CZT REACh™ Detector Hardware Operating Procedure (OP)

WMG-P-126

Rev. 0

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Prepared by:

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CZT REACh™ Detector Operating Procedure
WMG-P-126
Rev. 0

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REVISION LOG

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1.0 Purpose

The purpose of this procedure is to document and detail the operating procedure for the CZT REACh™ Detector.

2.0 Scope

This revision covers the operating procedure for the "A"-Series CZT REACh™ Detectors.

3.0 References

3.1 ANSI N323AB-2013; "American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments" 2013

3.2 H3D Visualizer User Manual Version 2.9

3.3 WMG-P-122; REACh™ Software Operating Procedure

3.4 WMG-P-127; CZT REACh™ Detector Maintenance and Calibration Operating Procedure

3.5 WMG-P-129; CZT REACh™ Driver Application Operating Procedure

4.0 Definitions and Acronyms

4.1 Definitions

4.1.1 Alarm

An audible and/or visual signal activated when the Detector Reading, or response exceeds a preset value or falls outside of a preset Range.

4.1.2 Alert

A notification or signal, which may be audible, visual, or electronic, activated to draw attention to a condition or status that requires user awareness or action but is not necessarily critical or outside preset limits. Alerts may indicate non-critical warnings, information updates, or system statuses.

4.1.3 Calibration

A set of operations under specified conditions that establishes the relationship between values indicated by a measuring Instrument or measuring system and the conventionally true values of the quantity or variable being measured.

4.1.4 Detector

A material or device that produces a signal suitable for measurement or analysis.

4.1.5 Detector Name

A unique "name" identifying each Detector that can be found on the Detector along with the serial number.

4.1.6 Dose

A generic term that means absorbed dose or dose equivalent, as appropriate.

4.1.7 Dose Rate

The radiation Dose delivered per unit of time measured in rem per hour (or equivalent, such as μR/h).

4.1.8 Drift

Change in Readout, usually gradual, without concomitant change in the influence quantity.

4.1.9 Energy Range

The set or Range of continuous energies for a specific type of radiation in which the Instrument meets specified criteria.

4.1.10 Instrument

A complete system designed to quantify one or more characteristics of ionizing radiation or Radioactive Material.

4.1.11 Radioactive Material

Material where one or more constituents exhibit radioactivity (radioactive decay). In this standard, Radioactive Material includes special nuclear material unless otherwise specifically noted.

4.1.12 Range

All values between upper and lower indicated values.

4.1.13 Reading

The indicated value of the Readout.

4.1.14 Readout

The device that conveys visual information regarding the measurement to the user.

4.1.15 Scale

A subrange of the total range of measurement.

4.1.16 **Spectrometer**
An apparatus used for recording and measuring spectra, especially as a method of analysis.

4.1.17 **Test**
A procedure whereby the Instrument, component, or circuit is evaluated for satisfactory operation.

4.2 Acronyms

4.2.1 **ABS** – Acrylonitrile Butadiene Styrene

4.2.2 **AC –** Alternating Current

4.2.3 **ANSI –** American National Standards Institute

4.2.4 **CBR** – Chemical, Bacteriological, and Radiological

4.2.5 **COTS** – Commercial Off-The-Shelf

4.2.6 **CPS** – Counts Per Second

4.2.7 **CPM** – Counts Per Minute

4.2.8 **CZT –** Cadmium Zinc Telluride

4.2.9 **DC** – Direct Current

4.2.10 **DNDO** – Domestic Nuclear Detection Office

4.2.11 **DU** – Depleted Uranium

4.2.12 **FWHM –** Full Width at Half Maximum

4.2.13 **HEU –** Highly Enriched Uranium

4.2.14 **NIST –** National Institute of Standards and Technology

4.2.15 **NORM** – Naturally Occurring Radioactive Material

4.2.16 **PC** – Polycarbonate

4.2.17 **RoHS** - Restriction of Hazardous Substances

4.2.18 **REACh™** - RADMAN™ Enhanced Accurate Characterization

4.2.19 **SNM** – Special Nuclear Material

4.2.20 **TCS** – Technical Capability Standard for Handheld Instruments Used for the Detector and Identification of Radionuclides

4.2.21 **USB** – Universal Serial Bus

4.2.22 **WGPu** – Weapons Grade Plutonium

5.0 Responsibilities

5.1. Detector Operator

Perform daily pre-operational checks to ensure the Detector is functioning as expected.

Report any observed anomalies, errors, or malfunctions.

Follow the standard Calibration and operational guidelines as outlined in this procedure, as well as those referenced above.

Maintain accurate records of Detector usage and performance logs, as necessary.

6.0 Procedure Details

6.1 Detector Model Numbers

This procedure applies to WMG, Inc. branded CZT Detectors: A100, A101, A200, A201, A400, and A401. If your Detector looks like the Detector shown throughout this procedure, it is covered by this procedure. Generally speaking, the differences between models are efficiencies or whether or not a neutron detector addon was included. Additional details are provided below on each model.

A separate manual exists for post-processing Visualizer software (Reference 3.2).

Throughout, A100, A101, A200, A201, A400, and A401 will collectively be referred to as the Detector, unless there is a difference between the operations of the systems.

Note that the standard CZT REACh™ Detector utilizes the A400 model.

6.2 Part List

The table below provides a summary of the hardware which is included with the purchase of one Detector.

Table 1: Pelican Case Contents Overview

Description
CZT REACh™ Detector (typically the A400)
Pelican Case
Country Specific AC Cable
AC-DC Adapter
USB-C to Barrel Jack Adapter
USB male Type-C to male Type-C Cable
Micro USB to Ethernet Adapter
USB to Ethernet Adapter
1-ft Cat 6 Ethernet Cable
Power-Communication Adapter Box
Wrist Cuff and Lanyard

The figure below illustrates the packaging for a CZT REACh™ Detector. Please note that the packaging design and contents may vary depending on the time of purchase. Always refer to the latest version of this procedure for the most accurate information.

Figure 1 – Pelican Case Contents Illustration

6.2.1 Additional Accessories

The accessories in the table below may be included in the case depending on the purchased configuration:

Table 2: Listing of Additional Accessories (May be Included)

Description
USB Flash Drive
USB-A to **USB-C** Adapter
DC-DC Charging Assembly
Fan Assembly
Handle Assembly

6.2.2 Tool List

The following tools are used to perform maintenance on the CZT REACh™ Detector, but are not included:

^{137}Cs radiation check source of known activity (for Calibration)

6.3 Overview

6.3.1 General Information

The CZT RADMAN™ Enhanced Accurate Characterization (REACh™) Detector is a handheld directional Spectrometer that uses position-sensitive large-volume Cadmium Zinc Telluride (CdZnTe) (CZT) as the gamma-ray detection medium. The A401, A201, and A101 models can be configured to include a Micro-Structured Neutron Detector (MSND) with sensitivity of 4.8 cps/nv (thermal) with a maximum Count Rate of 1,000 **CPS**.

Table 3 – CZT Model Overviews

Model Number	CZT Crystal Size	Neutron-Detection?	Weight
A100	>4.5 cm^3	No	2.5 lb (1.1 kg)
A101	>4.5 cm^3	Yes	2.5 lb (1.1 kg)
A200	>9 cm^3	No	2.6 lb (1.2 kg)
A201	>9 cm^3	Yes	2.6 lb (1.2 kg)
A400	>19 cm^3	No	2.6 lb (1.2 kg)
A401	>19 cm^3	Yes	2.6 lb (1.2 kg)

6.3.2 Icons Used in this Procedure

Throughout this procedure, you will see the icons which are illustrated in the table below.

Table 4 – Icons used in this manual.

Icon	Meaning	Icon	Meaning
	Safety Warning		Electrical Warning
	Usage Warning		Helpful hint

6.3.3 Designed Product Specifications

The designed capabilities and performance characteristics of the standard CZT REACh™ Detector are listed in the table below.

Table 5 – Standard CZT REACh™ Detector Product Specifications

Property	Value(s)
Dimensions	3.0” (H) × 3.75” (W) × 11.0” (L)
Weight	~2.6 lbs (1.18kg) configuration dependent
Battery Life	> 8 hours
Power Supply	90-264 VAC to 15 VDC, 4 A, 60 W, 47-63 Hz
Operating Temperature	-20° C to 50° C (-4° F to 122° F)
Operating Humidity	Up to 93% at 35° C (95° F)
Ingress Protection	IP 53 (minimum IP rating to satisfy **ANSI** N42.34)
Energy Resolution	≤ 1.1% FWHM at 662 keV (gamma; coincident interactions combined) at 25° C (77° F)

Property	Value(s)
Sensitivity	Detects 10-μCi ^{137}Cs at 1 m (~3 μR/hr) in < 22 s (in natural background) Localize 10-μCi ^{137}Cs point source at 1 m (~3 μR/hr) in < 90 s to ±3°
Energy Range	50 keV to 3 MeV (spectroscopy) 250 keV to 3 MeV (directionality)
Gamma-Ray Detector	>19 cm^3 CZT (CdZnTe) [A400/A401]
Standard Calibrated Dose Rate Range	0.1 mR/hr – 200 mR/h
Startup Time	<60 s
Isotope Library	User enabled or disabled from manufacturer-provisioned master library.
User Interface	3.5" embedded screen with 3-button control Also viewable on any internet browser
Views	Scan, Search, Spectrum, Detected Isotopes, Trends, Settings
Communication	Embedded Wi-Fi and Bluetooth, and external **USB-C** devices
Data Storage	32 **GB** internal (> 1 million measurements)
Data Stored	**ANSI** N42.42 xml file
Certifications	**ANSI** N42.34 and **DNDO TCS** Test reports available by request
Warranty Includes	2 years (includes annual Calibration and firmware updates)

6.4 Standard Operating Procedures

	Usage Warning: While we strive to give the most accurate results in all situations, the system should not be relied upon solely in life-threatening situations or to protect critical infrastructure. Use discretion in interpreting all results.

