0
0
+0.0
RD
0
0
+0.0
This step will calibrate the ULD measured from the ULD Test-point.
Measure the ULD from the test-point of each channel and enter the values in the fields to the left.
The software will calculate the correct calibration constant automatically.
When finished click Next to continue or Cancel to exit.
Cancel
Back
Next

Section 11

Source Check

The Source Check screen can be used to perform a daily test on the detectors to verify they are still functioning correctly.

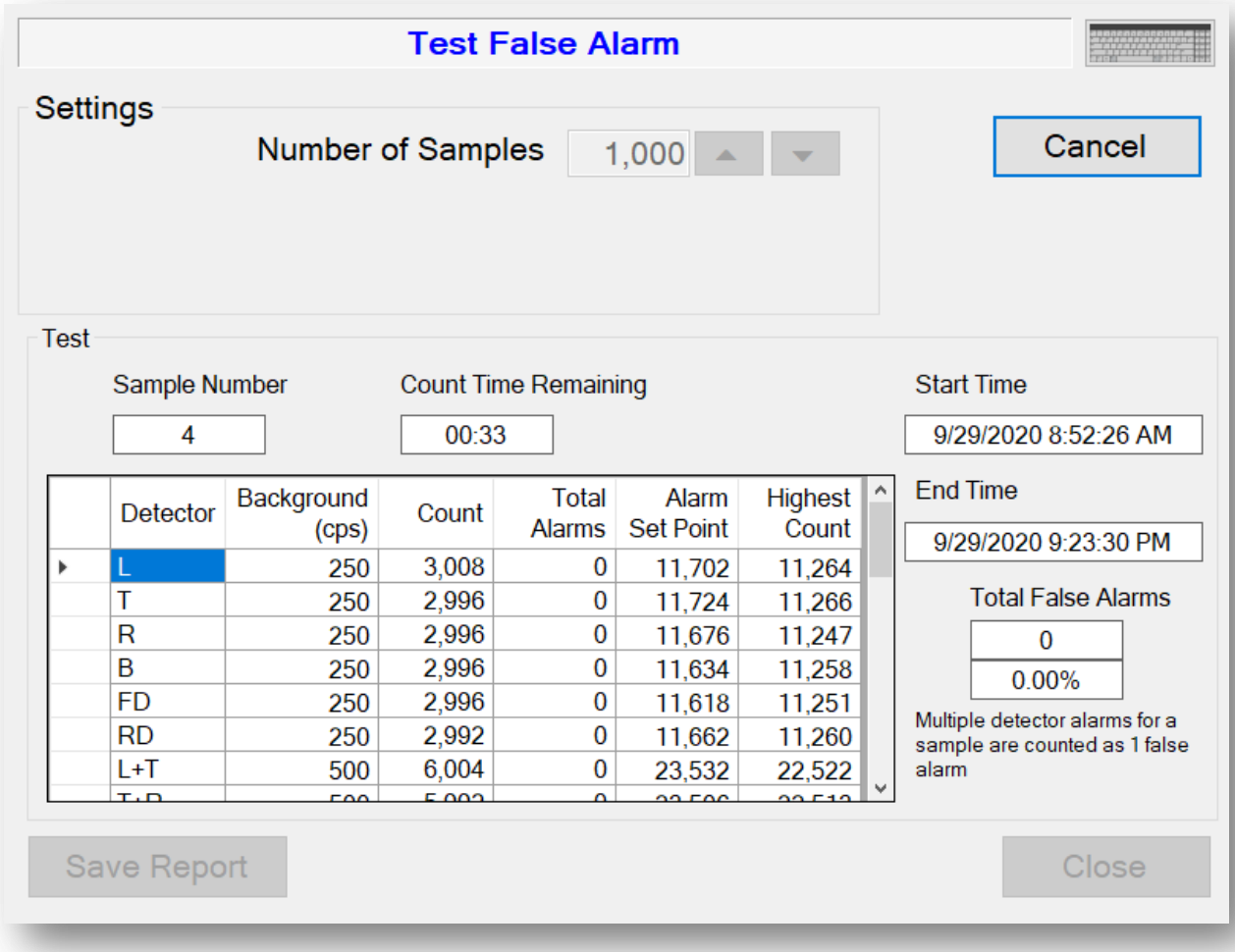


Enter the source size of the check source and a percentage that the counts must fall within to be considered acceptable. Open the door, position the source, and close the door. Click the Start button to start the test. The system will run continuous counts using the normal monitoring count time until all detectors pass or the test is cancelled.

Section 12

False Alarm

The False Alarm screen is used to run a series of counts to determine the false alarm rate. The number of samples to run, count time, and background count time are user adjustable.



Detector	Background (cps)	Count	Total Alarms	Alarm Set Point	Highest Count
L	250	3,008	0	11,702	11,264
T	250	2,996	0	11,724	11,266
R	250	2,996	0	11,676	11,247
B	250	2,996	0	11,634	11,258
FD	250	2,996	0	11,618	11,251
RD	250	2,992	0	11,662	11,260
L+T	500	6,004	0	23,532	22,522

After setting these parameters, click the Start button to begin the false alarm test. The current sample number, count time remaining, end time, and total false alarms are displayed.

Should an alarm be posted, an immediate background update will follow so as to track any potentially changing background average.

During the false alarm test, the current background, raw count, total alarms, alarm set point, and high count are displayed in the grid for each detector. Click the Cancel button to stop the test.

The criterion for an alarm is satisfied when the net (background-subtracted) count rate for any detector exceeds the alarm set point (R_A).

$$R_A = K_B \sqrt{\frac{R_B}{T} + \frac{R_B}{T_B}}$$

Where:
R_A = Alarm set point in cps.

K_B = Background sigma coefficient that determines the false alarm probability.

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

T = Count time in seconds.

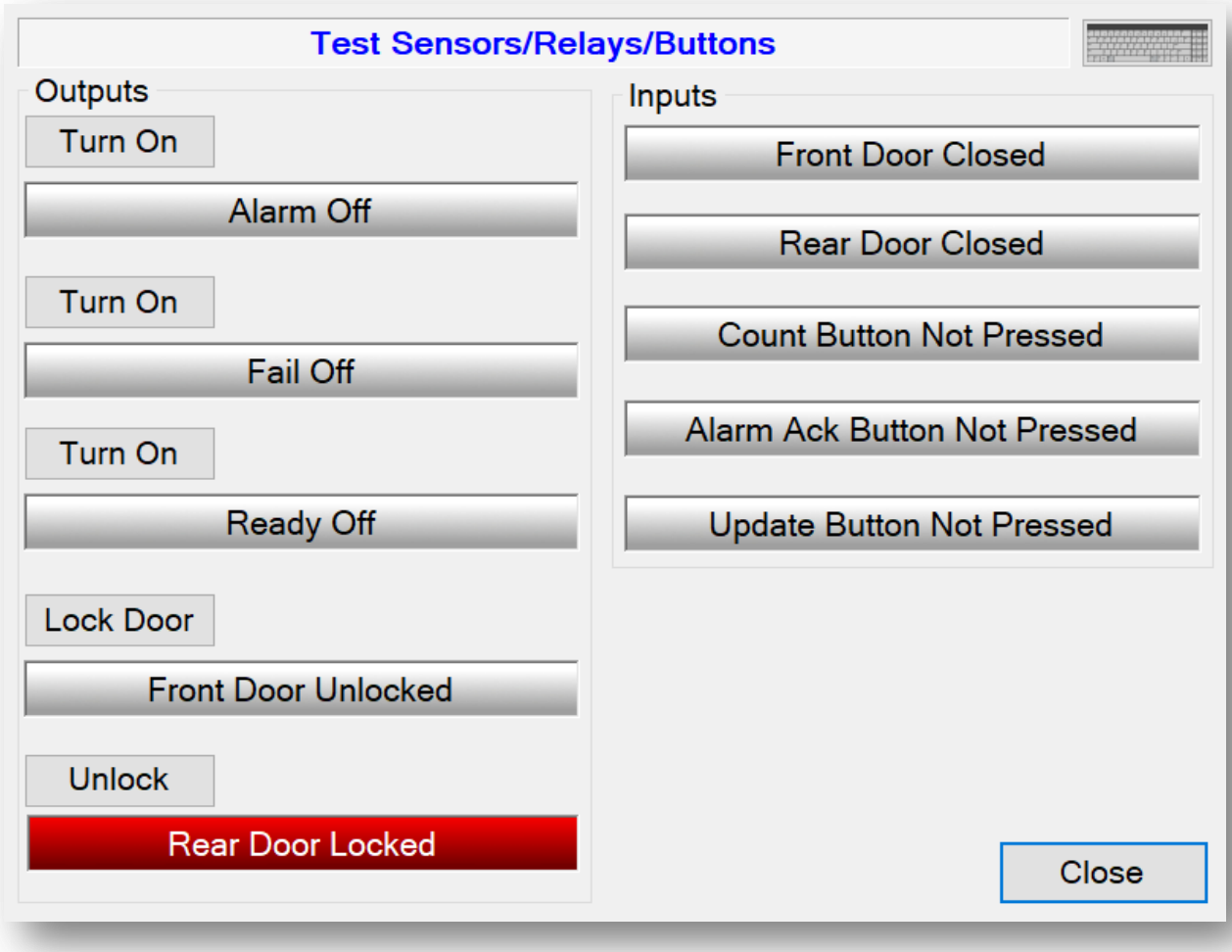
T_B = Background count time in seconds.

Only one false alarm will be reported regardless of how many detectors alarmed.

Section 13

Buttons/Relays

The Buttons/Relays screen is used to test the various inputs and outputs on the article monitor.

