CZT REACh™ Detector Maintenance and Calibration Operating Procedure (M&C OP)

WMG-P-127

Rev. 0

December 2024

Prepared by:

16 Bank Street
Peekskill, NY 10566

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WMG, Inc.		**16 Bank Street, Peekskill, NY 10566**
Controlled Copy No.	**Assigned to:**	
	Organization:	
Implementing Section of QA Program or Project Number		CZT REACh™ Detector Maintenance and Calibration Operating Procedure

APPROVALS

SIGNATURE - DATE

Rev No.	Prepared By	Reviewed By	Approved By
0	Sean Kelly Jr. Sean Kelly Jr. (Dec 18, 2024 22:22 EST)	Matthew Harper Matthew Harper (Dec 19, 2024 09:07 EST)	Heather Sullivan Heather Sullivan (Dec 19, 2024 09:10 EST)
1			

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REVISION LOG

Rev. No.	Date	Page No.	Description	Change Made By Print Name	Change Made By Signature/Date
0	12/18/2024	All	First version of maintenance and calibration operating procedure.	N/A	N/A

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1.0 Purpose

The purpose of this procedure is to provide best practices for routine performance checks of the WMG CZT REACh™ Detector, including operational checks, and Calibration tasks.

2.0 Scope

This procedure covers the maintenance and Calibration best practices for CZT REACh™ Detectors. This procedure does not apply to NaI REACh™ Detectors.

3.0 References

3.1 REACh™ Software Operating Procedure (WMG-P-122)

3.2 REACh™ CZT Detector Operating Procedure (WMG-P-126)

3.3 REACh™ Driver Operating Procedure (WMG-P-129)

3.4 American National Standards Institute (**ANSI**) N323AB-2013, "American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments" 2013

4.0 Definitions

4.1. Background Radiation

Radiation which is naturally present in the environment, including cosmic radiation and radiation from naturally occurring radioactive materials. Background radiation can also come from radioactive sources, items, contamination, or other materials in the area, such as the calibration area or laboratory. It can influence Detector readings and must be accounted for during Calibration and operation to ensure accurate measurements.

4.2. Built-In Test (BIT)

A feature of the Detector in which a series of tests are automatically performed by the Detector to test basic function and operation conditions.

4.3. Cadmium Zinc Telluride (CZT) {CdZnTe}:

A semiconductor material used in the Detector to convert radiation into electrical signals.

4.4. 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.

4.5. Dead Time

The period during which the Detector is unable to process additional events because it is still processing a previous one. Dead-time can affect the accuracy of measurements, particularly at high radiation count rates.

4.6. Detector

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

4.7. Detector Name

Each manufactured Detector is given a unique “name” that can be found on the Detector along with the serial number.

4.8. Full Width at Half Maximum (FWHM)

A measure of the Detector's resolution, defined as the width of a peak at half its maximum height.

4.9. Light Emitting Diode (LED)

A semiconductor light source that emits light when current flows through it. LEDs are used in the Detector to indicate power, status, or operating conditions.

4.10. Reference / Check Source

A radioactive source with known activity used for calibrating the Detector and verifying its accuracy.

4.11. Serial Number (SN)

A unique identifier assigned to each Detector for tracking and identification purposes.

4.12. Universal Serial Bus (USB)

A standard interface used for connecting the Detector to a computer or other devices for data transfer and communication.

4.13. Additional Acronyms

4.13.1. **ABS** – Acrylonitrile Butadiene Styrene

4.13.2. **DC** – Direct Current

4.13.3. **GB** – Gigabyte

4.13.4. **GPS** – Global Positioning System

4.13.5. **GUI** – Graphical User Interface

4.13.6. **PC** – Polycarbonate

4.13.7. **REACh™** - RADMAN™ Enhanced Accurate Characterization

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.

5.2. Calibration Technician

- Perform periodic Calibrations according to the defined schedule (e.g., monthly, quarterly, annually, or as needed).
- Verify the Calibration of the Detector as outlined in this procedure and document results.
- Troubleshoot and resolve minor Detector performance issues during Calibration.
- Maintain detailed records of Calibration activities and adjustments made.

6.0 Procedure Details

6.1. Prerequisites

Prior to performing activities governed by this procedure, confirm the following prerequisites have been met:

- Appropriate level of pre-job briefing completed per user's organizational requirements
- Worker(s) qualifications reviewed as applicable per user's organizational requirements.

6.2. Safety Guidelines

While performing activities governed by this procedure, the following safety guidelines should be considered:

6.2.1. Radiological Hazards

- Control radioactive sources in accordance with applicable site procedures.
- Be aware of the potential for radioactive contamination either on or in the Detector.