6.4.1 Pre-Operation

Before attempting to turn on the Detector, ensure that the battery is sufficiently charged or that the unit is plugged into wall power. To connect the Detector to power and communications:

6.4.1.1 Connect Country-Specific **AC** Cable to **AC-DC** Adapter and plug into wall power.

6.4.1.2 Connect the other end of **AC-DC** Adapter to Barrel Jack Adapter and plug into **USB-C** slot on the Detector.

6.4.1.3 Check that the green **LED** is on to confirm charging.

6.4.2 Powering on the Detector

6.4.2.1 To turn on the Detector, press and release the power button. This process is depicted further in this procedure.

6.4.2.2 The screen will turn on immediately and show the CZT REACh™ logo. After about 15 seconds, the Detector will boot, and a notification of the firmware loading will appear on the screen.

6.4.2.3 The screen will then display a biasing-up message with a countdown until it is ready to record data.

6.4.2.4 After the start-up sequence, the embedded screen will display the user interface. The full start-up time is about 60 seconds.

6.4.3 Standard Operation (Search Mode)

When the Detector first turns on, it will start in search mode. The primary page for search mode is the search page (see Section 6.9 for more details about all the pages), which provides the user with information on the Dose Rate and identified isotopes. The user can toggle the middle function button to access the trends page to look at the Count Rate history and the history of detected isotopes.

	Helpful Hint: No data is saved, and no directional information is provided while in search mode.

6.4.4 Standard Operation (Scan Mode)

When search mode indicates that there may be a source of interest present, or you wish to take a longer scan than in search mode, perform a scan. The Detector is most sensitive to sources placed directly underneath the display, as indicated by the crosshairs on the bottom of the Detector. For maximum efficiency, point the bottom of the Detector at the source (i.e., position the Instrument so that you look through the screen directly at the source).

6.4.4.1 Position the Detector in a stable location to allow for accurate direction information. If the Detector is not stationary for the scan, the direction information provided may not meet specification.

6.4.4.2 Navigate to the scan page. Press the right control button (labeled “Start”) to start the scan process. Select a User, Item, and Distance as needed.

6.4.4.3 Following these selections, proceed with starting the scan by pressing the left control button (labeled “Start!”). When the scan starts, the timer will begin counting down from the set time.

6.4.4.4 Keep the Detector stationary during the entirety of the scan. During the scan, you can follow the progress on the scan page or view the spectrum on the spectrum page.

6.4.4.5 Any isotopes that are detected will be displayed in the ID section of the scan page or labeled on the spectrum on the spectrum page. If the isotope is localized, a vector or vectors will be drawn on the system diagram on the scan page to show the direction to that isotope relative to the system.

	Helpful Hint: If the “Detections at End” setting is turned on, the IDs and direction vectors will not appear until the scan ends.
	Helpful Hint: For accurate directionality, do not move the Detector during the scan. Isotope direction assumes a stationary Detector.

6.4.4.6 The scan will conclude when the scan countdown reaches zero. Alternatively, if sufficient statistics are achieved before the scan time is concluded, you can stop the scan by pressing the right control button (labeled “Stop”).

6.4.4.7 When the scan stops, the Detector will show a summary page with the results from the scan. The first summary page shows general information. Scroll down to additional pages for a list of the isotopes that were identified as well as additional information that can be provided for certain scans. On the bottom of the summary page, there is an option to continue the scan in case a longer scan is desired. When satisfied, click "Done" to conclude the scan and return to the scan page.

6.4.4.8 At this point, the scan is stopped, the system is in search mode, and the button to return to the search page is enabled. While a scan is collecting data, the search page is disabled. Note that the spectrum and IDs from the last scan will remain on the scan page and spectrum page until a new scan begins.

6.4.4.9 The data from each scan is internally saved based on the scan number. It can be used for post-scan analysis and reach-back.

6.4.5 Shutting Down the Detector

The Detector must be shut down properly to minimize the probability of system errors. To turn off, press and release the power button, then press the right control button to confirm shutdown. The left control button will cancel the shutdown. After a few seconds, the screen will turn black.

6.4.6 Updating via USB

The system firmware may be updated using a firmware patch provided by WMG, Inc. Follow these steps:

6.4.6.1 Obtain an update file (.h3d) from WMG, Inc.

6.4.6.2 Push the update file to a flash drive.

⚠	**Usage Warning:** Use care when inserting and removing **USB** flash drive or other **USB** attachments. Ensure connector is in the correct orientation; connection should be made easily. Excessive force can break the **USB** socket.
⚠	**Usage Warning:** Only one update may be applied at a time, and they must be applied in chronological order of the patch date.

6.4.6.3 Using the **USB-A** to **USB-C** adapter, connect the flash drive to the Detector. When prompted, use the function button to confirm that you want to apply the update.

6.4.6.4 Once the system starts, confirm the update was applied by checking the firmware version number on the Settings Menu.

6.4.7 Updating via Maintenance Interface

An update to the system can also be pushed to the Detector using the Maintenance Interface. Follow these steps to perform a system update using this method:

6.4.7.1 Once you reach the screen shown in Figure 2, click on the link at the top that says, “Update System”.

6.4.7.2 Click on the “Choose File” button at the bottom of the Update System screen, as shown in Figure 2.

6.4.7.3 Select the update patch file (.h3d) from your computer and click “Apply”.

6.4.7.4 Wait for the file to upload. When it is done, the page will show a "Reboot" button.

6.4.7.5 Click on the “Reboot” button and the system should restart.

6.4.7.6 The prompt to accept the update should show up on the main interface. Accept the update to apply the patch.

6.4.7.7 Once the system starts, confirm the update was applied by checking the firmware version number on the Settings Menu.

6.4.7.8 This same window can be used to correct the real time clock by entering the time in the boxes next the “New Clock:”

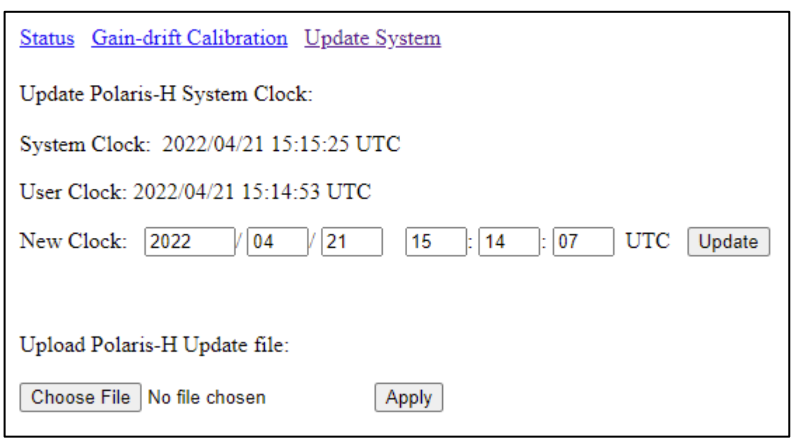

Figure 2 – The Update System screen in the Maintenance Interface.

6.4.8 Remote Control and Connections

It is possible to connect to the system via Wi-Fi or Ethernet in order to control the system remotely, or to download data. You should see the system's web interface, which looks identical to the screen interface. For details on downloading data to your computer, see Section 6.4.16.

	Usage Warning: Note that the wireless communication chip on this device has been tested by the manufacturer for emissions safety at 20 cm [8"] from the user. You should not enable Wi-Fi communication when holding the device. It is intended to be used to extract data from the system after collection and should be enabled when you are no longer in contact with the device.

6.4.9 Wi-Fi Connections

There are two options for a Wi-Fi connection with the Detector: client mode and hotspot mode. Navigate to the System Info menu, as shown in Figure 20, to set up the connection. The device will need to be unlocked using the password 0101. Once the Detector is unlocked, the screen will look like Figure 3.

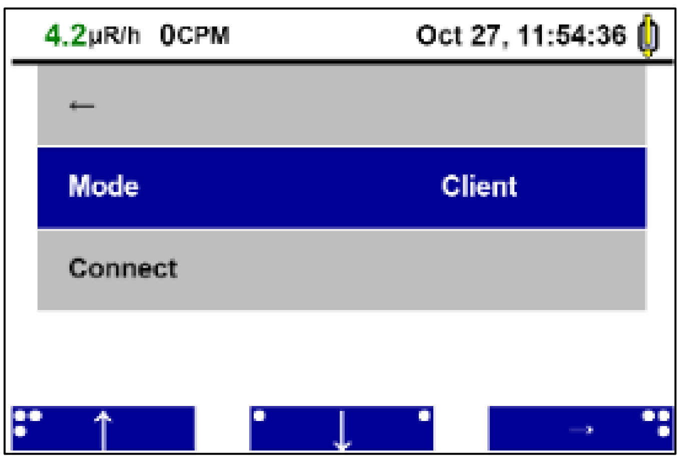

Figure 3 - Selecting a Wi-Fi Connection Mode.

6.4.10 Client Mode

Select client mode on this screen to search for available Wi-Fi networks. Select the desired network and enter the network's password. If the password is correct, the network name will be displayed, as shown in Figure 4. The Detector will also be assigned an IP address, which is listed next to the network's name. A computer or device connected to the selected network can bring up the Detector interface by navigating to the displayed IP address.

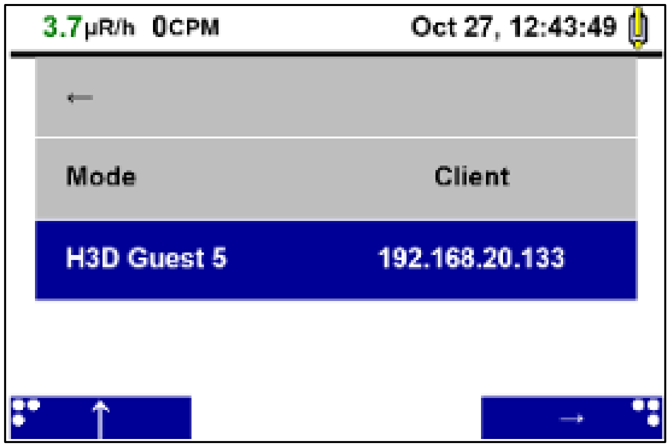

Figure 4 - Settings Menu Screen when Connected to a Network in Client Mode

6.4.11 Hotspot Mode

Select hotspot mode from the screen shown in Figure 3 once the Detector is unlocked. If the hotspot is successful, the Detector Name should replace the word “Connect”. A network with the model number appended with the unit’s name will appear as an available Wi-Fi network to Wi-Fi-compatible devices (for example, “A401-Ned”). A computer or device connected to this network can bring up the Detector interface by navigating to **192.168.4.1** in any web browser (Google Chrome and Mozilla Firefox are preferred).