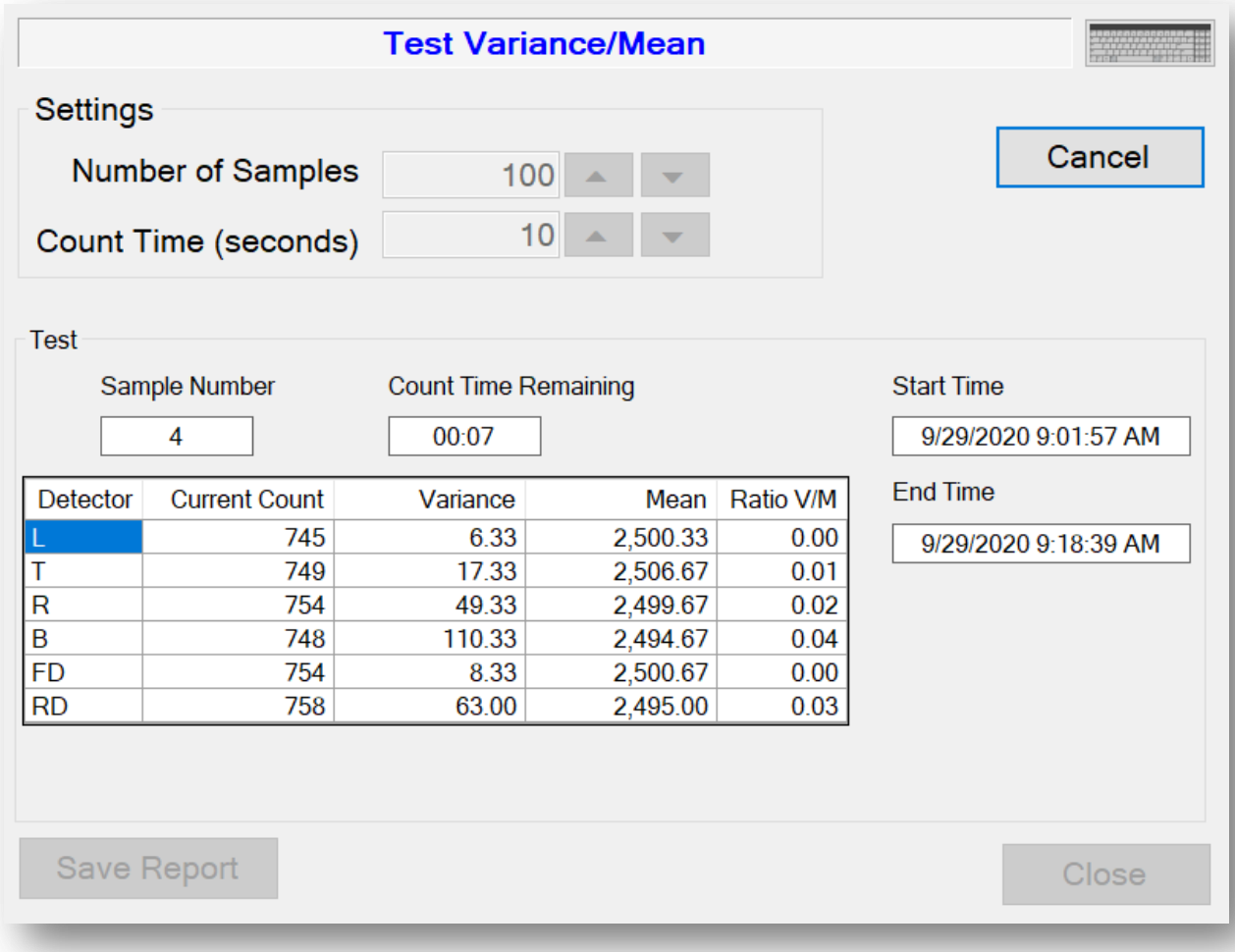


The outputs include the lights in the stack, relays, and door locks. The inputs include the door sensors and pushbuttons. Click on the buttons to turn on/off the lights/relays or lock/unlock the doors. When a pushbutton is pressed, the indicator should light up to indicate the button was read successfully. The article monitor should be taken out of service if any button, sensor, or light fails to respond correctly.

Section 14

Variance/Mean

The Variance/Mean screen is used to determine the stability of the background and should be run once the article monitor is setup. The number of samples and count time are user adjustable.



Click the Start button to begin the test. The current sample number, count time remaining, and end time are displayed along with the detector count, mean, and variance. Click the Cancel button to stop the test.

The algorithm for computing the variance and mean at the end of each sampling period follows:

Initialization at beginning of Variance/Mean Test:

mean = 0
sampleCounter = 0
m2 = 0

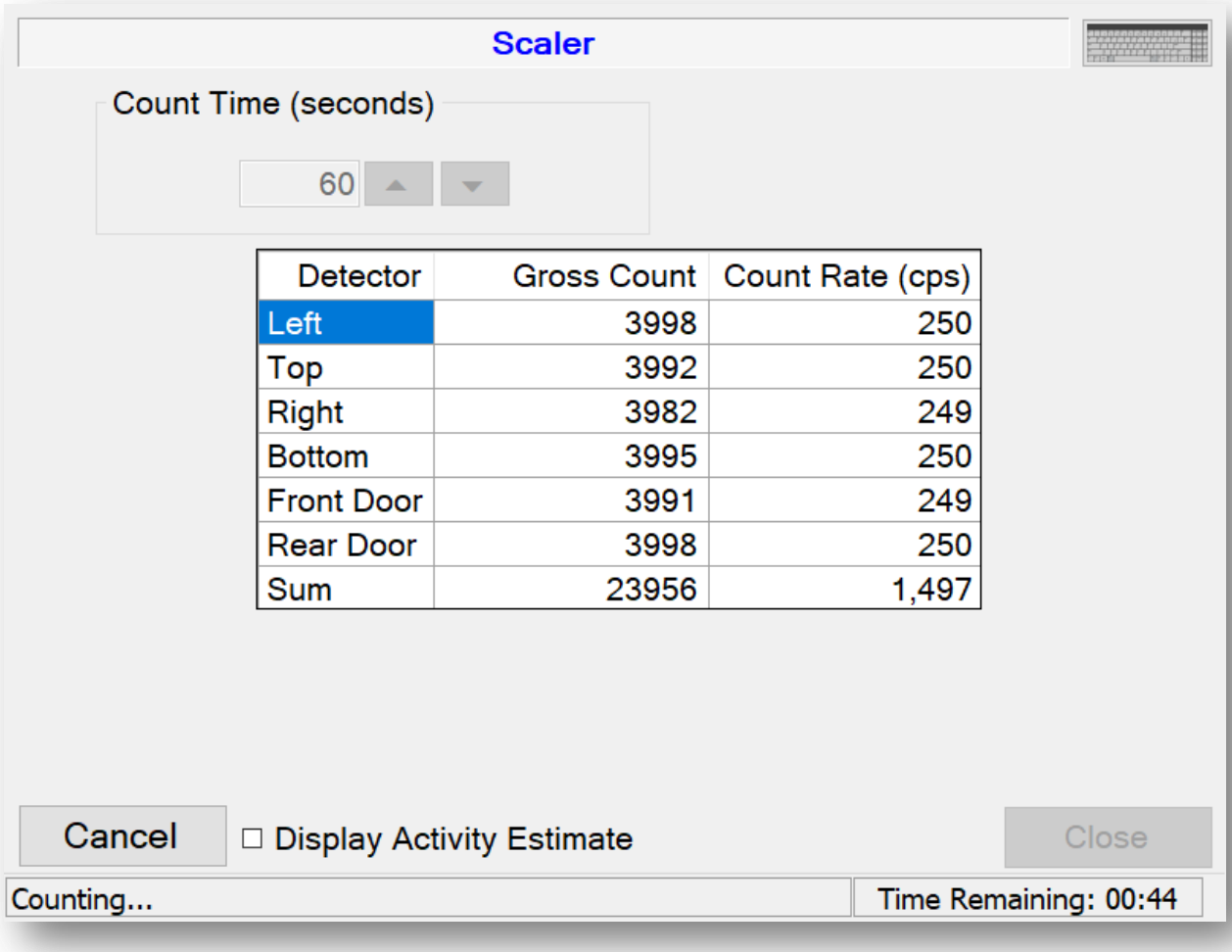
At end of each count:

sampleCounter = sampleCounter + 1
delta = count – mean
mean = mean + delta
m2 = m2 + delta * (reading / sampleCounter)
variance = m2 / (sampleCounter -1)

Section 15

Scaler

The Scaler screen provides a way to start a count and see the results as gross counts and count rate.