6.2.2. Conventional Hazards

The Detector contains static-sensitive devices. When working on static-sensitive components, proper skill-of-trade work practices must be applied, including the use of appropriate electrostatic discharge (**ESD**) precautions such as grounding straps, anti-static mats, and ESD-safe tools to prevent damage.

6.3. Test Equipment, Tools, and Consumables

Verify that the following required equipment, tools, and consumables are available prior to performing activities governed by this procedure:

- Power Supply for CZT REACh™ Detector
- Daily Operational Checks: Box Calibrator or Similar
  (^{137}Cs Source characterized for dose rate at distance)
- Detector / Source positioning jig for consistent measurement geometry
- **Calibrations:** ^{137}Cs source approximating a point source
  Recommended Source activity: ~50-100 µCi
- Computer running Visualizer software (Version 2.9.7 or newer)

6.4. Environmental Qualification

6.4.1. Not Applicable.

6.5. Verification Plan

6.5.1. Not Applicable.

7.0 Instructions

7.1. Operational Checks / Source Response Checks

Recommended Frequency: Daily or before use, whichever is less frequent.

7.1.1. **ENSURE** Detector is **charged.**

7.1.2. **TURN ON** Detector and **ALLOW** time to stabilize before performing a source response check. The stabilization process is automatically completed by the Detector.

7.1.3. **ENSURE** a current Calibration sticker is attached**.**

7.1.4. **INSPECT** the Detector for physical damage by observing the following and **RECORD** any damage, such as:

- General condition of the Detector's housing.
- Any potentially damaged ports.
- Any loose or broken screws, buttons, handles, etc.
- Any potentially loose internal components.

7.1.5. **ENSURE** Detector is in **SEARCH MODE** to allow easy dose rate reading and radionuclide identification.

7.1.6. **POSITION** Detector in an appropriate location(s) and geometry(ies) to which a pre-determined actual dose rate(s) has been characterized (e.g., within a ^{137}Cs box calibrator or other characterized radiation field).

7.1.7. **VERIFY** Detector responds within ± 20% of an acceptable range for

dose rate. Typically, this may include exposing the Detector to multiple dose rates. For instance:

7.1.7.1 **EXPOSE** the Detector to approximately 1 mR/hr (acceptable range of 0.8-1.2 mR/hr).

7.1.7.2 **EXPOSE** the Detector to approximately 100 mR/hr (acceptable range of 80-120 mR/hr).

7.1.8. During dose-rate testing, **VERIFY** that the Detector identifies the correct radionuclide to which the Detector is exposed (e.g., ^{137}Cs identified on the face of the Detector).

7.1.9. **DOCUMENT** results of these checks as required by the user's organization.

7.2. Built-In Test (BIT)

Recommended Frequency: As determined by user.

7.2.1. **NAVIGATE** to BIT in the Settings Menu to start the test.

7.2.2. **PLACE** a ^{137}Cs check source near the Detector (e.g., 2-inches from the Detector center).

7.2.3. **FOLLOW** the instructions on the screen to perform the BIT.

7.2.4. **REFER** to Appendix A-2 for troubleshooting actions applicable to BIT results.

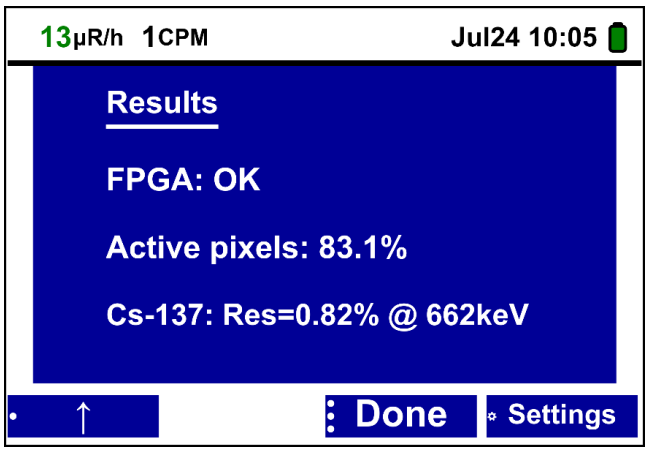


Figure 1: Results Screen of a Built-In Test

7.3. Pre-Calibration Checks

Recommended Frequency: Annually or more frequently per user's organizational requirements or performance trending.

7.3.1. **RECORD** the SN and Detector Name on Calibration Certificate**.**

7.3.2. **INSPECT** the Detector for physical damage by observing the following and **RECORD** any damage on calibration certificate, such as:

- General condition of the Detector's housing.

- Any potentially damaged ports.
- Any loose or broken screws, buttons, handles, etc.
- Any potentially loose internal components.

7.3.3. **CLEAN-UP** the Detector and **REPLACE** any damaged or worn labels, such as those affected by surface contamination, wear, or environmental exposure.