Usage Warning: With the Wi-Fi on, an open Wi-Fi network is created, allowing anyone within range access to system data.

6.4.12 Bluetooth Connections

To connect via Bluetooth, Bluetooth-compatible devices should be able to see and pair with the Detector. To do this, search for Bluetooth devices and choose the device with the same model and name as your Detector to pair. On some mobile phones, you may also need to connect to the device. On Android phones you will also need to disable Wi-Fi and cellular data.

Usage Warning: Unlike some Bluetooth devices, the Detector’s Bluetooth is always open to pairing, allowing anyone within range access to system data.

You can then access the same interface as on the system’s embedded screen by entering the IP address **192.168.5.1** in any web browser (Google Chrome and Mozilla Firefox are preferred).

6.4.13 Ethernet Connections

The Detector can be set up to be on any network by changing its IP address, subnet mask, and gateway in the Settings Menu (Section 6.9.10) and connecting it via Ethernet to your network. Contact your IT professional if you need help in appropriately assigning these addresses.

To connect directly to the Detector via Ethernet, you must first know your computer's IP address. In Windows, this can be found by running "ipconfig" on a command prompt, or in the Network Connection Ethernet settings. Then, set an IP address for the Detector (in the Settings Menu – Section 6.9.10) that uses the same first three sections as your computer's IP4 address but using a number between 1 and 255, excluding 10, as the fourth section. The subnet mask and gateway will be automatically configured, so do not change these. Alternatively, you could change the IP address of your computer, **<u>or ethernet adapter</u>** (if you are using one), to be similar to the IP address of the Detector. Plug the Ethernet cable between your computer **<u>or ethernet adapter</u>** and the Detector as described in Section 6.4.1 and power the unit up. It will be properly connected after one minute of powering it up, confirmed by the **LED** on the Ethernet adapter being green or orange. You should now be able to ping the unit at the IP4 address you set earlier. You can also then access the same interface as on the system's embedded screen by entering that IP address in the Settings Menu in any web browser (Google Chrome and Mozilla Firefox are preferred).

6.4.14 Downloading and Deleting Data

There are three ways the user can download data from the Detector for advanced analysis or record keeping. The first is to download data directly to a **USB** flash drive plugged into the system through an adapter. The second is to download them to your computer over an Ethernet or Wi-Fi connection using a web interface. The third is to download them to your PC computer over an Ethernet or Wi-Fi connection using manufacturer's Visualizer post-processing software. These will be discussed in further detail below.

6.4.15 Download to USB Flash Drive or Delete Data

Follow these instructions to download the scan data to a **USB** drive or delete data:

6.4.15.1 Navigate to the "manage scans" setting on the settings menu. Press the right control button to enter the manage scans interface.

6.4.15.2 **<u>IF</u>** a **USB** flash drive is not plugged into the **USB-C** port on the Detector through an adapter, please plug in a **USB** drive. With a **USB** drive present, the manage-scans Interface will appear as shown in Figure 5. If a **USB** drive is not present, the options to download will be replaced with a message asking the user to insert a **USB** drive. The fourth option to delete all scans (shown on next page of interface if the user scrolls to the bottom) is always available even if a **USB** drive is not inserted.

Usage Warning: Use care when inserting and removing **USB** flash drive adapter or other **USB** attachments. Connections should be made easily. Excessive force can break **USB** sockets.

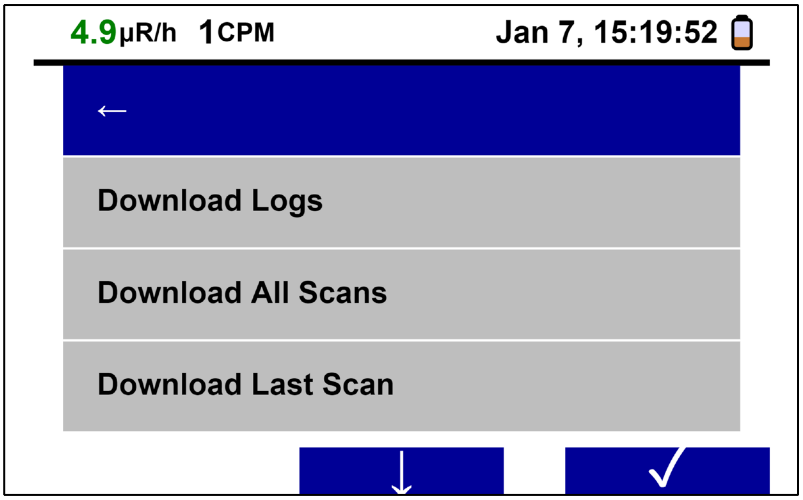

Figure 5 – Manage Scans Interface

The manage scans interface shown above shows three options for downloading data. A fourth option to delete all scans is available on the second page of the interface if the user scrolls all the way to the bottom.

6.4.15.3 There are four options on the manage scans Interface. “Download Logs” will download just the log files. “Download All Scans” will download all the scan data that have been recorded. “Download Last Scan” will download only the last scan’s data. “Delete All Scans” will delete all scan data. Pressing the right control button will initiate the download or delete action. Once started, it cannot be cancelled and no other selection can be made on the interface until the operation is complete, however, the settings menu can be exited, or the user can return to the main settings menu by selecting the back arrow. Returning to the manage scans Interface will continue to show the progress of the download or delete action. During the download, the progress will be shown as a percentage, as shown in Figure 6. When a download is complete, it will state that the scan (or scans) was downloaded, as shown in Figure 6 by the “Scan Downloaded” item.

Usage Warning: Do not unplug the **USB** flash drive when a download is occurring. This may corrupt the scan data or drive.

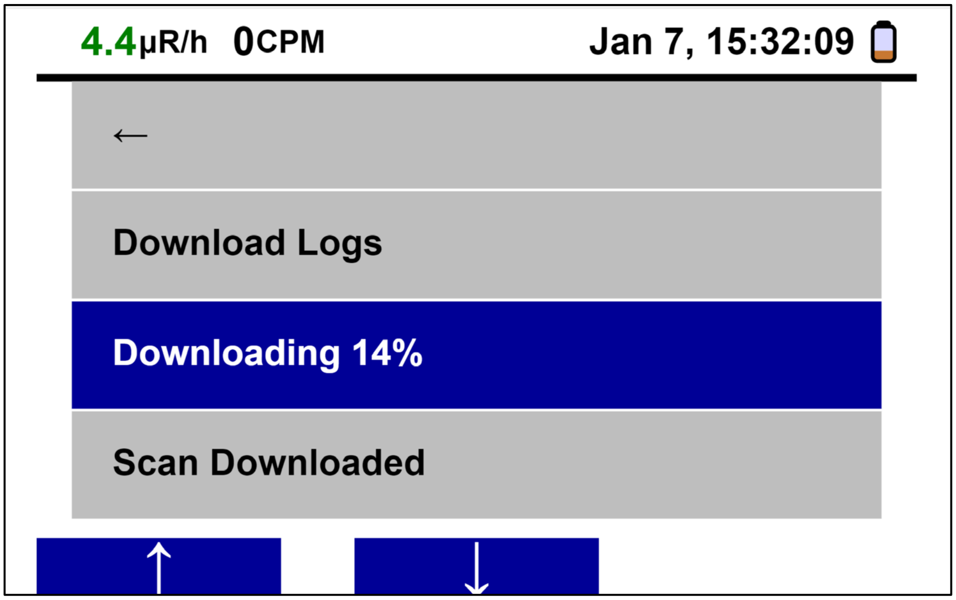

Figure 6 – Manage-Scans Interface during the Download Process

During the download process, progress of the current download will be shown as a percentage.

6.4.15.4 After the scan data has been downloaded, the **USB** drive can be inserted into a computer to access the downloaded scans. If all scans were downloaded, there will be a folder in the root directory of the **USB** drive titled with the serial number and Detector Name. That folder will contain all the scan data. If the only last scan was downloaded, only a single folder with the name and date of that scan will be downloaded and placed in the root directory of the **USB**. In the folder for each scan is all the data associated with that scan. The primary file containing the spectrum data is the ANSI ".N42" file.

6.4.16 Download via Web Interface

Please follow these instructions to download scan data over a web interface with the system connected to a computer via Wi-Fi or Ethernet.

6.4.16.1 With the Detector on, connect the Detector via Ethernet or Wi-Fi to a computer or network and go to the system's IP address in a web browser, appended with "/scans". For Example, "192.168.168.81/scans".

6.4.16.2 This opens the download interface, which is shown in Figure 7. The top of the interface has three buttons for downloading the logs, downloading all scans, or deleting all scans. Below these options is a list of all scans by their scan folders. scans can be downloaded or deleted at this level. If the user clicks on the folder name (i.e., the scan name), then they can view all of the files contained in the scan folder and choose to download any of them.

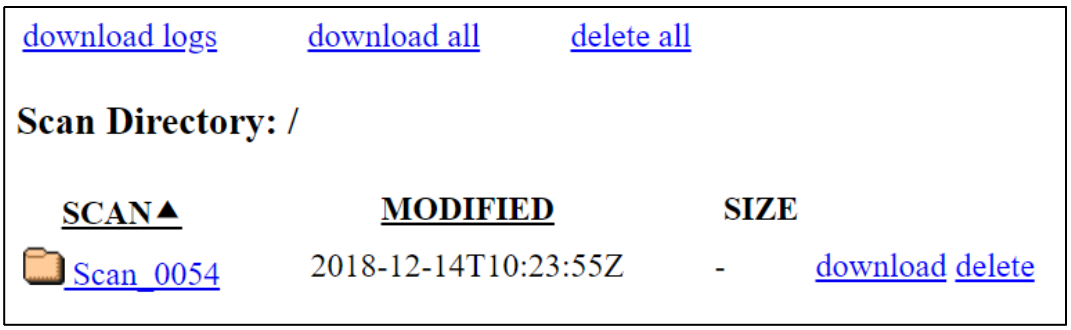

Figure 7 – Download Interface for the Detector on its' Web Interface.

6.4.16.3 Choosing to download a file will download that file to the default download location or allow the user to pick their download location if they do not have a default location. If they choose to download all scans, they will be downloaded into an "AllScans.zip" file. The ANSI ".N42" files can be used for spectrum analysis, or the files can be loaded into Visualizer for further analysis.