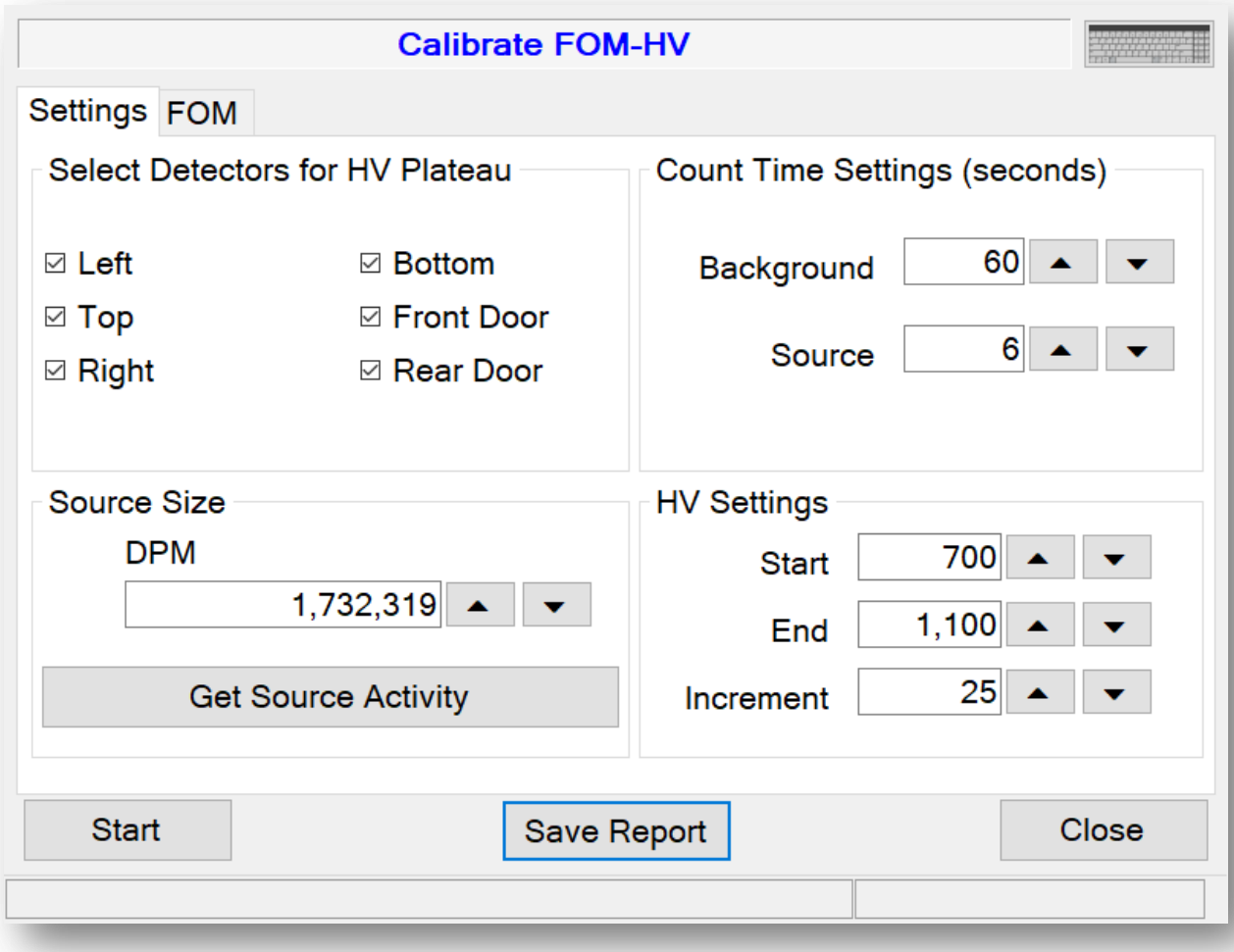


Set the desired count time in seconds and click the Start button. Click the Cancel button to stop a count that is in progress.

Section 16

FOM-HV

The FOM-HV screen is used to calculate a Figure of Merit to find the optimum high-voltage operating point for each detector. A background count and source count are taken at various high-voltage set points and the best high voltage is chosen. The Settings tab allows which detectors are calibrated, along with the count time for background and source counts.



Select Detectors for HV Plateau

Select which detectors will be included in the calibration. The FOM-HV calibration can be run on multiple detectors or just a single detector.

Count Time Settings

The background and source count times can be set individually and are adjustable from 1 to 300 seconds.

Source Size

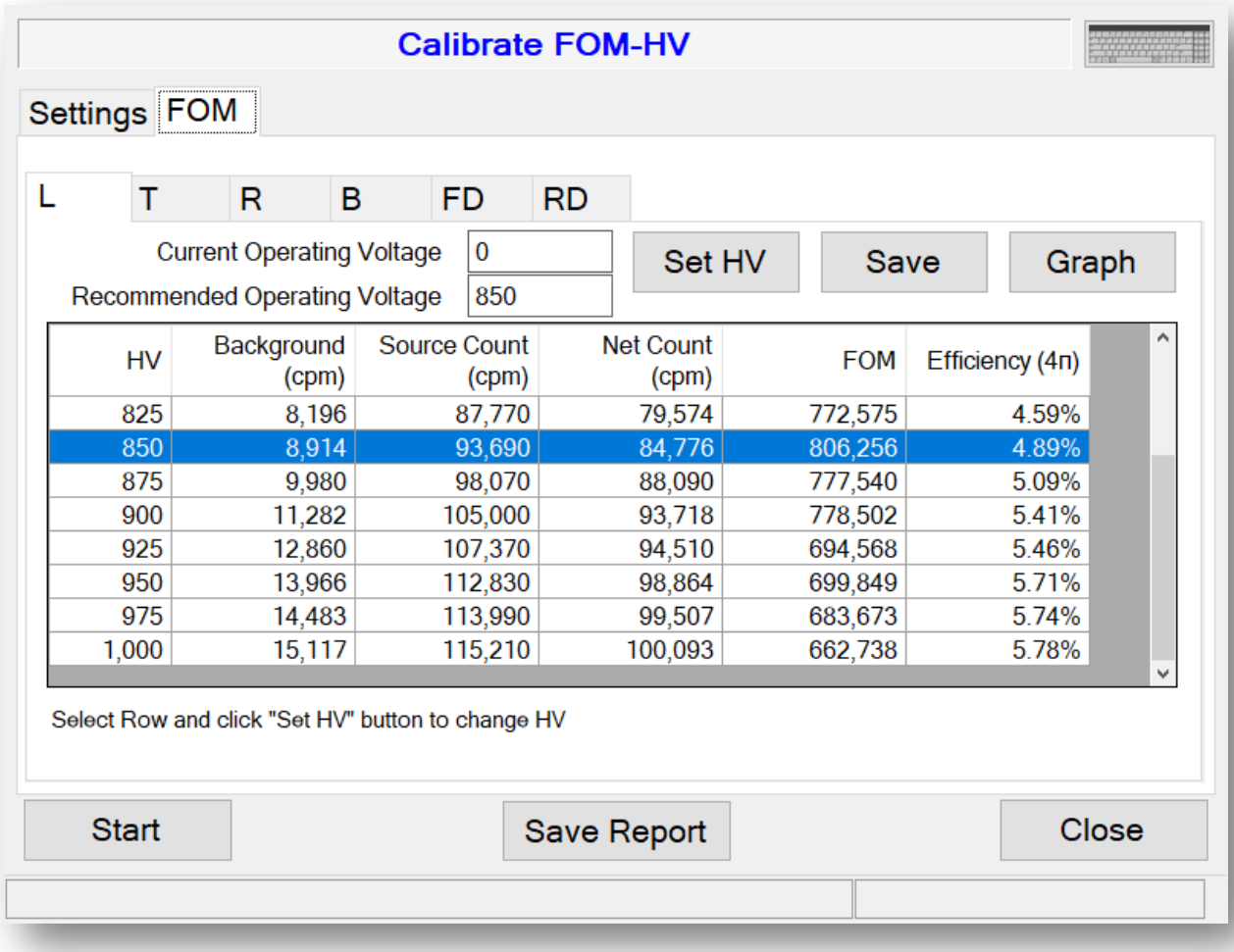
The source size in DPM is used to calculate the detector efficiency.

HV Settings

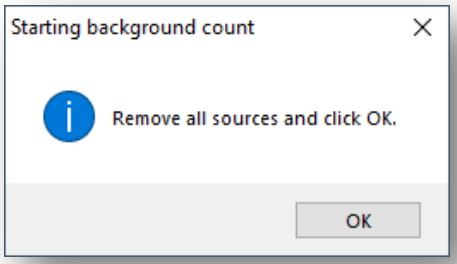
The start and end of the high-voltage plateau are defined. The default start high voltage is 700 V and the default end high voltage is 1100 V. The high voltage increment defaults to 25 V and can be adjusted from 1 to 500 V.

Running the FOM-HV

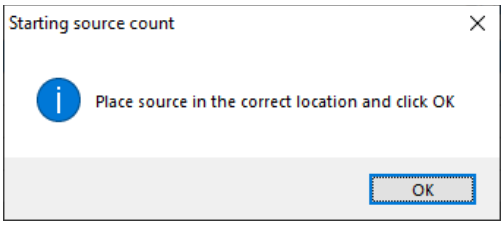
Click the Start button to begin the FOM process. The FOM tab will automatically be selected if necessary. This tab shows a grid that displays the background, source, and net counts as well as the FOM and efficiency at each high-voltage step.



A prompt will be displayed indicating that all sources should be removed from the chamber. After acknowledging this prompt, background counts will be taken at each high-voltage step.



When all background counts are complete, a prompt will be displayed indicating that the source must be placed in the center of the article monitor chamber. Open the door, place the source inside, and close the door. Click the OK button when done.



The article monitor will begin taking source counts at each high-voltage step until completed. Once the current detector is complete, the process will begin for any remaining detectors.

When the FOM is complete, the recommended voltage will be displayed. Click the Set HV button to set the detector's high voltage to the recommended set point.