- **Surface Cleaning**: Use a mild to strong detergent with M100 sorbent material to clean the detector's PC/ABS housing. Avoid abrasive pads on the acrylic screen protector.
- **Decontamination**: Follow site-specific procedures for radioactive contamination. Contamination may include particulates on surfaces, in the fan subsystem, or within small cavities.
- **Replaceable Components:** The fan assembly and handle shroud can be disposed of and replaced through WMG Inc. if needed.
- **Material Considerations:** The detector housing resists acids, alkalis, and radiation, making it relatively easy to clean with standard decontamination kits. Handle all cleaning materials per site-specific procedures.

7.3.4. **CHARGE** the unit to full capacity**.**

7.4. Energy Calibration

Recommended Frequency: Annually or more frequently per user's organizational requirements or performance trending.

7.4.1. **TURN ON** Detector and **ALLOW** time to stabilize before performing Calibration measurements. The stabilization process is automatically completed by the Detector.

7.4.2. **ENSURE** unit is plugged in to a power supply to avoid power loss during the Calibration process**.**

7.4.3. **CONNECT** to the Detector with a Windows-based computer via ethernet cable or Wi-Fi communication.

7.4.4. **OPEN** a web browser (e.g. Microsoft Edge or Google Chrome).

7.4.5. **TYPE** {Detector IP Address}:8080 into the web browser and **PRESS** Enter to display the Maintenance Interface for the Detector. See the figure below for a representation of the expected browser display.

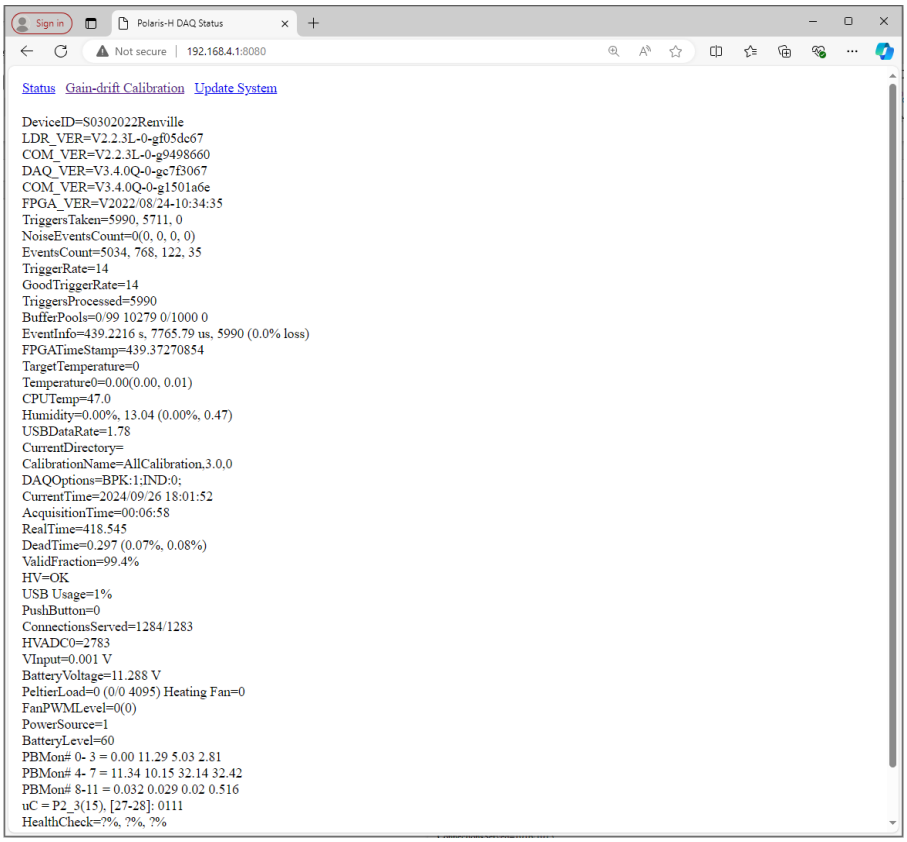


Figure 2: Detector Maintenance Interface – Status Display

7.4.6. **SELECT** “Gain-drift Calibration” at the top of the page.