6.4.16.4 To exit the download interface, retype the IP address into the web browser's address bar to get back to the main interface. This can be done simply be deleting the "/scans" portion of the address bar.

6.4.17 Download using Visualizer

Visualizer is manufacturer's proprietary post-processing software. With the purchase of any H3D product, such as Branded WMG Detectors, the user is granted access to Visualizer, which can be downloaded from H3D's support website. For more information on Visualizer and its operation, please ask WMG or refer to the Visualizer User Manual.

To download the data from the Detector, please follow these steps:

6.4.17.1 With the Detector powered on, connect the system via Ethernet or Wi-Fi to a computer or network. See Section 6.4.8.

6.4.17.2 Run Visualizer.

6.4.17.3 Verify that Visualizer is directed to the appropriate directory where you want to save the scans. Change the directory using the "Change Directory" feature from the File Menu. It is ideal to store all scans in the same directory.

6.4.17.4 Choose "Import Measurements from Detector" from the File Menu.

6.4.17.5 Select the Detector's IP Address from list, click "Connect". If the IP address is not present in the list, add the appropriate IP address first using the "Add Detector" button.

6.4.17.6 Check the scans you wish to import on the list. The quick links to select "All" or "None" just above the list may be useful. If scans were previously downloaded, those scans would be grayed out and will not need to be downloaded again.

6.4.17.7 Click "Import" to begin the download of all scans. The scans will be downloaded to the previously selected directory.

6.4.17.8 In Windows File Explorer, navigate to the chosen directory to view the data, which includes ANSI N42.42-format files. The data is saved in directories with names based on the date, scan number and time for each scan. If you are interested in using Visualizer to analyze the results, please consult the Visualizer User Manual.

6.5 Hardware Overview and Operation Reference

The figure below illustrates a CZT REACh™ Detector. Please note that the design may vary depending on the time of purchase.

Figure 8 – The CZT REACh™ Detector

6.5.1 Buttons

The CZT REACh™ Detector has five buttons. The three buttons closest to the screen are the control buttons. These buttons perform the operations that are labeled on the bottom portion of the screen. The two buttons below the control buttons are the power button (lower-left button) and settings button (lower-right button).

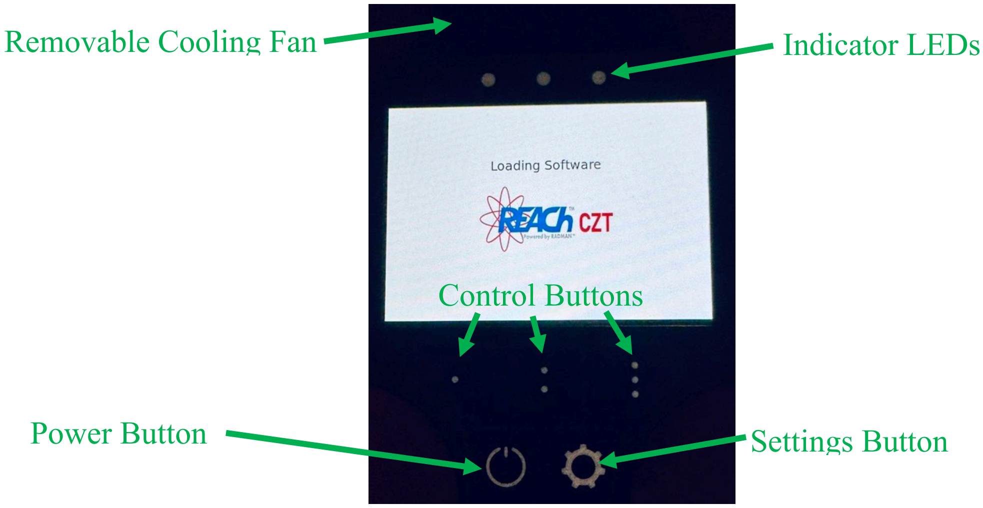

Figure 9 – Labeled Interface Buttons on the Detector.

6.5.2 Sensory Notifications

The Detector has visual (**LEDs**), tactile (vibrational), and auditory (beeping sound) notifications in the forms of Alarms and Alerts. **ALARMS** are major occurrences, such as Dose Rate crossing the alarm thresholds, the detection of special nuclear material (**SNM**), or the detection of neutrons. **ALERTS** are minor occurrences, such as isotope identification of medical, industrial, or naturally-occurring-radioactive-material (**NORM**) sources or status messages for the battery or temperature.

6.5.3 LED Indicators

The CZT REACh™ Detector has three **LEDs** located above the screen. Each **LED** provides different notifications to the user.

The left **LED** provides the user with Detector status information. When the Detector is plugged in to charge while off, this **LED** will turn on. When it is amber, the Detector is charging; when it is green, the Detector is fully charged. Please note that if the battery is not properly connected or not present, the Detector will show the battery is fully charged via a green **LED**.

The center **LED** provides an Alarm for the gamma-ray Dose Rate. When the lower Dose Rate threshold is reached, it will blink slowly. When the higher Dose Rate threshold is reached, it will blink quickly.

The right **LED** provides an Alarm for detected isotopes. When an isotope in the special-nuclear-material (SNM) category is detected, it will blink red to notify the user. When any other isotope is detected, it will blink green to notify the user of the presence of a new isotope. When the neutron Count Rate is elevated, if a neutron Detector is integrated into the system (e.g., A401 branded Detectors) it will blink red as well. These are described below:

Table 6 – Alarm State (LED Lights for Detector).

Alarm Type	Center LED	Right LED
Dose Rate at lower threshold	Blink Green at 2.5 Hz	--
Dose Rate at higher threshold	Blink Green at 5 Hz	--
New isotope detected	--	Blink Red for SNM Blink Green for Other Isotopes
Neutrons detected (if neutron Detector present)	--	Blink Red

6.5.4 Vibration Indicator

The CZT REACh™ Detector has tactile feedback via a vibration motor to inform the user of Alarms or Alerts. Vibration can be turned on for all Alarms and Alerts, for just Alarms, or for neither Alarms nor Alerts in the settings menu. The Alarms and Alerts for vibration are described below.

Table 7 – Alarm States (Vibration Indicators for Detector)

Type	Category	Vibration Mode
Dose Rate at lower threshold	Alarm	Constant Vibration at 1.5 Hz
Dose Rate at higher threshold	Alarm	Constant Vibration at 3 Hz
SNM Detected Or Neutrons detected (if neutron Detector present)	Alarm	Single Vibration
New isotope detected	Alert	Single Vibration

6.5.5 Sound Indicator

The CZT REACh™ Detector has a speaker to provide beeps for auditory notifications. The speaker beeps can be turned on for all Alarms and Alerts, for just Alarms, or for neither Alarms nor Alerts in the settings menu. If headphones are connected and the volume is turned on, the speaker will be silent. The Alarms and Alerts for the speaker beeps are described below.

Table 8 – Alarm States (Sound Indicators for Detector)

Type	Category	Sound Mode
Dose Rate at lower threshold	Alarm	Constant beeping at 2.5 Hz
Dose Rate at higher threshold	Alarm	Constant beeping at 5 Hz
SNM Detected Or Neutrons detected (if neutron Detector present)	Alarm	Single Beep
New isotope detected	Alert	Single Beep

6.5.6 Storage and Operating Temperature

When not in use, store the Detector between -20°C and 50°C (-4°F and 122°F) in a dry environment.

⚠	**Usage Warning:** The Detector will automatically bias down if it is operating at ambient temperatures above 50°C (122°F) and the internal temperature exceeds the maximum allowable operating temperature. A warning message will be shown on the screen to notify the user that the system has biased down the Detector.

6.5.7 Charging and Battery

The Detector was designed to run on battery power for eight (8) hours. The standard method of charging is to attach the enclosed adapter, as described in Section 6.4.1, to the Detector and plug it into a wall outlet. To verify that power is applied, check the battery symbol on the embedded screen. Charging should complete more than 90% of the way in about 4 hours. Charging when the Detector powered on takes longer because the system has to ensure it can charge at high ambient temperatures.

The Detector can also be charged when the system is off. The system will charge faster when it is powered off, reaching a full charge in less than 4 hours.

Refer to the following list for additional charging information if you have circumstances different than the standard charging method (see Section 6.4.1).

⚠	**Usage Warning:** Failure to comply with this information could result in damage to the system:

6.5.7.1 The unit is charged using the 15-V rail on a **USB-C** power delivery charger.

6.5.7.2 WMG Inc. provides a charger with the system that will charge the system at an appropriate current and voltage.

6.5.7.3 If you are using a different **USB-C** charger please make sure it can deliver at least 3 A of current on the 15-V power rail. Additionally, a ferrite bead (Digikey PN 240 2077-ND or equivalent) should be fitted to the Detector end of the **USB-C** cord.

	Helpful Hint: When not in use, the battery in the Detector will discharge very slowly over many months. Before use after an extended period in storage, recharge battery by plugging into wall power.
	Safety Warning: Lithium-ion battery is enclosed in the battery cartridge and is not accessible to end users. Do not attempt to remove the battery from the battery cartridge. Contact WMG Inc. for questions or assistance.
	Electrical Warning: The Detector only accepts DC power. Only use an appropriate DC adapter or damage to the Detector may occur. Do not apply other voltages or AC power. **ENSURE** that power socket can deliver up to 100 W. Failure to comply with standard charging protocol and not using included charging adapter could result in damage to the Detector.
	Safety Warning: Power adapter may get hot, especially during charging. Do not place in an enclosed space and exercise caution while handling.

6.5.8 Connection for Simultaneous Charging and Readout

In some advanced cases, you may wish to charge the Detector while connecting it to a network. Follow these steps to use the supplied power-communication adapter box to connect power and ethernet to the single **USB-C** port:

6.5.8.1 **CONNECT** the **AC** cable to the **AC-DC** adapter.

6.5.8.2 **CONNECT** the **AC-DC** adapter to barrel jack on the power-communication adapter box.

6.5.8.3 **CONNECT** the **USB-C** extension cable to **USB-C** port on power-communication adapter box.

6.5.8.4 **CONNECT** the opposite end of extension to **USB-C** port to the Detector.