The Figure of Merit is calculated using the following equation:

$$FOM = \frac{S^2}{\left(\sqrt{S} + \sqrt{S+B}\right)^2}$$

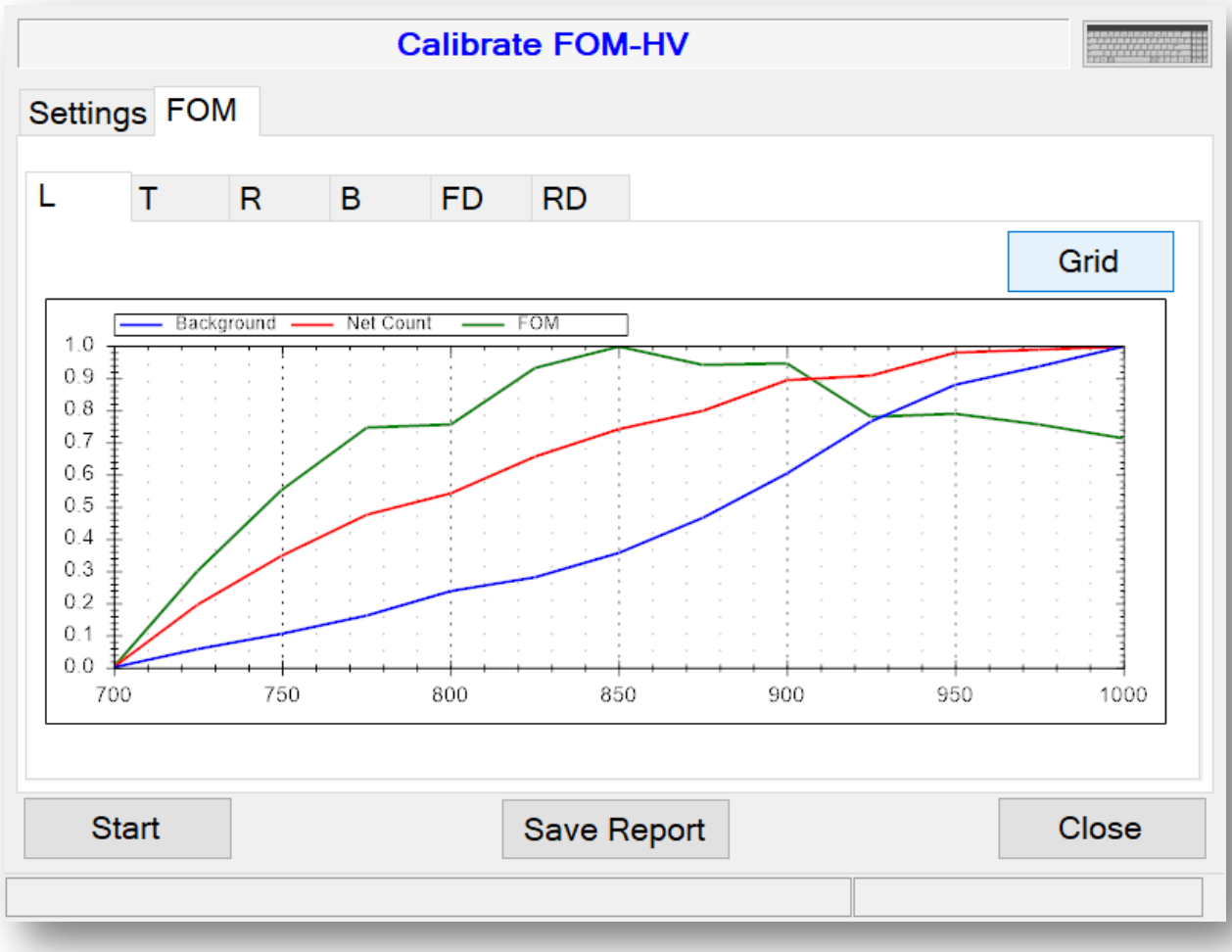
Where:

S = Net (background subtracted) source count rate

B = Background count rate

Click the Save button to save an FOM report. Click the Graph button to display a graph of the three curves. The curves are normalized, i.e., each one peaking at

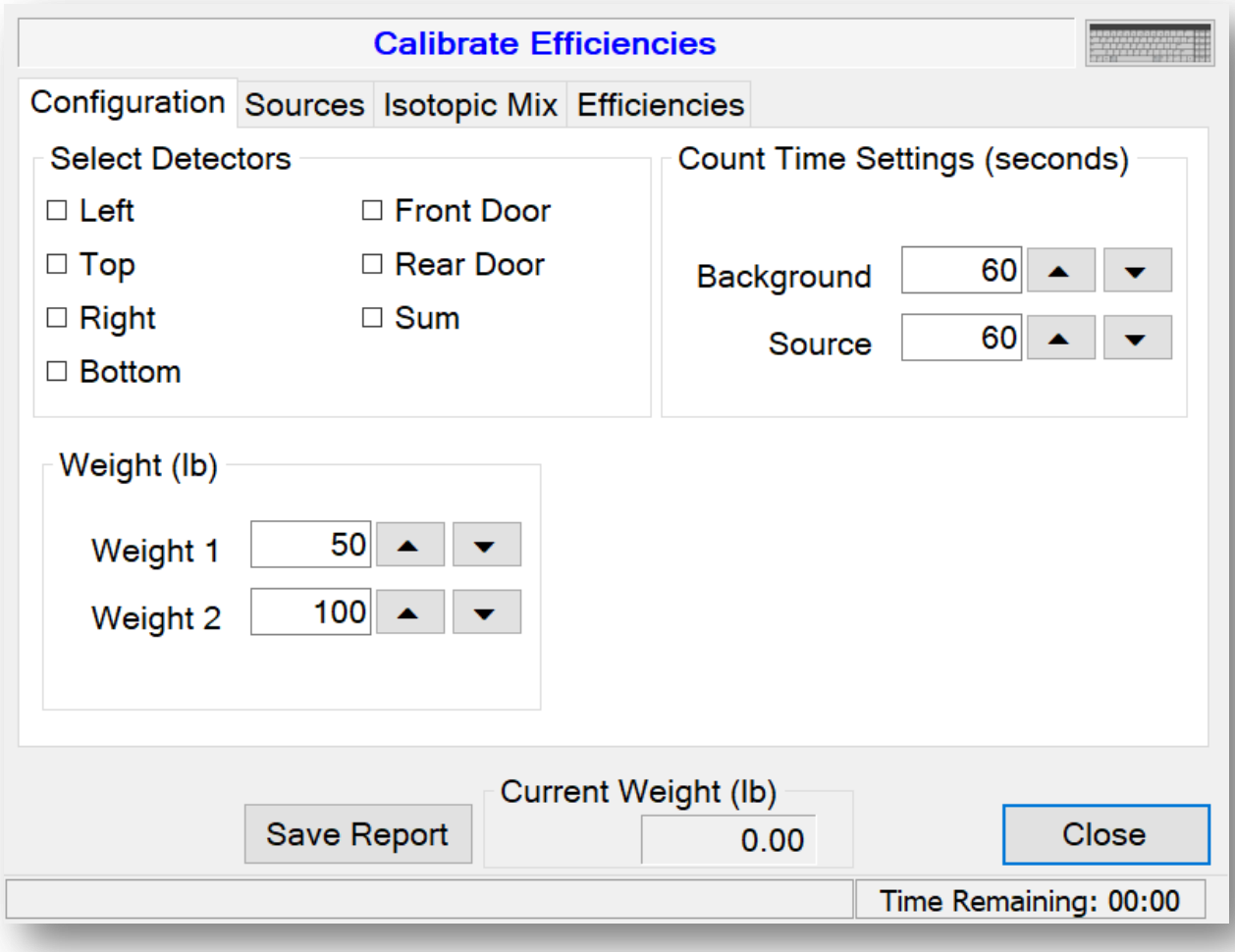
1, since the scales of the curves can vary dramatically from one another. The background curve is displayed as blue, the net source curve is displayed as red, and the FOM curve is displayed as green.



Section 17

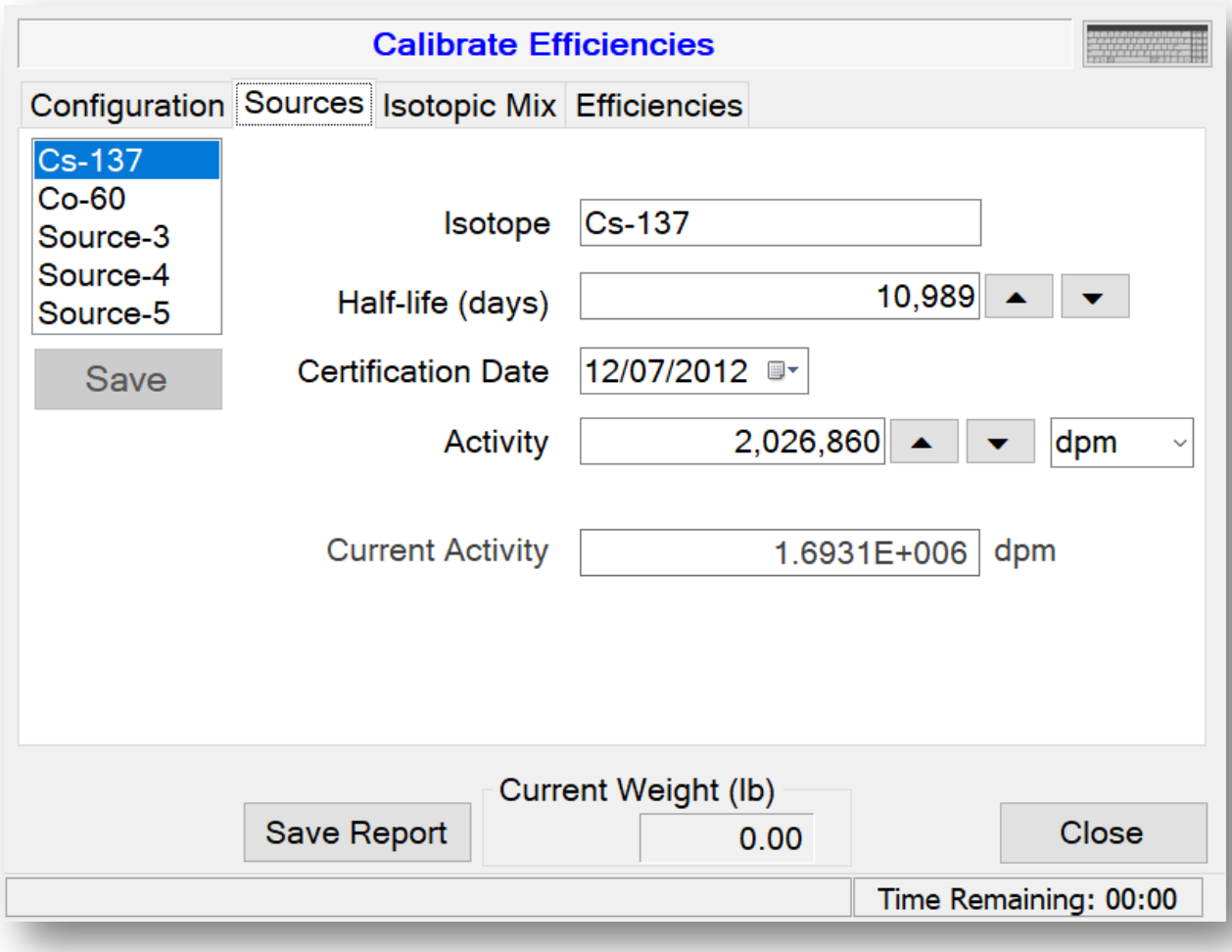
Efficiencies

The Efficiency screen is used to configure the efficiencies for each detector. These efficiencies are used in calculating alarm points and determining the specific activity if the weight option is enabled.