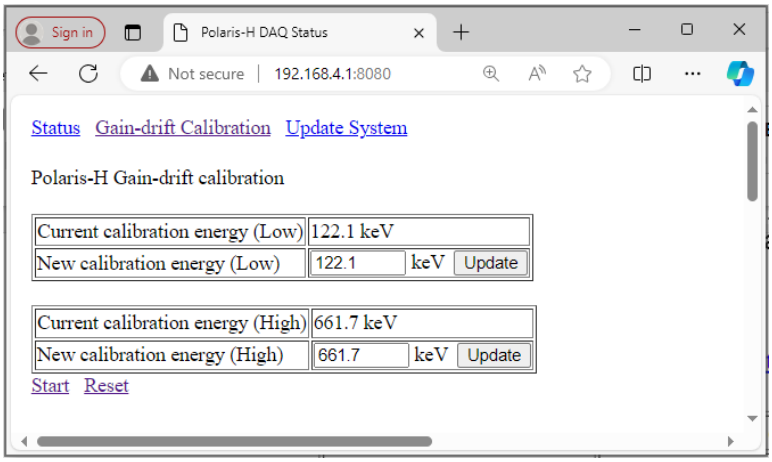


Figure 3: Gain-Drift Calibration Screen (With Default Entries)

NOTE:

If either of the input energies are incorrect, the Detector’s Calibration will **NOT** be accurate.

The Gain-Drift Calibration is designed to accept two Calibration energies. The default entries are 122.1 keV for ^{57}Co and 661.7 keV for ^{137}Cs. Most customers use only ^{137}Cs, which is accomplished by setting the low Calibration energy to 0 keV as shown below.

7.4.7. **ENSURE** that the “New Calibration energy (Low)” value is set to 0 keV and **SELECT** “Update”.

7.4.8. **ENSURE** that the “New Calibration energy (High)” value is set to 661.7 keV and **SELECT** “Update”.

7.4.9. **CONFIRM** that the two energy values are correct.

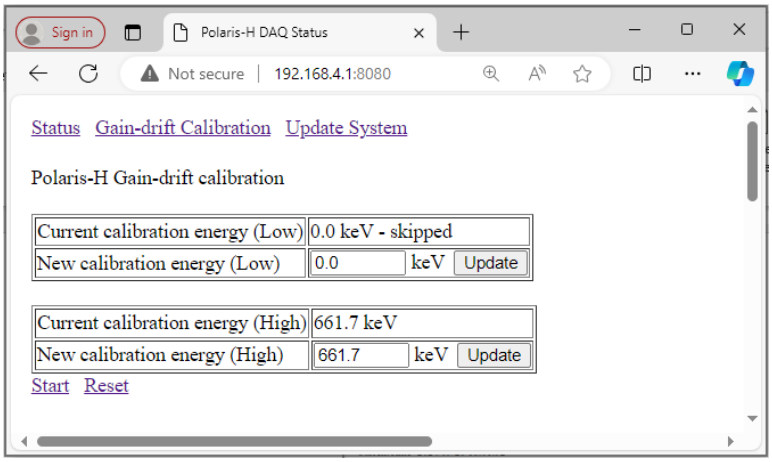


Figure 4: Gain-Drift Calibration screen showing correct entries (^{137}Cs Only Calibration)

7.4.10. **PLACE** Calibration source (50-100 μCi ^{137}Cs Check Source is recommended) at approximately 2 inches from the Detector center.

> **NOTE**:
>
> If there is no source placed and the process is started, the Detectors' Calibration will **NOT** be accurate.
>
> The Calibration process should take approximately 20-30 minutes.
>
> When Calibration is complete, the Gain-Drift Calibration Quality should be above 95%.

7.4.11. **SELECT** "Start" to begin the Calibration.

7.4.12. **WAIT** for the process to be completed. A Calibration progress update is provided at the top to the Maintenance Interface display (see Figure 5 below). The results will display once complete (see Figure 6 below).

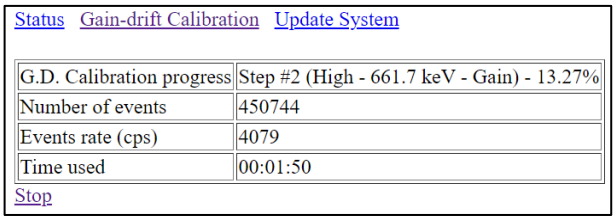


Figure 5: Maintenance Interface - Calibration

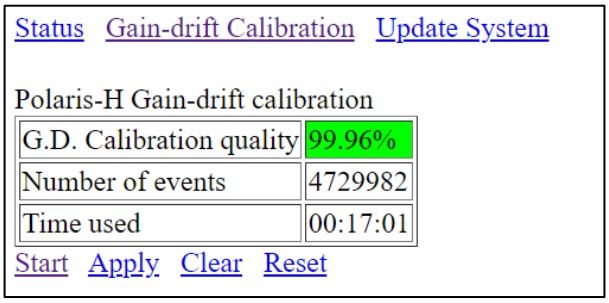


Figure 6: Gain-Drift Calibration Results

7.4.13. **IF** the Gain-Drift Calibration quality is less than 95%:

STOP and **CONTACT** the most appropriate individual (e.g., Health Physicist, Manager, etc.) per user organization's program requirements for the path forward. Contact WMG as needed to evaluate unexpected results.