6.5.8.5 **CONNECT** the **Micro-USB** to ethernet adapter into the **Micro-USB** port on power-communication adapter box.

6.5.8.6 **CONNECT** the ethernet cable to network or computer.

6.5.8.7 **CHECK** that green **LED** is on to confirm charging.

	Safety Warning: To reduce the risk of fire, or product damage, do not use it in a confined space. Ensure unit is well ventilated.
	Safety Warning: Do not open any Detector enclosures. Internal components are to be serviced by the manufacturer only. Opening of the system may result in the voiding of any warranty and access to safety hazards.
	Safety Warning: Do not operate the Detector if the unit is defective or broken, including a damaged or cut power cord or plug, if wires are exposed, if it malfunctions, or if it is dropped and damaged.

6.5.9 Disposal

The Detector contains three potentially hazardous materials – Li-ion batteries, CZT, and circuit boards. Proper disposal of the CZT consists of shipping the CZT crystals back to manufacturer for appropriate disposal; the manufacturer has contractual agreements with third parties to recycle the CZT back into the production process of future CZT crystals or be discarded through environmentally appropriate channels. The rest of the materials in the Detector are industry standard materials that when discarded will be categorized as non-hazardous electronic waste, plastic containing ABS, defined as recycling code 7, and bulk aluminum which is readily recyclable. Sub-assemblies not specifically manufactured by are standard COTS parts conforming to industry standards specifications, such as RoHS, which includes provisions for not creating hazardous waste.

The Detector **DOES NOT** contain any radioactive check sources.

6.6 Maintenance and Calibration

Please refer to WMG Procedure WMG-P-127, CZT M&C OP for the maintenance and calibration procedure in regard to the CZT REACh™ Detector.

6.7 Semi-Annual Inspection

If the Detector is stored for at least one (1) year between uses, WMG, Inc. recommends performing an inspection on the Detector twice per year. Periodically taking the Detector out from storage ensures that the Detector is ready to use when required.

The following checks should be made on a semi-annual basis:

6.7.1 **PLUG** the Detector into an outlet using the **AC** adapter and the **AC-DC** adapter.

6.7.2 **CHARGE** the Detector until the left **LED** light turns green. This may take up to six hours.

6.7.3 **NOTE:** that with a less than full battery, the light will be yellow.

6.7.4 Once the Detector turns on, **RUN** the **BIT**. Please refer to WMG-P-127 in regards to running the **BIT**.
NOTE: that this Test requires a ^{137}Cs check source. If you do not have access to this check source, please refer to WMG-P-127.

6.7.5 While the system is on, follow the isotope-identification check in WMG-P-127.

6.7.6 **NOTE:** this Test only needs to be performed if the steps above could not be completed.

6.7.7 **INSPECT** the screen to ensure there are no dead pixels.

6.7.8 **INSPECT** the Detector for mechanical defects.

6.7.9 **NOTE:** Mechanical defects include cracks in the housing.

6.7.10 **INSPECT** the Detector to ensure all pieces are intact.

6.7.11 **INSPECT** the Detector label to ensure it is intact and readable.

6.7.12 **INSPECT** the calibration label to ensure it is intact and readable.
NOTE: If the calibration is due, please contact WMG.

6.8 Decontamination

If the Detector is used in an environment that causes it to become radioactively contaminated, defer to site-specific policies for decontamination.

Contamination is most likely to occur as particulate matter on the outside, contamination in the fan and thermal subsystem, or contamination within the smaller system cavities. Both the fan assembly and handle shroud may be disposed of, and replacements may be purchased from WMG Inc. The bulk of the outer surface materials in the Detector are PC/ABS plastic which has excellent resistance to weak acids, good resistance to strong acids, weak alkalis, and gamma radiation. This material has fair resistance to strong alkalis and UV radiation. Importantly, the main housing material of the Detector is not going to absorb the CBR contaminants and will be relatively easy to decontaminate with standard procedures including weak to strong alkalis, which are fairly typical in decontamination kits.

Specifically, WMG Inc. recommends using the M100 sorbent material in combination with a mild to strong detergent for CBR decontamination. A mild abrasive pad can certainly be used on the PC/ABS housing but is ideally **NOT** used on the acrylic screen protector.

Be sure to handle all materials used for decontamination per site-specific protocols, where applicable.

6.9 Firmware Overview and Operation Reference

6.9.1 Overview

Operation of the Detector is done in either search or scan mode. While in search mode, the Detector will detect and identify radiation sources. No data is saved while in search mode. Therefore, if a spectrum is needed for reach-back, the Detector needs to be switched to scan mode, where spectra are recorded and saved. During a scan, isotopes are also detected, and directions are provided if available.

NOTE: Any movement of the Detector during a scan will blur the determined direction of the gamma-ray source.

When the Detector turns on, it begins in search mode. To start a new scan, navigate to the scan page and press the right control button (labeled “Start”) to start the scan process. If a second scan is desired to better localize the gamma-ray source, the first scan needs to conclude or be stopped prior to moving the Detector to its’ new position and starting a new scan. When a scan stops, the Detector automatically switches into search mode.

6.9.2 Info Region

The info region is at the top of every page. It holds basic information about the Detector status. From left to right, the info region shows the gamma-ray Dose Rate, the neutron Count Rate, the current date, time, and the Detector battery level. The Dose Rate and Count Rate are not displayed in the info region when on the search page, where the Dose Rate and Count Rate are prominently displayed on the screen

NOTE: If your Detector is an A400, in other words has no neutron Detector, the info region will show the gamma Count Rate adjacent to the gamma-ray Dose Rate.

6.9.3 Temperature

The thermometer icon is color coded to tell if the Detector is too cold (blue), OK (green), or too hot (yellow and red alternating) for useful operation. When it is too cold or too hot, performance may degrade. Operation while too hot may damage the Detector. When moved to a drastically different temperature environment, the thermometer may oscillate between too hot and cold for a few minutes as the Detector adapts to the new environment. If the temperature falls outside the appropriate Range, a flashing exclamation point will appear over the thermometer to draw your attention to it. If the humidity inside the Detector head becomes too high, a humidity-warning symbol will appear over the thermometer icon. This looks like a water droplet with a “%” sign. If this occurs, contact WMG Inc. for service and discontinue use.

6.9.4 Battery Level

The remaining battery level is shown in the middle icon in the upper right of the screen. The level is also colored green, yellow, or red depending on if the level is full, medium, or near empty, respectively. When the battery level is below 10%, a flashing exclamation point will appear over the battery icon. When charging, a lightning-bolt symbol will appear on the battery.

The expected battery life is eight (8) hours.

For more about the battery and charging, see Section 6.5.7.

6.9.5 Search Page

The search page is displayed when the Detector turns on. As seen in the figure below, the search page predominantly shows the Dose Rate and Count Rate for gamma rays. If your Detector is an A401, in other words it has a neutron Detector integrated into the system, then the Count Rate shown will be the neutron Count Rate in place of the gamma ray Count Rate.

Below the Dose Rate and Count Rate bars are displayed alongside any detected isotopes.

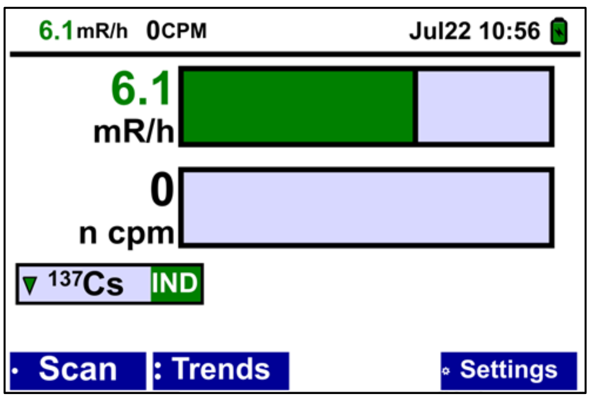

Figure 10: Search Page Example

For the Dose Rate and Count Rate bars, the current value is identified by the colored region of the bar. The color for the Dose Rate will change to yellow when the lower threshold is reached and red when the upper threshold is reached. If the maximum value for the Dose Rate or Count Rate is not the current level of the Dose Rate or Count Rate, a vertical line in the Dose Rate and Count Rate bar will identify the maximum level that has been seen by the Detector since the last time search began (a scan concluded or was stopped).

Please note that while on the search page, no data is saved. In order to save data, a scan needs to be started from the scan page. While a scan is running, the search page is disabled. Once the scan is stopped, the search page can be accessed again.

From the search page, you can navigate to either the scan page or trends page using the control buttons.

6.9.6 Trends Page

The trends page can be reached from the search page. The trends page shows the Count Rate history for the Detector for gamma rays, as shown in the figure below. The time Range for the history can be adjusted using the zoom feature controlled by the right control button. The isotopes that were detected at any time during this history are displayed below the trends plot. For each detected isotope, the times during the history for which the isotope was detected is displayed on the trend plot via a symbol that corresponds to each isotope – this feature can be turned on and off using the "Detection History" setting. Note that some isotopes listed on the trends page may not be currently detected since the trends page shows all detections from the plotted history.

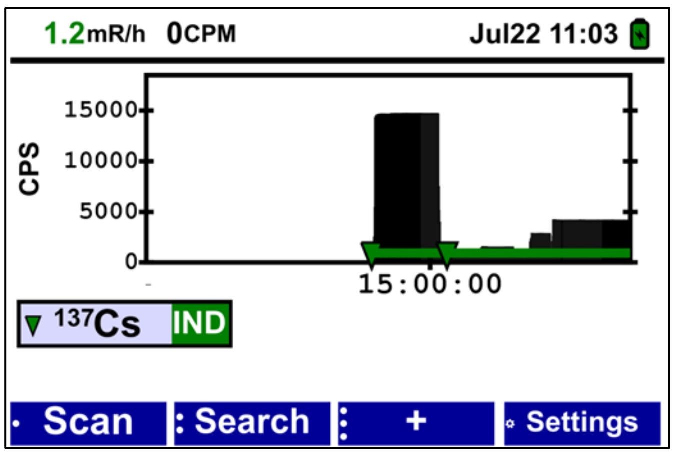

Figure 11: Trends Page

From the trends page, you can navigate to the scan page or back to the search page.