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.



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:

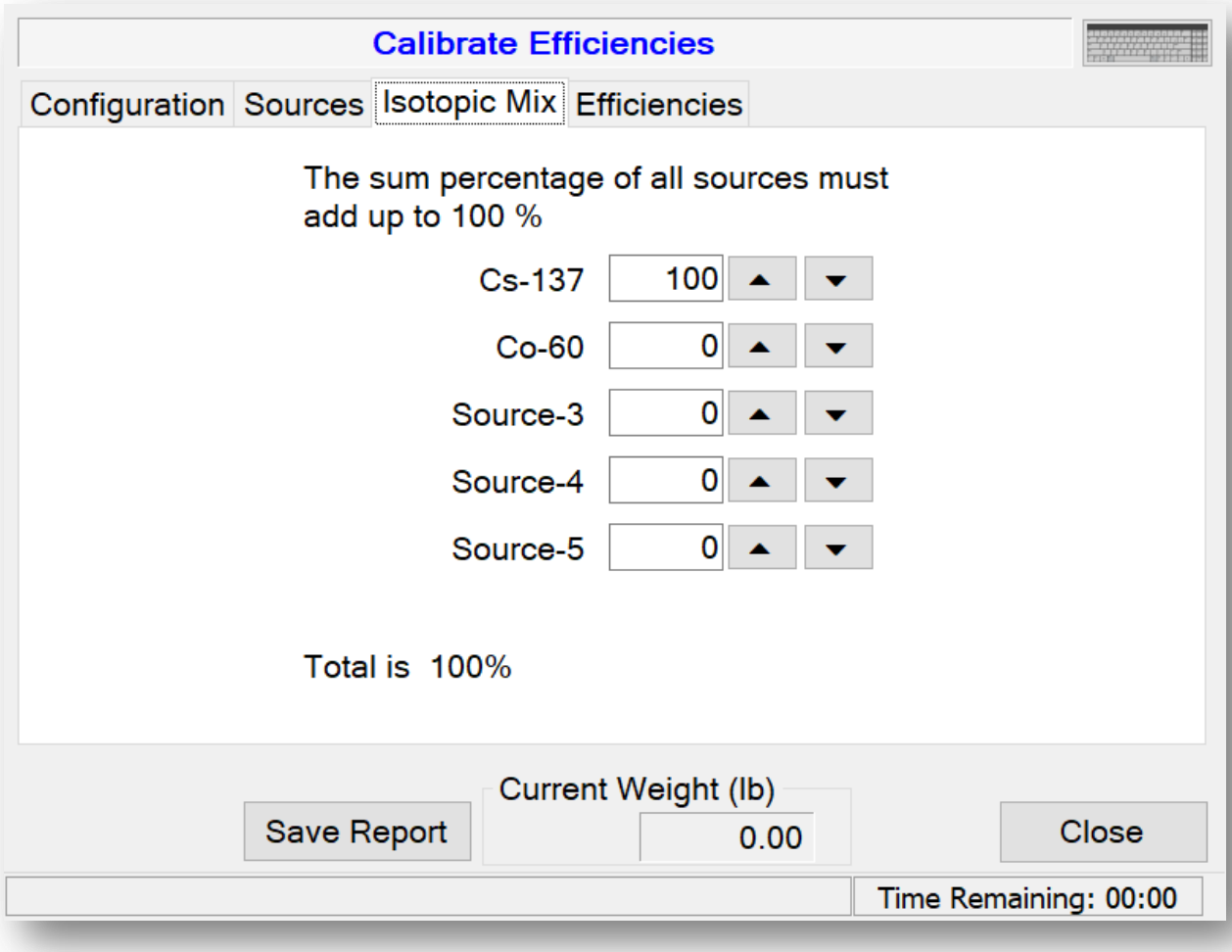
A_F = Current activity

A_O = Original activity

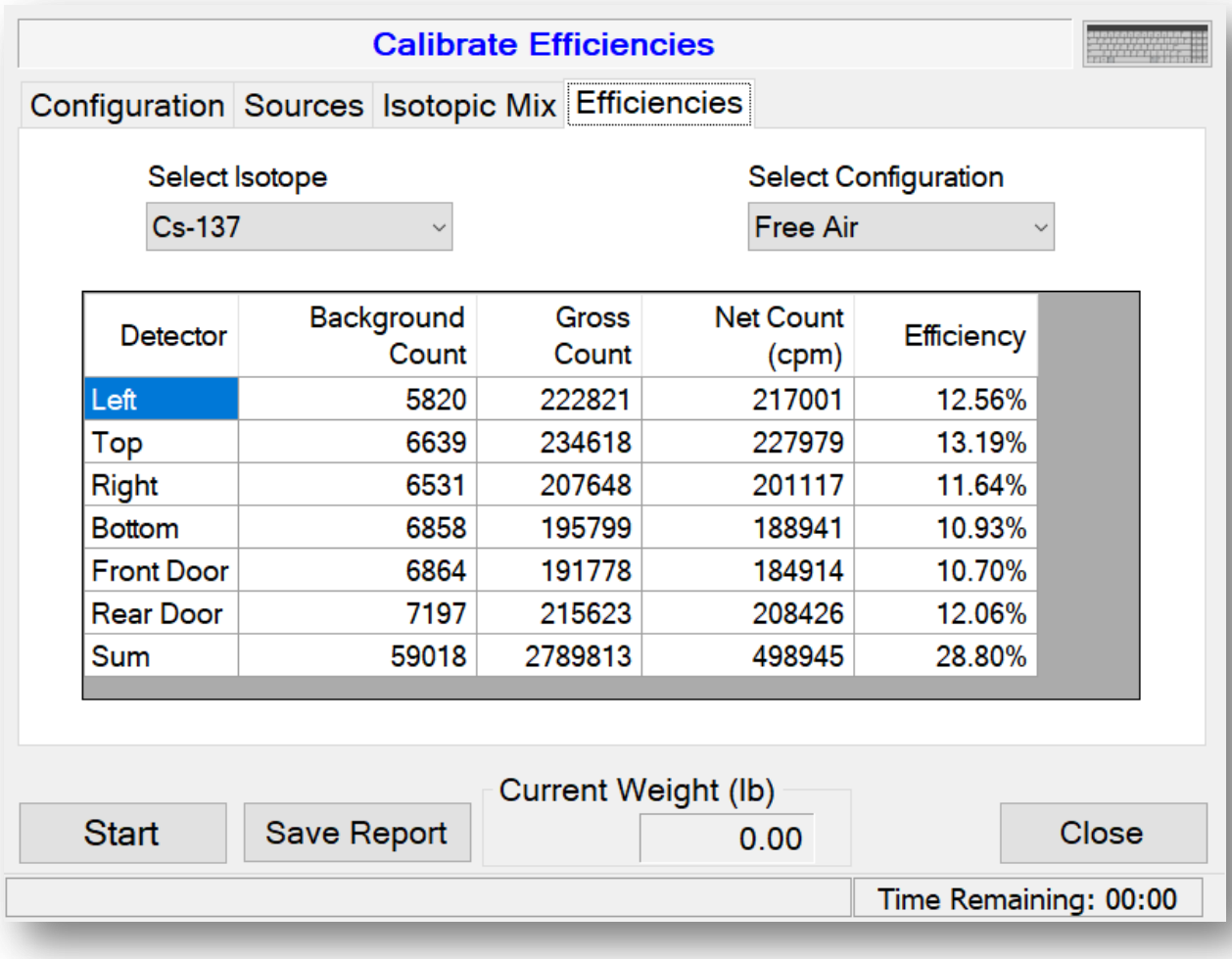
K = 0.693 / half-life in days

T = Elapsed time in days from certification date

The isotopic mix is used to create a weighted average efficiency during monitoring cycles. Up to five isotopes may be used, which are defined in the Efficiency screen. The percentages must add up to 100 percent. 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 on the Efficiency screen.



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



A grid displays the count and efficiency data for all detectors. Each detector and the Sum channel have efficiency data for five isotopes and three configurations for a total of 15 separate efficiencies. The configurations are:

- Free Air
- 50 pounds
- 100 pounds

Only the selected detector(s), isotope, and configuration efficiency is updated. After selecting an 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 center of the chamber. The efficiency will be calculated after the source count is taken and is the net count divided by the source size.

After the efficiency is calculated for the configuration, the isotope efficiency is calculated. If the weight option is disabled, then the isotope efficiency is the free air efficiency. When the weight option is enabled, the isotope efficiency is calculated using the following equation:

$$Efficiency = Ae^{-Bx}$$

Where:

A = Free air coefficient.

B = Weight coefficient.

E = base of the natural logarithm.

X = Weight of the object.

The A and B coefficients are calculated using the following:

Eff_0 = Efficiency measured in free air.

Eff_1 = Efficiency measured with 22.7 kg (50 lb) sphere.

Eff_2 = Efficiency measured with 45.4 kg (100 lb) sphere.

Coefficient A is equal to Eff_0 because e^0 is one. Coefficient B is calculated using the equations for the 22.7 and 45.4 kg (50 and 100 lb) weights:

$$B = -\frac{\ln\left(\frac{Eff_1}{Eff_0}\right)}{50}$$

$$B = -\frac{\ln\left(\frac{Eff_2}{Eff_0}\right)}{100}$$

Both computations of B should be almost identical. The larger of the two values is used for B.