7.4.14. **RECORD** the Gain-Drift Calibration "Quality", "Number of Events", and "Time Used" on the calibration certificate**.**

7.4.15. **SELECT** "Apply" to finalize the Calibration.

7.4.16. **RECORD** calibration adjustment as complete on the calibration certificate.

7.5. Efficiency and Health Checks

Recommended Frequency: Annually or more frequently per user organization's program or performance trending requirements.

> **NOTE:**
>
> The manufacturer's Visualizer software includes a feature to quickly perform an automated Health Check of the Detector. To perform the Health Check, the user collects a measurement of a single stationary ^{137}Cs source, with the 662-keV peak clearly visible. For best results:
>
> 1. No other isotopes and or radionuclides should be present in the measurement,
> 2. Dead Time should be less than 10%,
> 3. There should be at least 10,000 counts in the photopeak,
> 4. The source and Detector should be stationary during the measurement, and,
> 5. The Background Radiation should be small relative to the source.

7.5.1. **TURN ON** the Detector and **ALLOW** time for it to stabilize before performing Calibration measurements.

7.5.2. **ENSURE** there are no sources of radiation around the Detector other than the source intended for the Health Check measurement.

Recommended Source Activity: 50-100 µCi

7.5.3. **PLACE** the source at approximately 12-inches from the Detector center. **DOCUMENT** the source distance for efficiency calculations.

Note that a Detector and source positioning jig is **RECOMMENDED** for consistent measurement geometry.

7.5.4. Utilizing the REACh™ Software and Driver, **CREATE** surveys which are intended for use as Health Check Surveys. **REFER** to references 3.1-3.3 above regarding how to set up and synchronize surveys to and from the Detector **IF UNFAMILIAR**.

Recommended Survey Naming Convention: [Detector Name] – Health Check

7.5.5. **ENSURE** the Detector and the source are not moved during the duration of the measurement.

7.5.6. **ALLOW** the measurement to acquire for at least 15 minutes.

7.5.7. **STOP** the measurement **IF** the Scan Time in the menu settings on the Detector was not set to 15 minutes prior to starting the measurement.

NOTE:

Appendix A-3 provides instructions for formatting USB storage drives for Detectors.

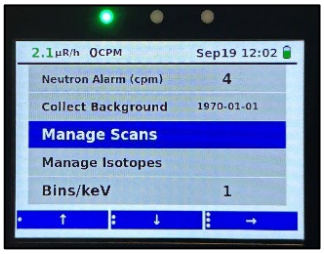
7.5.8. **IF DOWNLOADING** the measurement data to a manufacturer-formatted USB drive:

7.5.8.1 From the setting meu, **SELECT** Manage Scans (see the figures below).

7.5.8.2 When prompted, **INSERT** USB storage drive into Detector.

7.5.8.3 When prompted, **SELECT** Download Last Scan (see the figures below).

7.5.8.4 **REMOVE** the USB storage drive from the Detector.



Manage Scans

Download Last Scan

Figure 7: Measurement Download Menu

7.5.9. **UPLOAD** measurement to a computer running Visualizer:

7.5.9.1 **INSERT** the USB storage device into the computer.

7.5.9.2 **OPEN** the Visualizer software application. Visualizer will automatically search for any inserted manufacturer-formatted USB drives, look for any unimported measurements, and ask if you want to import new measurements. If prompted:

7.5.9.3 **THEN SELECT** “Yes” to importing new measurements.

7.5.9.4 **CHECK** the measurement you want imported.

7.5.9.5 **SELECT** “Import”. The measurement will begin to import.

7.5.9.6 **CHECK** the measurement folder (see the figure below).

7.5.9.7 **SELECT** “Post-Process” (see Figure 8 below).