6.9.7 Scan Page

The scan page, illustrated in the subsequent figures, allows the user to start scans for which data is saved for reach-back or post-scan analysis using WMG's REACh™ Software, or the manufacturers Visualizer Software. Alternatively, any scan's associated N42 file may be post-processed in gamma spectroscopy software which accepts the N42 file format.

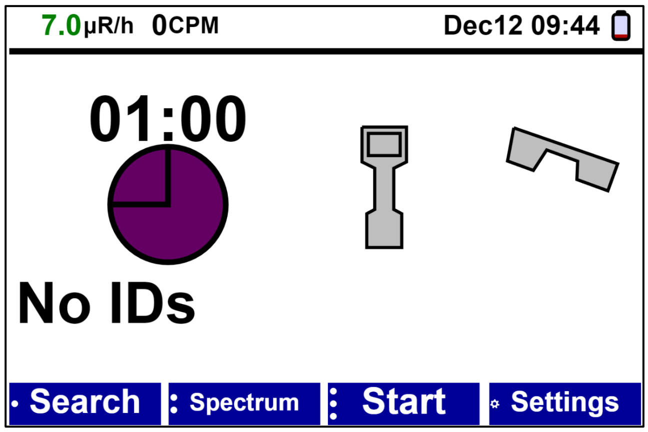

Figure 12: Scan Page Starting Screen

Navigating from either the search page or trend page to the scan page will bring you to the starting screen of the scan page. Before a scan is started, the scan page shows the results from the previous scan. When the Detector is first turned on, these results are blank, as no scan has been completed.

After navigating to the scan page, from left to right, the control buttons allow the user to return to the search page, view the spectrum page associated with the last scan taken, and allow the user to start the scan setup process. Note, like before, when the Detector is first turned on, these results are blank, as no scan has been completed. Lastly, although not visually shown, the settings menu can be accessed by pressing the settings control button on the Detector.

From the starting screen of the scan page, users can start a new scan, by pressing the right control button (labeled "Start") to start the scan setup process.

	Helpful Hint: Once the scan setup process has started, it must be completed to return to the search page or trend page. If your goal is to simply view items, users, or distances configured prior to starting a scan, these can be reviewed in the settings menu as opposed to starting the scan process.

The figure below illustrates what the scan setup process page might look like for you, depending on the users, items, or distances you have configured on your Detector.

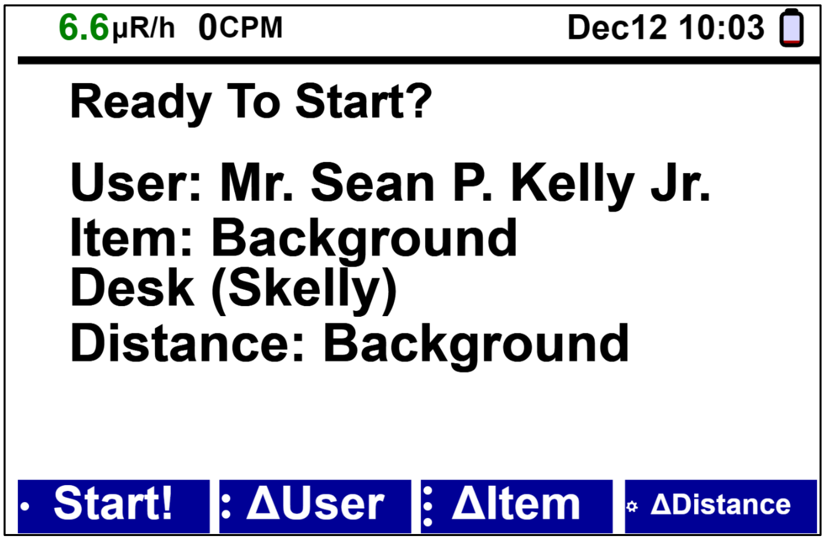

Figure 13: Scan Setup Process Page

There are several control buttons available. These controls allow the user to configure specific data, such as the user or operator of the Detector, the item being measured (e.g., “55-Gallon Drum 12345”, “Intermodal 12345”, “Misc. Item 12345”, etc.), and the acquisition distance. These data points will automatically be associated with the each scan you take. Furthermore, this data will be uploaded to the REACh™ Software when you synchronize data using the REACh™ Driver.

From left to right, the control buttons allow the user to start a scan by pressing the control button labeled “Start!”, change the user or operator of the Detector by pressing the control button labeled “User”, change the item being measured by pressing the control button labeled “Item”, or to change the acquisition distance the user is performing a scan at by pressing the control button labeled “Distance”.

When the control button labeled “Start!” is pressed, the scan acquisition process will begin. The acquisition time will utilize the preset time you have selected in the menu settings. The figure below depicts what this process should look like:

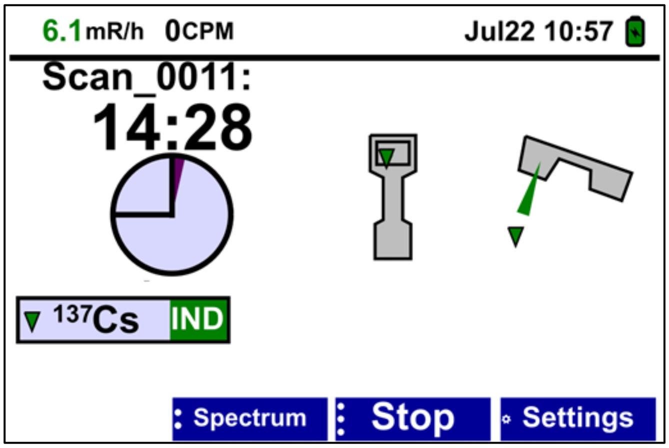

Figure 14: Scan Acquisition Process Page

Above the control buttons are several different icons. On the left side of the page is a clock, timer, and isotope identification indicators. Once a scan is started, the clock will begin to show the fraction of time remaining, and the timer will count down to zero. Above the timer, the scan number (e.g., “Scan_0011”) is shown as a unique identifier for the current scan. Below the timer, the detected isotopes will be displayed, if there are any. On the right side, direction vectors will be displayed on the diagram of the Detector to show where the detected isotopes are located relative to the Detector. Each isotope has a symbol that will correspond to the direction vectors. Not all detected isotopes will have direction vectors since there may be poor statistics or no localized hot spot for the isotope.

The control buttons allow the user to navigate to the spectrum page, stop the scan, or view settings while the scan is underway. Both the spectrum page and the settings menu will be discussed in greater detail below.

	**Helpful Hint:** Note that a scan does not need to be stopped prior to the time elapsing. When the timer reaches zero, the scan will automatically stop. Alternatively, a scan can be stopped at any time during the scan process by pressing the control button labeled “Stop”.

Prior to starting a scan, when the control button labeled “User” is pressed, the correct user or operator may be selected for the acquisition process. The selected user will be indicated as the surveyor of all scans until this selection is changed to a different user. This selection allows the REACh™ Software to know **WHO** took the survey. The figure below depicts what this process should look like:

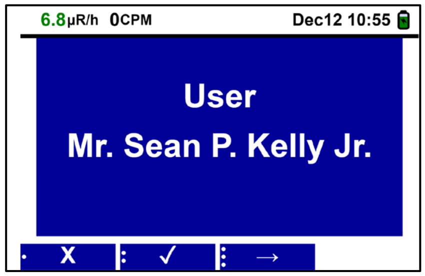

Figure 15: User Selection Page

The control buttons in this menu, from left to right, allow the user or operator to return to the scan setup process page, select the user, or cycle between available users. Users are managed in the REACh™ Software and subsequently synchronized the Detector using the REACh™ Driver. Alternatively, the user can be selected via the menu settings.

Prior to starting a scan, when the control button labeled “Item” is pressed, the correct item may be selected for the acquisition process. The selected item will be indicated as the “survey name” for all scans until this selection is changed to a different user. This selection allows the REACh™ Software to know the survey name associated with each survey. The figure below depicts what this process should look like:

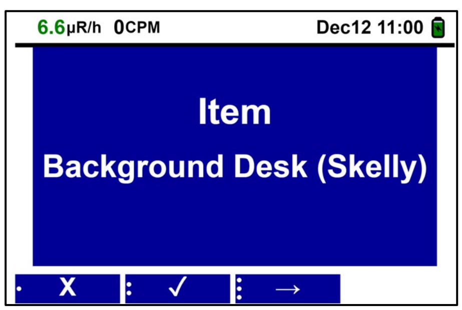

Figure 16: Item Selection Page

The control buttons in this menu, from left to right, allow the user or operator to return to the scan setup process page, select the item, or cycle between available items. Items are managed in the REACh™ Software and subsequently synchronized to the Detector using the REACh™ Driver. Alternatively, the item can be selected via the menu settings.

Helpful Hint: When conducting surveys for a single package (e.g., drum) or object (e.g., tool), use the same selected item for consistency. For instance, when surveying a large ISO container, you might take several measurements along its length. In this case, select the item (e.g., "ISO 123") and begin taking measurements. After completing each measurement, continue using the same item for additional measurements at different locations on the container.

This approach ensures all surveys for the package are grouped under the same item. You don't need a unique item for each individual survey; instead, assign a unique item for all related surveys of the same package or object.

Prior to starting a scan, when the control button labeled "Distance" is pressed, the correct acquisition distance may be selected for the acquisition process. The selected distance will be indicated as the "reading distance" for all scans until this selection is changed to a different distance. This selection allows the REACh™ Software to know the correct reading distance for each survey. The figure below depicts what this process should look like:

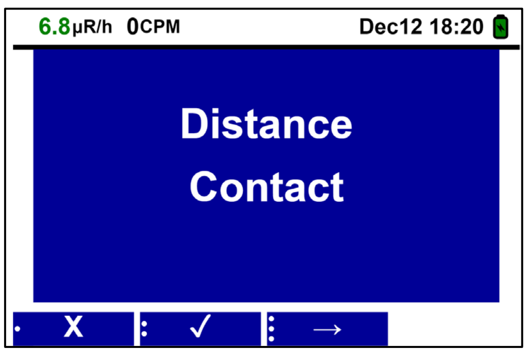

Figure 17: Distance Selection Page

The control buttons in this menu, from left to right, allow the user or operator to return to the scan setup process page, select the desired acquisition distance, or cycle between available distances. Available distances include Contact (i.e., 1-inch), 0.5 ft (i.e., 6-inches), 1-ft (i.e., 12-inches), 1-m (i.e., 100-cm or 39.7-inches), 2-m (i.e., 200-cm or 78.74-inches), and 3-m (i.e., 300-cm or 118.11-inches). Reading distances are managed by the Detector and are subsequently associated with scans. This data is uploaded to the REACh™ Software when the Detector is synchronized using the REACh™ Driver. Alternatively, the distance can be selected via the menu settings.