If the weight option is disabled, then the composite efficiency is the sum of the isotopic efficiencies multiplied by their isotopic mix percentages. If the weight option is enabled, then the composite efficiency will be calculated when the weight of the object is determined. The efficiency when using the weight of the object is calculated as follows:

Calculate the mean path length using the weight of the object using:

$$x - \sqrt[3]{weight}$$

Calculate the isotope efficiencies using:

$$Efficiency = Ae^{-Bx}$$

Calculate the composite efficiency by summing the isotope efficiencies, which are multiplied by their isotopic mix percentages.

Section

18

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 article monitor 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 article monitor such as:

- Starting and stopping the Supervisor application
- Commands sent to the host board
- Current status
- Door and pushbutton 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 monitoring of an article including:

- Date/Time
- Employee 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 19

Changes

Firmware Compatibility
Version 1.0.6 and higher– 50401n03
Version 0.9.1 –54001n01

Version 1.1.2
Changed to allow enabling the option to input the weight manually to not disable individual detector alarms.

Version 1.1.2
Fixed issue with rear door sensor logic on standard 54.

Version 1.1.1
Fixed issue with 54R-11 door sensors being reversed and only one active door. Changed in software instead of requiring jumpers.

Version 1.1.0
Added support for 54R-11.

Version 1.0.9
Unreleased version with changes that were rolled back for the 54R-11 as they were not needed.

Version 1.0.8
Added manual weight entry.

Version 1.0.7
Fixed issue with source test not working reliably.

Version 1.0.6
Added non-latching failures.
Changed alarm time extension factor to indeterminate time extension factor.
Changed FOM to use net squared over background for calculation.
Bug fixes.

Version 0.9.1
Beta release.

Section 20

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. electronics 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.

Section 21

Lead Installation

Customers have the option to either provide their own lead or have lead installed by a Ludlum technician.

If the customer desires to provide his or her own lead, following is the number of lead bricks required. (See drawings in the back of this manual for sizes.)

Quantity required for the first layer of lead:
7540-395 = 28
7540-396 = 50
7540-397 = 2

Quantity required for the first layer of lead:
7540-395 = 28
7540-396 = 54
7540-397 = 2

NOTE: The Ludlum Model 54R and 54R-1 are retrofits (electronics and detectors) and use the lead size of the existing system.

Section 22 Parts List

	Reference	Description	Part Number
Model 54 and 54A Article Monitors	UNIT	Completely Assembled Model 54 Article Monitor	48-3263
	UNIT	Completely Assembled Model 54A Article Monitor	48-3792
	UNIT	Electronics and MHV Cables Only Model 54R-1 (Contact Sales to order Model 54R parts)	48-4212
Host Board	BOARD	Completely Assembled Circuit Board	5540-140
CAPACITORS	C3	10µF, 10V	04-5757
	C4	0.01µF, 50V	04-5741
	C5-C6	4.7µF, 50V	04-5819
	C7	6.8µF, 50V	04-5756
	C8	4.7µF, 50V	04-5819
	C9	0.1µF, 25V	04-5744
	C10	4.7µF, 50V	04-5819
	C11	100µF, 10V	04-5820
	C12	1µF, 10V	04-5745
	C13	0.1µF, 25V	04-5744
	C14	10µF, 10V	04-5757
	C15	0.1µF, 25V	04-5744
	C16	680pF, 100V	04-5801
	C20	10µF, 10V	04-5757
	C22	1µF, 10V	04-5745
	C23	0.1µF, 25V	04-5744
	C24	1µF, 10V	04-5745
	C28	10µV, 25V	04-5728
	C53-C56	0.1µF, 25V	04-5744
	C58	4.7µF, 50V	04-5819

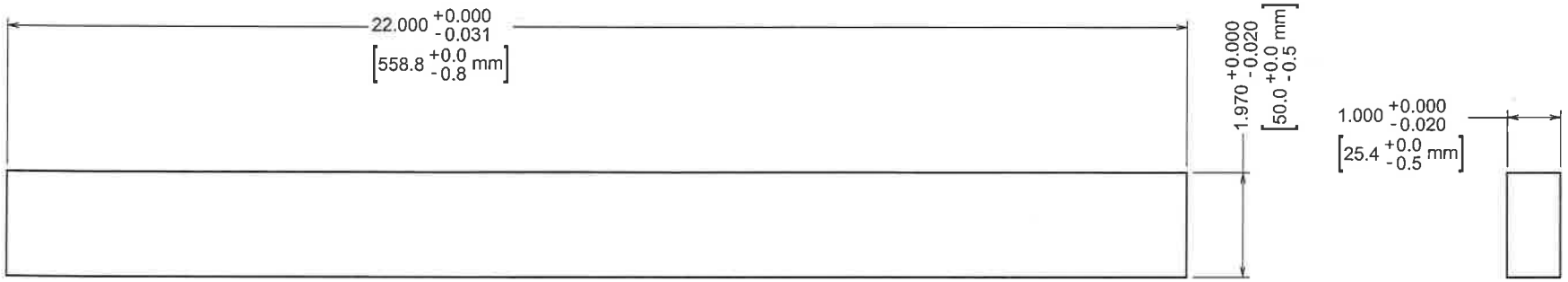
	Reference	Description	Part Number
	C59	1µF, 10V	04-5745
	C60	0.1µF, 25V	04-5744
	C65	10µF, 10V	04-5757
	C74	0.01µF, 50V	04-5741
	C83	0.01µF, 50V	04-5741
	C92	0.01µF, 50V	04-5741
TRANSISTORS	Q1	RK7002AT116	05-5931
	Q4-Q7	RK7002AT116	05-5931
	Q8	NDS356PCT	04-55877
	Q9-Q10	RK7002AT116	05-5931
	Q76	RK7002AT116	05-5931
	Q85	RK7002AT116	05-5931
	Q94	RK7002AT116	05-5931
VOLTAGE REGULATOR	VR1	TPS71533DCKR	05-5936
	VR2	TPS5420D	05-5941
	VR3	TPS61170DRVT	05-5940
INTEGRATED CIRCUITS	U1-U2	SN74AHC138DS	06-6480
	U3	MSP430F2112IRH	06-6767
	U4	SN74HC151D	06-6750
	U5	ADUC843BSZ62-3	06-6703
	U6	TPS3825-33DBVT	06-6558
	U7	SN74AHC1G14DBVR	06-6556
	U8-U9	SN74AHC14DR	06-6474
	U57	TPA2012D2	06-6766
	U64	SN74HC151D	06-6750
	U70	SN74AHC157D	06-6535
DIODES	CR1	MBRS130LT3	07-6423
	CR2-CR3	MBR0540LT1	07-6546
	CR4	MBRS340T3G	07-6469
	CR5	MBR0540LT1	07-6546
RESISTORS	R1	1M, 100MW	12-7081
	R2	150K	12-7150
	R3	1M, 100MW	12-7081
	R4	10K	12-7083
	R5	3.01K	12-7135
	R6	10K	12-7083
	R7-R9	3.01K	12-7135
	R18-R19	1K	12-7084
	R23	10K	12-7839
	R24-R25	10K	12-7083

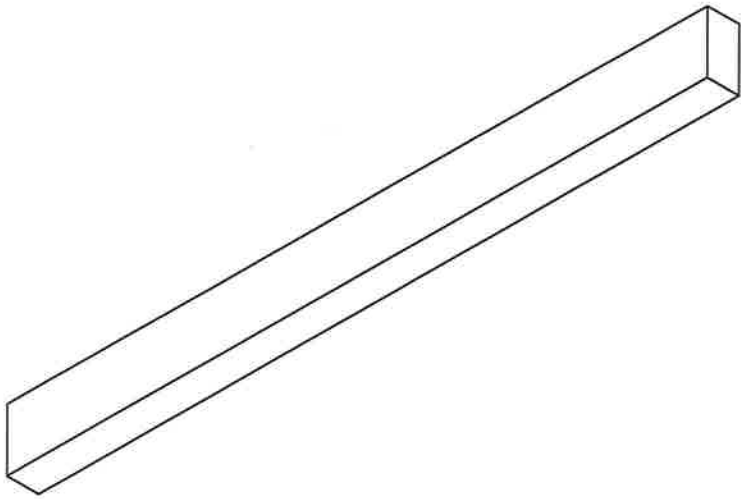
	Reference	Description	Part Number
	R26	187K	12-8016
	R27	3.16K	12-7903
	R28-R32	10K	12-7083
	R34-R41	1K	12-7084
	R50-R52	10K	12-7083
	R66-R67	10K	12-7083
	R71	499Ohm	12-7907
	R72	10K	12-7083
	R75	150K	12-7150
	R78	499Ohm	12-7907
	R79	1K	12-7084
	R80	0Ohm	12-7104
	R81	10K	12-7083
	R84	150K	12-7150
	R87	0Ohm	12-7104
	R88	1K	12-7084
	R89	499Ohm	12-7907
	R90	10K	12-7083
	R93	150K	12-7150
	R96	499Ohm	12-7907
	R97	1K	12-7084
	R100-R107	1K	12-7084
CONNECTORS	J1-J8	MOLEX 43860-002 (LP RJ-11 6P)	13-9037
	J9	MTA 100X3 (640456-3 MTA100)	13-8081
	J11	MTA 100X2 (640456-2 MTA100)	13-8073
	J16	MTA 100X6 (640456-6 MTA100)	13-8095
	J17	MTA 100X8 (640456-8 MTA100)	13-8039
	J18	MTA 100X6 (640456-6 MTA100)	13-8095
	J19	MTA 156X3 (640445-3 MTA 156)	13-8125
	J21	MTA 100X3 (640456-3 MTA100)	13-8081
	J61	MTA 100X4 (640456-4 MTA100)	13-8088
	J68-J69	MTA 156X3 (640445-3 MTA 156)	13-8125
	J72	MTA 100X3 (640456-3 MTA100)	13-8081
	J73	MTA 100X4 (640456-4 MTA100)	13-8088
	J77	MTA 100X4 (640456-4 MTA100)	13-8088
	J82	MTA 100X4 (640456-4 MTA100)	13-8088
	J86	MTA 100X4 (640456-4 MTA100)	13-8088
	J91	MTA 100X4 (640456-4 MTA100)	13-8088
	J95	MTA 100X4 (640456-4 MTA100)	13-8088
	P3	MTA 100X2 (640456-2 MTA100)	13-8073
MISCELLANEOUS	DS1-DS4	LED-LN1271RALTR RED	07-6378
	F1-F9	FUSE (MF-MSMF030-2)	21-8924