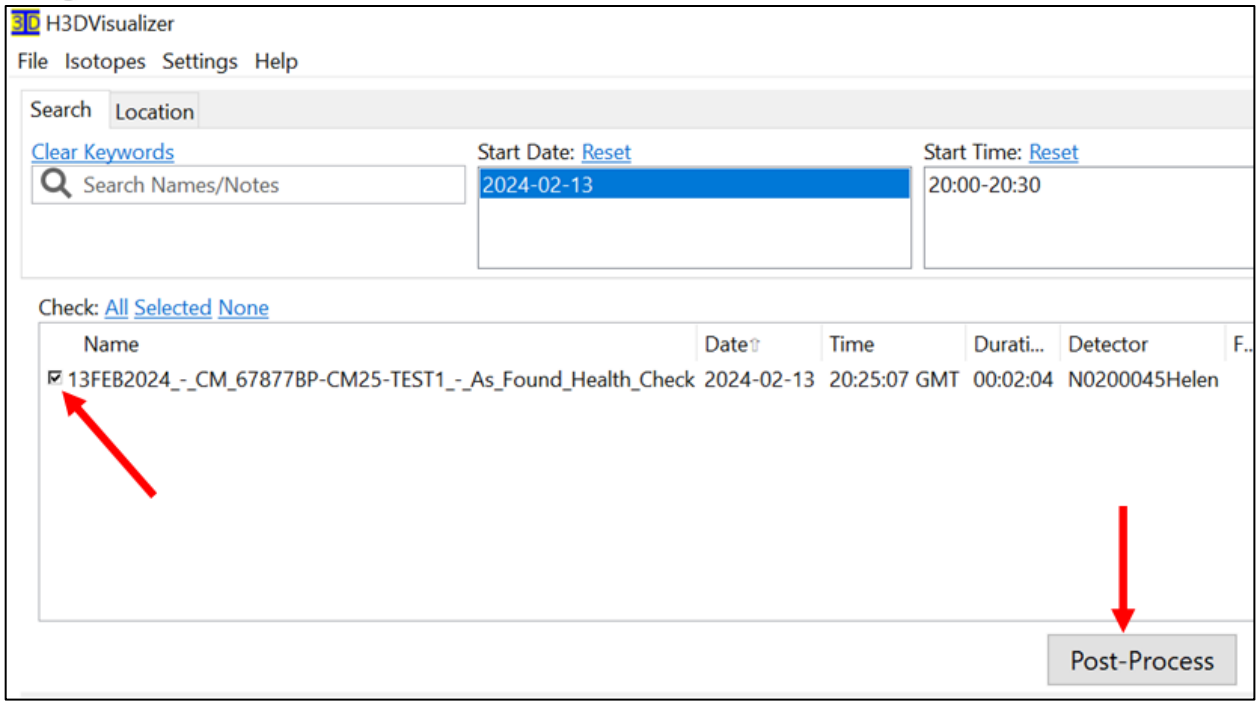


Figure 8: Measurement Selection in Visualizer

7.5.10. After the measurement has been "Post-Processed" in Visualizer, **SELECT** Analyze from the top task bar followed by Health Check to run the Detector Health Check. The Health Check results for all tested variables will be as shown in Figure 9 below.

NOTE:

A **GOOD** result is indicated by a green check mark next to the variable.

An **OK** result is indicated by a yellow check mark next to the variable.

A **POOR** result is indicated by a red check mark next to the variable.

7.5.11. **RECORD** the Health Check results for all variables on the calibration certificate.