6.9.8 Summary Page

When the scan stops, a summary is shown on the screen. The first summary page displays the detected isotopes with confidence percentage in parentheses. If there are more isotopes than can fit on a single page, they will be continued on multiple pages. On the second summary page, shown in Figure 18, the scan number (e.g., “Scan_0020”) is shown at the top along with the date (e.g., “2018-07-17”, the time (e.g., “10:32:39”), the scan real time (“2 mins 0 secs”), the dead time percentage (e.g., “0.22%”), the average gamma-ray Dose Rate (e.g., “,7.0µR/h”), and the average gamma-ray Count Rate (e.g., “38 **CPS**”). If the advanced spectroscopy feature is turned on in the settings menu, then there will be additional pages to show the estimated activity for each isotope at 1 m in front of the point of maximum sensitivity.

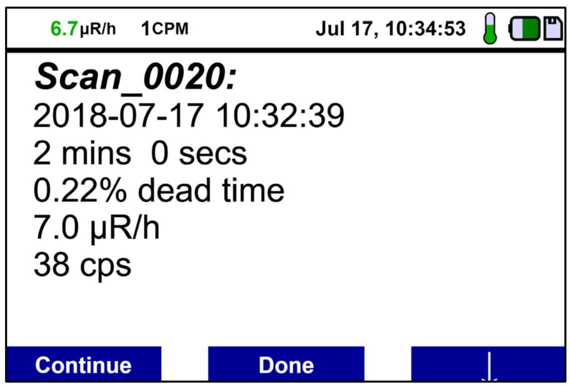

Figure 18 – Summary Page Example

The control buttons in this menu, from left to right, allow the user or operator to press “Continue” to add more time to the scan. This continuation time is set in the menu settings. This is quite useful in the field when viewing the results or spectrum and realizing additional time might be justified (i.e., visual indication in the spectrum a new photopeak is forming). As opposed to adjusting the scan time, and starting a new scan entirely, you can just continue your initial scan from the point where you left off. Next, you can press “Done” to exit the summary page and return to the scan page. Lastly, you can press the down arrow to scroll through the summary pages.

	Helpful Hint: The data from the scan is stored internally on the Detector automatically following the completion of each scan. It is date-and-time stamped based on the current system time as well as labeled with the scan number. Additionally, the REACh™ Item Name / Description is available for reference. When using the REACh™ Driver, all scans saved on the Detector will be uploaded to the REACh™ Software at time of synchronization.

6.9.9 Spectrum Page

The spectrum page can be navigated to from the scan page. Before a scan is started, it shows the spectrum collected from the previous scan. When a new scan is started, the new spectrum is updated in real time. Detected isotopes are labeled on the spectrum. The spectrum page is illustrated in the figures below.

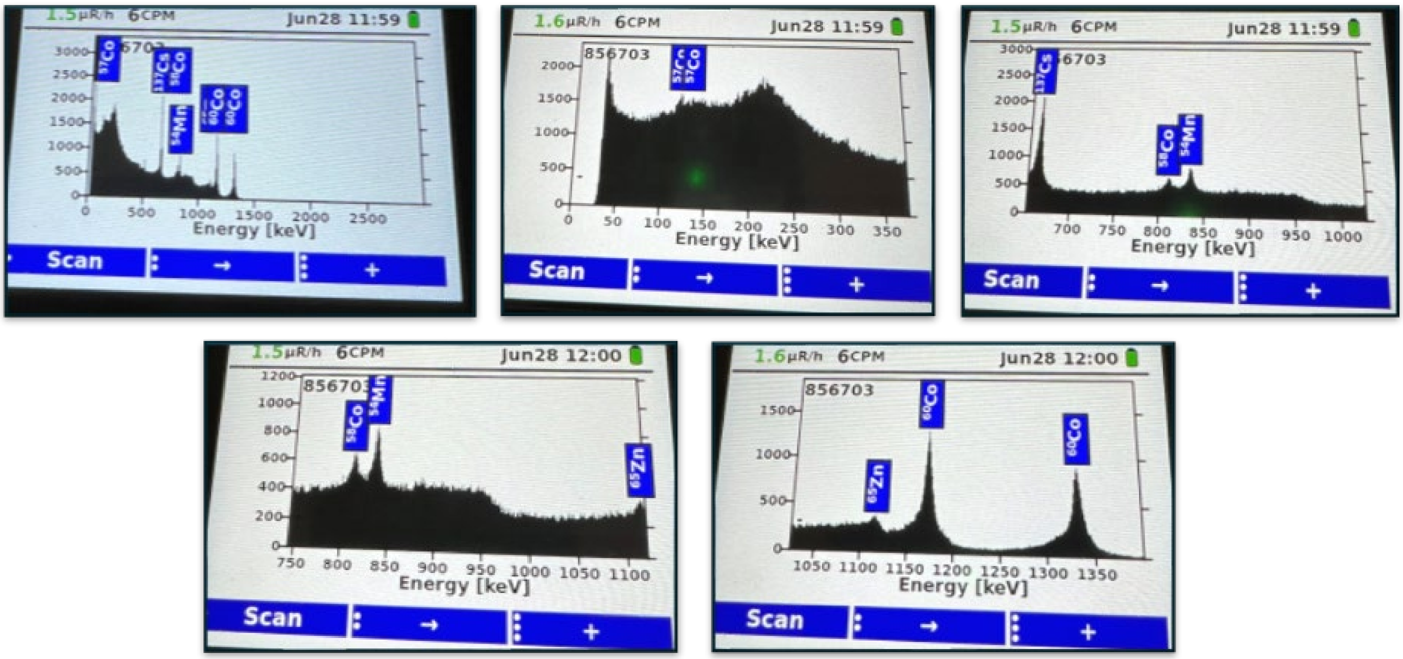

Figure 19: Spectrum Page Overview

The control buttons in this menu, from left to right, allow the user or operator to navigate back to the scan page by pressing the button labeled “Scan”. The center control button allows you to scroll from left to right through the energy spectrum. The right control button allows you to zoom in. Note that once the highest zoom level is reached, pressing the zoom button will reset to the lowest zoom level. Once the maximum energy is reached, the scroll will wrap back to the lowest energy.

	Helpful Hint: The dynamic Range of the Detector is from 50 keV up to 3000 keV.

6.9.10 Settings Menu

The settings menu allows the user to change settings for the Detector. It can be accessed by clicking the settings control button, generally speaking, at any point while using the Detector. It is illustrated in the figure below.

The settings that are currently able to be changed are described below. More settings may be added in the future based on customer feedback.

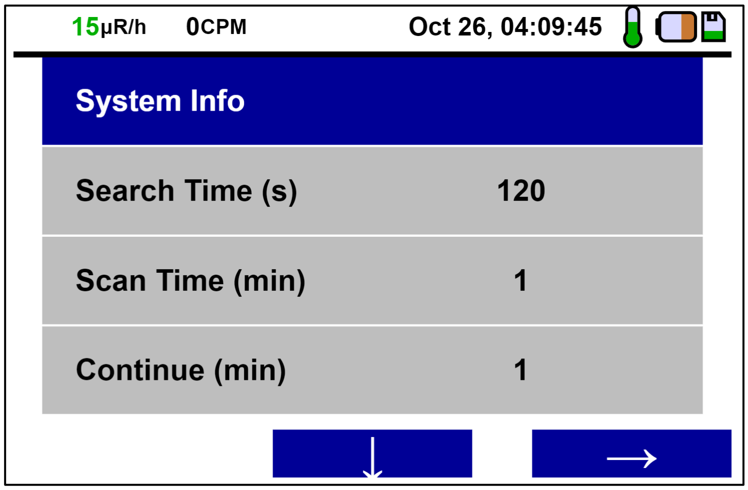

Figure 20: Settings Menu

Menu Setting	Description
System Info	Allows users to view the product model number, firmware version, and wireless connection settings.
Distance	Allows users to adjust the reading distance for scans. Managed in the REACh™ Software.
Item	Allows users to select or modify the item associated with a scan. Managed in the REACh™ Software..
User	Allows users to assign or change the surveyor associated with a scan. Managed in the REACh™ Software.
Search Time	Allows users to set the rolling time window for isotope detection in search mode.
Scan Time	Allows users to define the count time for scan mode.
Continue Time	Allows users to set the additional time added to a scan when "Continue" is pressed on the summary page.

Menu Setting	Description
CPS Scale	Allows users to toggle the spectrum count Scale between log and linear.
Vibrate	Allows users to enable or disable vibration notifications.
Sound	Allows users to enable or disable auditory notifications.
Volume	Allows users to adjust the volume of auditory notifications.
Brightness	Allows users to adjust the screen brightness. The screen auto-dims after 5 minutes of inactivity when set above 25% to preserve battery and screen life.
Text Alerts	Allows users to enable or disable pop-up messages for Alarms and Alerts.
Detections at End [R]	Allows users to toggle whether detections are shown during scans (off) or only at the end (on). Default is off.
Detection History	Allows users to enable or disable the display of trend IDs on the trend plot. IDs remain listed at the bottom of the trends page..
Radiation Transient Alarms	Allows users to enable or disable Alerts for significant Count Rate changes, aiding in detecting transient sources. Disabled by default to minimize frequent notifications in known radiation environments.
Fan Enabled	Allows users to enable or disable the fan.
Advanced Spectroscopy [R]	Allows users to enable or disable reporting of activity at the end of a scan.
IP Address	Allows users to adjust the IP address, subnet mask, and gateway for ethernet connection.
Units	Allows users to switch units between English and SI.
Dose Rate Alarms	Allows users to set lower and upper thresholds for Dose Rate Alarms. Notifications are triggered when Dose Rates exceed these levels.