	Reference	Description	Part Number
	J12	SOCKET (SLM-104-01-S-S)	13-8986
	L1	INDUCTOR (33µF SMT)	21-8926
	L2	INDUCTOR (10µF D53LC SMT)	21-8925
	P14-P15	USB-MINI-B (UX60-MB-5S8)	13-9075
	P20	USB-MINI-B (UX60-MB-5S8)	13-9075
	P22	USB-MINI-B (UX60-MB-5S8)	13-9075
	SW1-SW2	SWITCH (KSC241G)	08-6827
	Y1-Y2	32.768KHZ	01-5740
Power/Relay Board	C1	4.7µF, 50V	04-5819
	C2	10µF, 6.3V	04-5746
	C3	0.01µF, 50V	04-5741
	C4-C7	10µF, 6.3V	04-5746
CAPACITORS	C8	10µF, 25V	04-5824
	C9	0.01µF, 50V	04-5741
	C10	4.7µF, 50V	04-5819
	C11	330µF, 10V	04-5832
	C12	4.7µF, 50V	04-5819
	C13	0.01µF, 50V	04-5741
	C14-C15	0.1µF, 25V	04-5744
TRANSISTORS	Q1-Q5	RK7002AT116	05-5931
	Q6	RK7002	05-5840
VOLTAGE REGULATORS	VR2	TPS5450	05-5947
INTEGRATED CIRCUITS	U2	TLC372ID	06-6290
DIODES	C1-C5	MBR0520LT1	07-6422
	CR6	MBRS540T	07-6230
	CR7	MBR0520LT1	07-6422
RESISTORS	R1-R5	2.21K	12-7139
	R6-R8	1M, 1/10W	12-7081
	R9-R10	1K	12-7084
	R11-R13	1M, 1/10W	12-7081
	R14	2.21K	12-7139
	R15	1K	12-7084
	R16-R17	1M, 1/10W	12-7081

	Reference	Description	Part Number
	R18	10K	12-7083
	R23	10K	12-7839
	R27	3.16K	12-7903
CONNECTORS	J1	RAPC712 (+12VDC)	13-8445
	J2	MTA 156X3 (640445-3 MTA156)	13-8125
	J3-J4	MTA 100X2 (640456-2 MTA100)	13-8073
	J5	CON5	13-9071
	J6-J7	RAPC-722	21-9781
	J8	MTA 100X2 (640456-2 MTA100)	13-8073
	J9	MTA 100X5 (640456-5 MTA100)	13-8057
	J10	MTA 156X2 (640445-2 MTA156)	13-8098
	J11-J12	MTA 100X2 (640456-2 MTA100)	13-8073
	J13	MTA 156X6 (640445-6 MTA156)	13-8071
	J14-J15	MTA 156X3 (640445-3 MTA156)	13-8125
	J16	MTA 100X2 (640456-2 MTA100)	13-8073
	J18	MTA 100X6 (640456-6 MTA100)	13-8095
RELAYS	RY1-RY3	G6B-2114P	22-9254
	RY4-RY5	AZ850-5	21-8905
	RY6	G6B-2214P	21-9255
MISCELLANEOUS	DS1-DS8	LED-LN1271RALTR RED	07-6378
	F1-F2	FUSE-3A, 60V	21-8890
	L1	INDUCTOR-15µH, 5.65A	21-8889
	SW1	SWITCH-KSLV411	08-6798

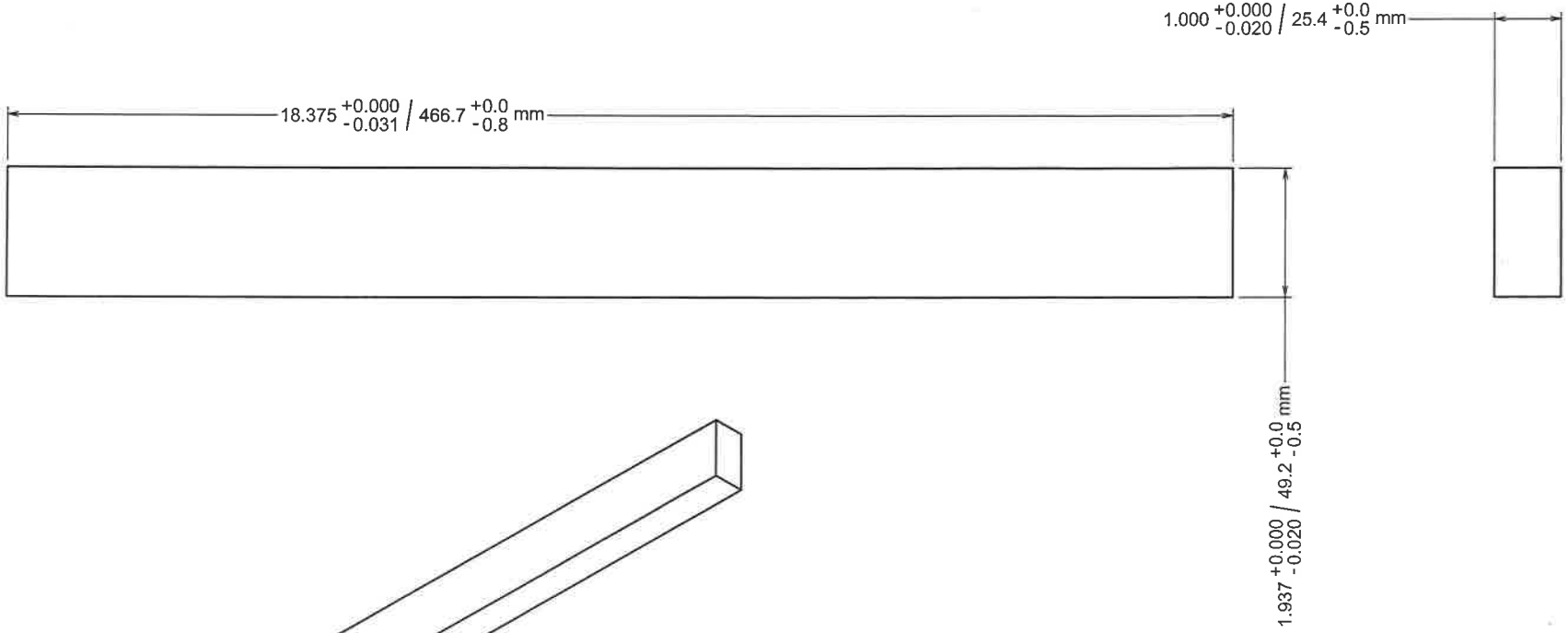
REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	5/11/2010	JGW





DESC: DOOR LEAD					
MODEL NO.: 54A				PART NO.: 7540-395	
MAT'L: LEAD					
SIZE: ---					
MAT'L. NO.: ---					
FINISH: ---				NO. REQ'D: 1	
FINAL ASSY NO.:				SILK SCREEN: N	
DWN: TMM	DATE: 5/13/2010	CHK:	DATE:	APP: WB	DATE: 6-1-10
TOLERANCES UNLESS NOTED OTHERWISE MILL, LATHE, STRIPPIT ± 0.005 BENDS ON SHEETMETAL PARTS ± 0.010				SCALE: 3/8 ANGLES ± 0.5°	
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556				SERIES: 540	SHEET: 395

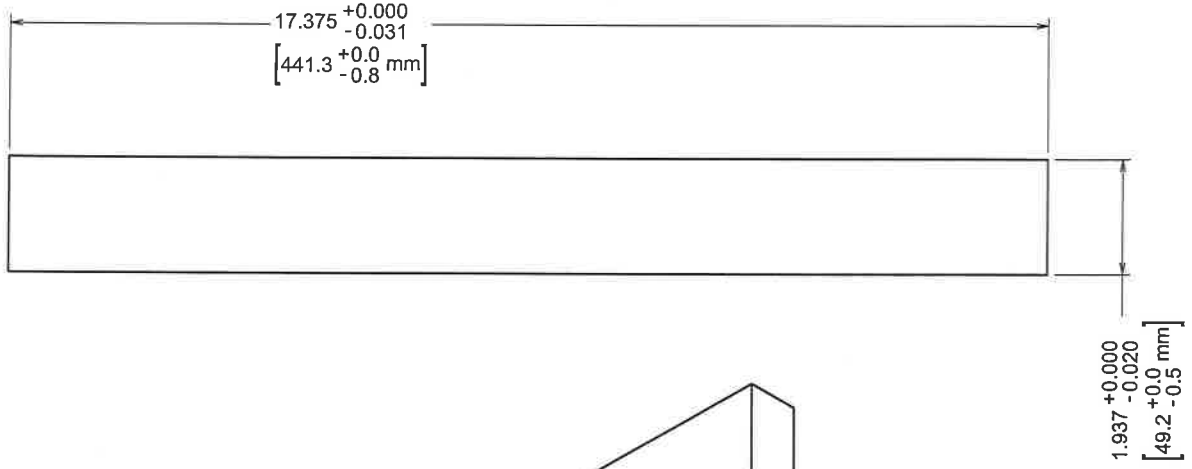
REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	5/11/2010	JGW