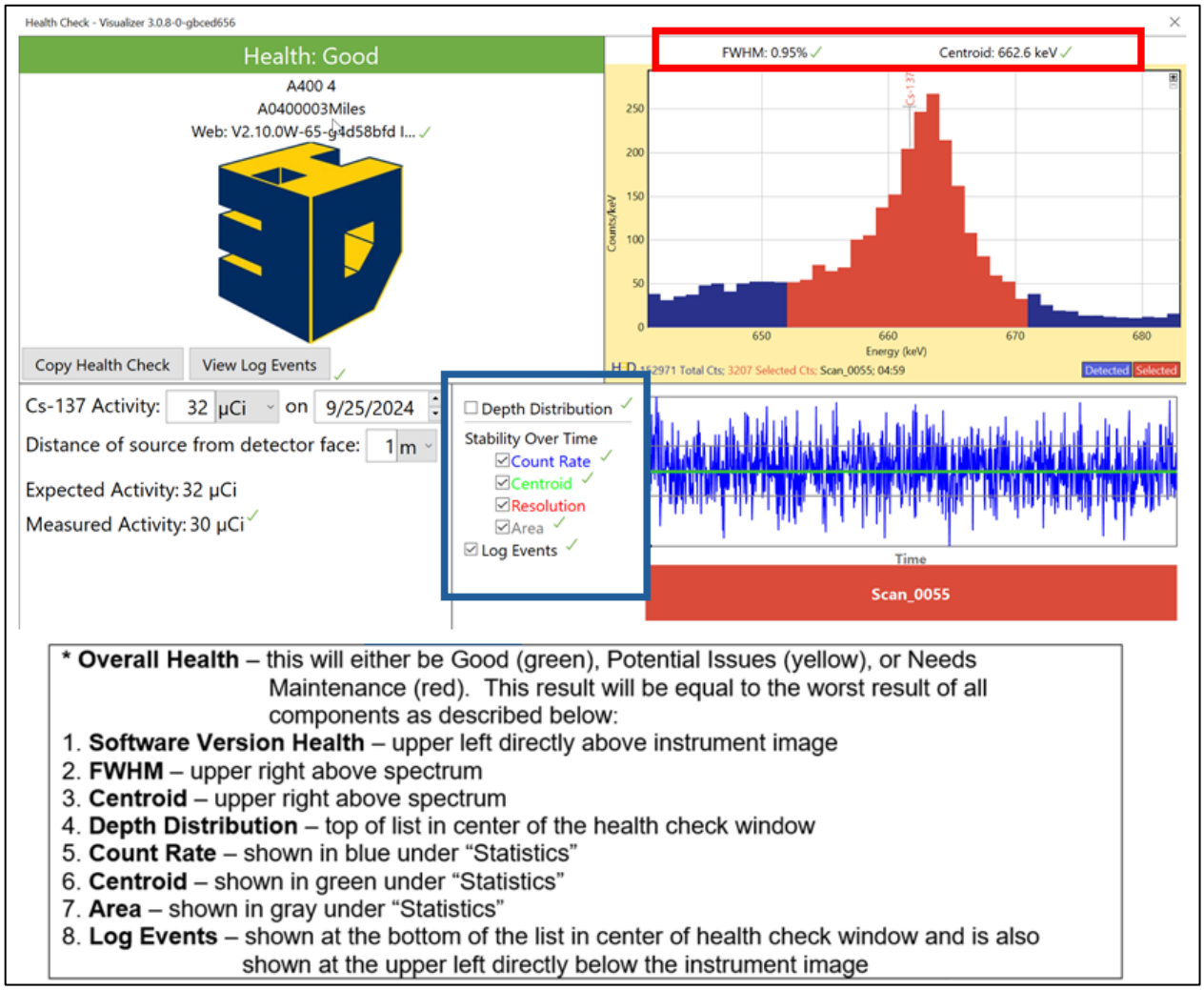


Figure 9: Detector Health Check Results

7.5.12. **PRINT** a screenshot of the Health Check screen to include with the calibration certificate.

7.5.13. **RECORD** the previous step as complete on the calibration certificate.

7.5.14. **IF** the As-Found "**FWHM**" or "Centroid" at the top right of the Health Check Summary (refer to the red square in the figure above) results are **OK** or **POOR** during As-Found Health Check:

THEN PERFORM energy Calibration adjustments per Section 7.4 above.

7.5.15. **IF** any "Depth Distribution", "Statistic" or "Log" (refer to the blue square in the figure above) variable results are **OK** or **POOR** during a first Health Check:

THEN RE-PERFORM the Health Check from the start of Section 7.5. At step 7.5.6, **ALLOW** the measurement to **CONTINUE** for an additional 30 minutes.

7.5.16. **IF** **ANY** "Depth Distribution", "Statistic" or "Log" (refer to the blue square in the figure above) variable results are **OK** or **POOR** during **SECOND** Health Check,

THEN STOP and **CONTACT** the most appropriate individual (e.g., Health Physicist, Manager, etc.) per user organization's program requirements for the path forward.

7.5.17. **IF DOWNLOADING** the measurement data to a manufacturer-formatted USB drive is not preferred, alternative methods exist to transfer measurement data from the Detector and into the Visualizer software, such as the Scan's page within the local Detector web-application. If this method is desired, please **CONTACT WMG** for assistance.

7.6. Dose Rate Calibration

Recommended Frequency: Annually or more frequently per user organization's program requirements or performance trending.

> **NOTE:**
>
> The Dose Rate Calibration process involves exposing the Detector to various dose rates to evaluate response within the operating range and to determine Calibration and Dead Time correction factors for input into the Detector. This section details the measurements and calculations required.
>
> As of this revision, consultation with WMG is recommended when revising the Detector's Calibration factor and Dead-Time adjustment.
>
> Future development will provide GUI-based tools for entering these values.

7.6.1. **ENSURE** Detector is charged.

7.6.2. **TURN ON** the Detector and **ALLOW** time to stabilize before performing a dose rate Calibration.

7.6.3. **PERFORM** physical inspection of Detector.

7.6.4. **ENSURE** the Detector is in **SEARCH MODE** to easily read the dose rate and radionuclide identification.

7.6.5. **POSITION** Detector in an appropriate location(s) and geometry(ies) to which a pre-determined actual dose rate(s) has been characterized (e.g., within a ^{137}Cs box calibrator or other characterized radiation field).

7.6.6. **PERFORM** As-Found measurements **AND COMPARE** Detector response to an acceptance range of ±10%:

7.6.6.1 **EXPOSE** the Detector to approximately 1.0 mR/hr (acceptable range of 0.9-1.1 mR/hr).

7.6.6.2 **EXPOSE** the Detector to approximately 100 mR/hr (acceptable range of 90-110 mR/hr).