<table>
<tr><th>Menu Setting</th><th>Description</th></tr>
<tr><td>Neutron Alarm (CPM)</td><td>Allows users to configure the neutron Alarm. Ineffective if no neutron Detector is present. Future firmware updates will disable this setting for Detectors without neutron capability..</td></tr>
<tr><td>Collect Background</td><td>Allows users to collect a background spectrum. REACh™ Software users should perform background scans for upload into the REACh™ Software instead of using this feature.</td></tr>
<tr><td>Manage Scans</td><td>Allows users to download or delete stored scans.</td></tr>
<tr><td>Manage Isotopes [R]</td><td>Allows users to enable or disable isotopes in the isotope library.</td></tr>
<tr><td>Bins/keV</td><td>Allows users to adjust the spectrum’s binning structure.</td></tr>
<tr><td>UTC Offset</td><td>Allows users to modify the UTC offset for date and time.</td></tr>
<tr><td>Language</td><td>Allows users to change the Detector’s language. Contact WMG for additional language options.</td></tr>
<tr><td>Wi-Fi [R]</td><td>Allows users to enable or disable Wi-Fi.</td></tr>
<tr><td>Bluetooth</td><td>Allows users to enable or disable Bluetooth.</td></tr>
<tr><td>Built-In Test (BIT)</td><td>Allows users to run the built-in diagnostic Test.</td></tr>
<tr><td>Admin Access</td><td>Allows users to enable or disable restricted mode for adjusting advanced settings. Restricted settings are indicated by [R]. Note:
Audible and visual Alarms are disabled simultaneously.
In routine mode, audible Alarms can only be disabled if visual Alarms are enabled, and vice versa.
In restricted mode, both can be disabled simultaneously.</td></tr>
</table>

Use the left and center control buttons to select a setting to change the highlighted setting. Then use the right control button to select that setting. Once the setting is selected, the settings menu will change into settings edit mode, where you can change the selected setting. Use the right control button to toggle between the setting modes and then cancel or accept the changed setting using the left or center control buttons.

Press the settings button again to exit the Settings Menu and return to the regular user interface.

6.10 Isotope Identification and Additional Algorithms

6.10.1. Isotope Identification

The isotope library on the A-Series is based on the **ANSI** standard for handheld radioisotope identifiers. Each isotope is also provided a category that is listed next to the identified isotope and is shaded a color based on its category. The isotope categories are industrial (green), natural (brown), medical (yellow), **SNM** (red), and unknown (magenta).

	Helpful Hint: For isotope identification, two-minute stationary dwells are recommended. Shorter times often provide similar results, but longer scan times primarily enhance statistical accuracy and may occasionally help identify additional isotopes.

Isotope libraries for the REACh™ Detector are managed by the user or operator through the REACh™ software. For guidance on creating custom isotope libraries, refer to Reference 3.3. Once created, these libraries can be synchronized with the Detector using the REACh™ driver. For details on synchronization, refer to Reference 3.5.

Isotope detection performance has been validated on all isotopes found in both the **ANSI** N42.34 and **DNDO TCS** standards: ^{241}Am, ^{133}Ba, ^{60}Co, ^{137}Cs, ^{67}Ga, ^{131}I, ^{192}Ir, ^{40}K, ^{99m}Tc, ^{201}Tl, ^{226}Ra, ^{232}Th, DU, HEU, ^{238}U, ^{235}U, WGPu, RGPu, ^{239}Pu, ^{240}Pu, ^{237}Np, Unk. A complete list of isotopes that system identification has been validated on includes: Hydrogen neutron capture, 511 keV, ^{228}Ac, ^{108m}Ag, ^{110m}Ag, ^{241}Am, ^{41}Ar, ^{133}Ba, ^{7}Be, ^{214}Bi, ^{82}Br, ^{109}Cd, ^{144}Ce, ^{252}Cf, ^{57}Co, ^{58}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, DU, ^{154}Eu, ^{155}Eu, ^{59}Fe, ^{67}Ga, ^{153}Gd, ^{159}Gd, HEU, ^{123}I, ^{131}I, ^{132}I, ^{133}I, ^{135}I, ^{111}In, ^{192}Ir, ^{194}Ir, ^{40}K, ^{42}K, ^{177}Lu, ^{54}Mn, ^{56}Mn, ^{22}Na, ^{95}Nb, ^{237}Np, ^{231}Pa, ^{212}Pb, ^{214}Pb, ^{103}Pd, ^{239}Pu, ^{240}Pu, ^{226}Ra, ^{118}Re, ^{122}Sb, ^{124}Sb, ^{125}Sb, ^{75}Se, ^{153}Sm, ^{113}Sn, ^{99m}Tc, ^{232}Th, ^{201}Tl, ^{202}Tl, ^{208}Tl, ^{232}U, ^{233}U, ^{235}U, ^{238}U, ^{187}W,^{133}Xe, ^{65}Zn, and ^{95}Zr.

The onboard isotope identification algorithm compares recorded photopeak's against isotopic lines in the isotope library. If a match is found, such as a 662 keV line corresponding to ^{137}Cs, the isotope is identified. However, if an isotope is not in the library (e.g., the 834 keV emission of ^{54}Mn), the algorithm will report it as "Unknown 834 keV." Low-statistics measurements of multi-emission isotopes, like ^{152}Eu, may initially list peaks as unknown until sufficient self-consistent lines and heuristic checks confirm the isotope.

Isotopic identification confidence is reported as an integer between 0 and 100, where 0 indicates low certainty and 100 indicates high certainty. This confidence is determined through a Bayesian framework, accounting for statistical fluctuations but not systematic uncertainties. The gamma-ray spectrum is bootstrapped and reprocessed 100 times. If an isotope is detected in all iterations, a confidence of 100 is reported, meaning it would likely be identified in nearly all identical measurements. If detected in only 10 iterations, a confidence of 10 is reported, implying it would be identified in approximately 10 out of 100 repeated measurements.

6.10.2. Activity Estimation

Activity estimation is available for detected isotopes when the "Advanced Spectroscopy" setting is enabled. The activity is calculated by assuming an unshielded source at 1 meter in the Detector's direction of maximum sensitivity (i.e., beneath the screen). For greater accuracy, users must adjust the estimation to account for different distances or shielding conditions. The algorithm corrects for continuum under the peaks, ensuring accurate calculations for multiple isotopes.

It is generally recommended to keep this feature disabled. Instead, upload scans into the REACh™ software for detailed characterization and classification of waste or materials. The software applies accurate gross gamma methodologies and automatically accounts for geometric attenuation and other variables through Geometric Correction Factors (GCFs).

6.11 Troubleshooting

This table describes typical notifications from the system indicating an error or warning coupled with typical cause and corrective action

Description	Type	Reason	Resolution
Detector fails to boot and hangs on WMG Splash Screen	Error	Failure to initialize CPU	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Detector screen does not power on	Error	Failure to initiate FPGA	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Detector indicates temperature out of Range during startup	Error	The Detector cannot bias up the high voltage until the temperature is within a proper Range	Move to a cooler or warmer environment and allow the unit to adjust temperature.
Detector indicates no drive is present	Error	The CPU failed to initialize internal memory	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Detector indicates single digit nR/hr	Error	The high voltage did not properly initialize	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Detector indicates no **CPS**	Error	The high voltage did not properly initialize	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Buttons do not function	Error	Communication failure between subsystems	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.

Description	Type	Reason	Resolution
Left **LED** fails **BIT**	Error	**LED** error or communication error	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Middle **LED** fails **BIT**	Error	**LED** error or communication error	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Right LED fails **BIT**	Error	**LED** error or communication error	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Vibration Motor fails **BIT**	Error	Motor error or communication error	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Buzzer fails **BIT**	Error	Buzzer error or communication error	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if problem persists.
Temperature fails **BIT**	Error	Cooling subsystem failure or communication error	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
GPS fails **BIT**	Error	GPS error or communications error	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Number of bad pixels fails **BIT**	Error	Various possible reasons	Contact WMG.
Energy Resolution fails **BIT**	Error	Calibration Drift or fault	Perform a quick Calibration, if problem persists contact WMG.
Humidity fails **BIT**	Warning	Humidity has intruded into Detector	Contact WMG if coupled with another error.

Description	Type	Reason	Resolution
Fan fails **BIT**	Error	Fan current or voltage out of Range	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Disk fails **BIT**	Error	Disk is either full or unreachable	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
DC-DC supply fails **BIT**	Error	**DC-DC** voltage supply within Detector is out of Range	Hardpower shutdown, wait 2 minutes before rebooting. Contact WMG if the problem persists.
Battery symbol is orange	Warning	Battery is low	Charge the battery.
Battery symbol is red	Warning	Battery is very low	Charge the battery.
Battery symbol is empty with exclamation	Warning	Battery is very low	Charge the battery.
Disk icon is present	Warning	Detector disk is filling up	Remove files from internal storage.
Disk icon is present with exclamation	Warning	Detector disk if full	Remove files from internal storage.

6.12 Third-Party Software Bill of Materials and Licenses

The following are the third-party software libraries used in the A-Series.

6.12.1 Boost

Boost Software License <https://www.boost.org/users/license.html>

https://www.boost.org/

6.12.2 FlatBuffers

Apache License Version 2.0
http://www.apache.org/licenses/LICENSE-2.0

https://flatbuffers.dev/

6.12.3 JAMA/C++ Linear Algebra Package

Public Domain

https://math.nist.gov/tnt/download.html

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6.12.4 JSON for Modern C++

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https://github.com/nlohmann/json

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6.12.5 Libcurl

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6.12.6 LibJPEG-Turbo

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6.12.7 Libunwind

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https://openssl-library.org/

6.12.10 Protocol Buffers

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6.12.11 pugiXML

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6.12.12 Simple-Web-Server

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6.12.13 SQLite

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https://www.sqlite.org/

6.12.14 Template Numerical Toolkit (TNT)

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https://math.nist.gov/tnt/download.html

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6.12.15 Ubuntu

Some portions licensed under the GPL license. Source code available on request or from <https://mongoose.ubuntu.com>.

6.12.16 V4L

License: GNU Lesser General Public License (available at <https://www.gnu.org/licenses/lgpl.html>) (C) 2008 Hans de Goede <hdegoede@redhat.com> <https://git.linuxtv.org/v4l-utils.git/>

7.0. ATTACHMENTS

None.

WMG-P-126 CZT REACh™ Hardware OP

Final Audit Report 2024-12-26

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