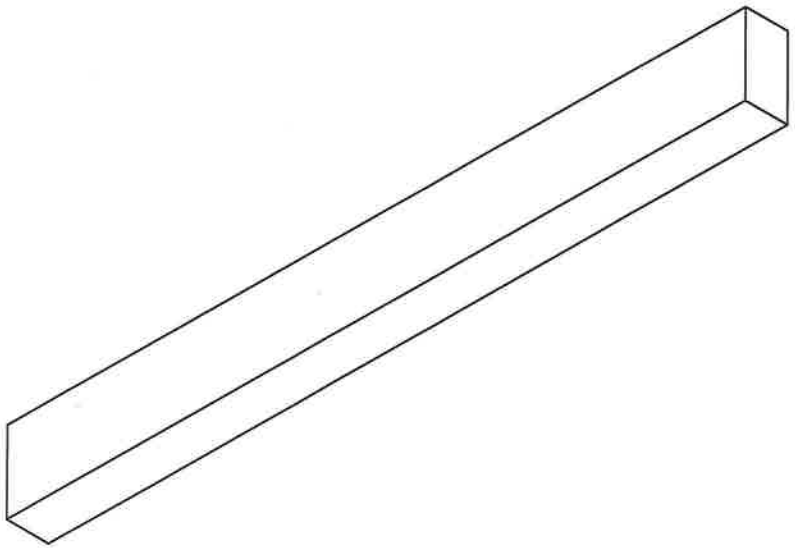


DESC: CHAMBER LEAD 18"					
MODEL NO.: 54A			PART NO.: 7540-396		
MAT'L.: LEAD					
SIZE: ---					
MAT'L. NO.: ---					
FINISH: ---			NO. REQ'D: 1		
FINAL ASSY NO.:				PICK SCREEN: N	
DWN: TMM	DATE: 5/3/2010	CHK:	DATE:	APP: JGW	DATE: 6-1-10
TOLERANCES UNLESS NOTED OTHERWISE MILL, LATHE, STRIPPIT= ± 0.005 BENDS ON SHEETMETAL PARTS= ± 0.010			SCALE: 5/8 ANGLES= ± 0.5°		
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556			SERIES 540	SHEET 396	

VE

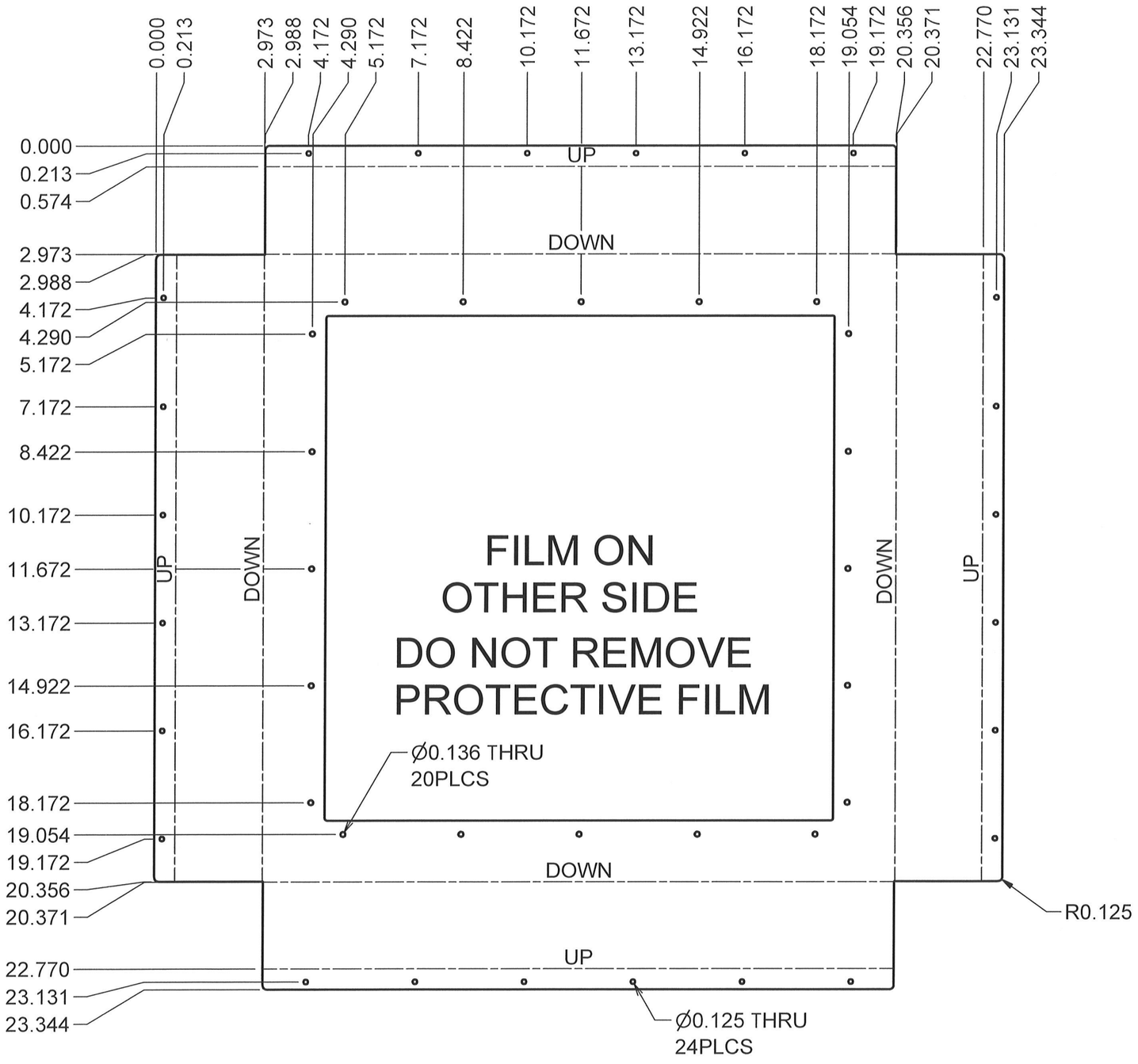
REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	5/11/2010	JGW

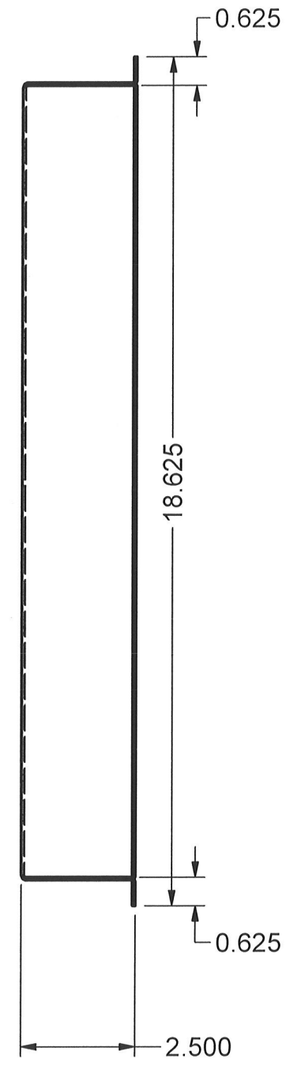


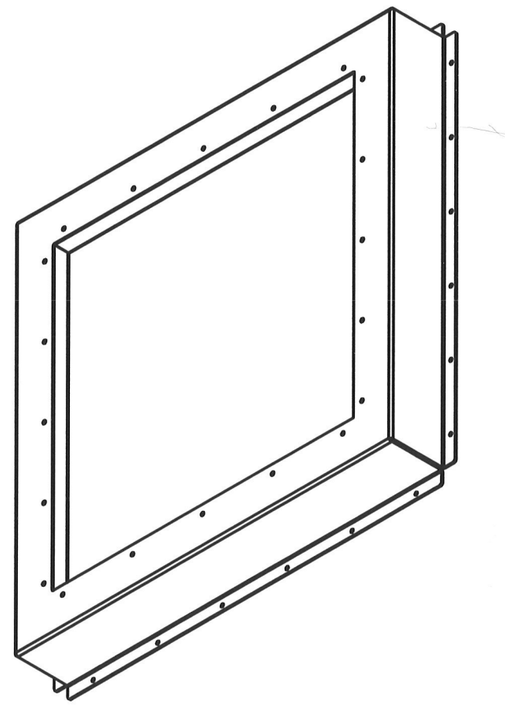


DESC: CHAMBER LEAD 17"					
MODEL NO.: 54A				PART NO.: 7540-397	
MAT'L.: LEAD					
SIZE:					
MAT'L. NO.:					
FINISH:				NO. REQ'D: 1	
FINAL ASSY NO.:				SILK SCREEN: N	
DWN: TMM	DATE: 5/13/2010	CHK:	DATE:	APP: JGW	DATE: 6-1-10
TOLERANCES UNLESS NOTED OTHERWISE MILL, LATHE, STRIPPIT: ± 0.005 BENDS ON SHEETMETAL PARTS: ± 0.010				SCALE: 1/2 ANGLES: ± 0.5°	
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556				SERIES 540	SHEET 397

REVISION HISTORY			
REV	DESCRIPTION	DATE	BY
1	VALID	5/11/2010	JGW
2	ECF #2621	11-21-12	RHS







DESC: LINER MIDDLE FLANGE						
MODEL NO.: 54A				PART NO.: 7540-401		
MAT'L.: 16GA CQ CF .0598* PLT						
SIZE: 545.0 SI						
MAT'L. NO.: 37-9809						
FINISH: CLEAN				NO. REQ'D: 1		
FINAL ASSY NO.:				SILK SCREEN: N		
DWN JLW	DATE 12-26-12	CHK	DATE	APP JOW	DATE 12-26-12	
TOLERANCES UNLESS NOTED OTHERWISE MILL, LATHE, STRIPPIT= ± 0.005 BENDS ON SHEETMETAL PARTS= ± 0.010				SCALE: 3/10 ANGLES= ± 0.5°		
LUDLUM MEASUREMENTS, INC. 501 OAK STREET SWEETWATER, TEXAS 79556				SERIES 540		SHEET 401