7.6.6.3 **EXPOSE** the Detector to approximately 200 mR/hr (acceptable range of 180-220 mR/hr).

7.6.7. During dose-rate testing, **VERIFY** that the Detector identifies the correct radionuclide to which the Detector is exposed (e.g., ^{137}Cs identified).

7.6.7.1 **IF** the correct radionuclide is not identified, then **PERFORM** an Energy Calibration per Section 7.4 above.

7.6.7.2 **IF** Detector dose-rate response is outside of acceptable ranges (or if desired), then **CALCULATE** and **REVISE** Calibration Factor and Dead Time adjustment as follows.

> **NOTE:**
>
> The Detector measurements in this section are designed to be performed using **SCAN MODE**. Following a completed measurement, the N42 file for the count will be used to identify the data required for these calculations.

7.6.7.3 **PERFORM** a measurement while exposing the Detector to **approximately** 1.0 mR/hr.

7.6.7.4 **CALCULATE** the Calibration Factor using the Detector response ($DoseRate_{Read}$) and true reference values ($DoseRate_{True}$) from the 1 mR/hr exposure.

$$Calibration\ Factor = \frac{DoseRate_{True}}{DoseRate_{Measured}}$$

INPUT the Calibration Factor in the Detector settings. Consultation with WMG is recommended for this step.

7.6.7.5 **PERFORM** a measurement while exposing the Detector to approximately 200 mR/hr.

7.6.7.6 **CALCULATE** the Dead Time Adjustment factor using the Detector response ($DoseRate_{Read}$) and true reference values ($DoseRate_{True}$) from the 200 mR/hr exposure.

$$\boldsymbol{DeadTimeAdjustment}\ (\mu\boldsymbol{sec}) = \frac{\boldsymbol{LiveTime}\left(\frac{\boldsymbol{DoseRate_{True}}}{\boldsymbol{DoseRate_{Measured}}} - \mathbf{1}\right)}{\boldsymbol{NumberofCounts}}$$

INPUT the Dead Time Adjustment factor in the Detector settings. Consultation with WMG is recommended for this step

7.6.7.7 **VERIFY** Dose Rate Calibration starting with Step 7.6.4.

7.6.7.8 **DOCUMENT** results of these checks as required by the user's organization.

Appendix A-1: Status Indicators

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.

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

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.

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

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 silenced. The alarms and alerts for the speaker beeps are described below.

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

Battery Indicator

Icon	Meaning
	The Detector has **GREATER** than 90% charge and **IS** plugged into charger.
	The Detector has **GREATER** than 40% charge and **IS** plugged into charger.
	The Detector has **GREATER** than 40% charge and **IS NOT** plugged into charger.
	The Detector has **LESS** than 40% charge and **GREATER** than 20% charge and **IS** plugged into charger.
	The Detector has **LESS** than 40% charge and **GREATER** than 20% charge and **IS NOT** plugged into charger.
	The Detector has **LESS** than 20% charge and **IS NOT** plugged into charger.
	The Detector has **LESS** than 10% charge and near empty.

Appendix A-2: Troubleshooting

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 (Counts Per Second)	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.

Appendix A-3: Formatting USB Storage Drive

Prior to using any new USB flash drive with a WMG Detector, it must be properly prepared to ensure settings are correct for use with the Visualizer software. To prepare a new drive:

NOTE:

- Correctly prepared USB drives will initially be named “WMG_Media”.
- The USB drive must be larger than 0.5 GB to use with a WMG Detector.
- The USB drive must be less than 100 GB to use with a WMG Detector.
- **It is possible to select an internal hard drive for formatting**. A warning message will appear if you try to do this, but do **NOT** select this as it could result in the computer being used to be completely wiped.
- All data on the USB drive selected will be lost during this process.

1. **PLUG** the USB drive into the computer.
2. **OPEN** Visualizer software application.
3. **GO TO** File/Push Data to Detector.
4. **SELECT** the USB Drive to be prepared.
5. **SELECT** “Prepare Drive”.
6. **SELECT** “Yes” to prepare the drive.
7. **SELECT** “Ok” when the drive is finished formatting.
8. **EJECT** the USB drive from the computer.

Appendix A-4: Adjusting Detector Date and Time

1. **CONNECT** to the Detector with a Windows-based computer via ethernet cable or Wi-Fi communication.
2. **OPEN** a web browser (e.g. Microsoft Edge or Google Chrome).
3. **TYPE** {Detector IP Address}:8080 into the web browser and **PRESS** Enter to display the Maintenance Interface for the Detector.
4. **SELECT** “Update System” at the top of the page.
5. **ENTER** the correct date and time. Note that the time should be provided in Coordinated Universal Time (UTC).
6. **SELECT** “Update”.

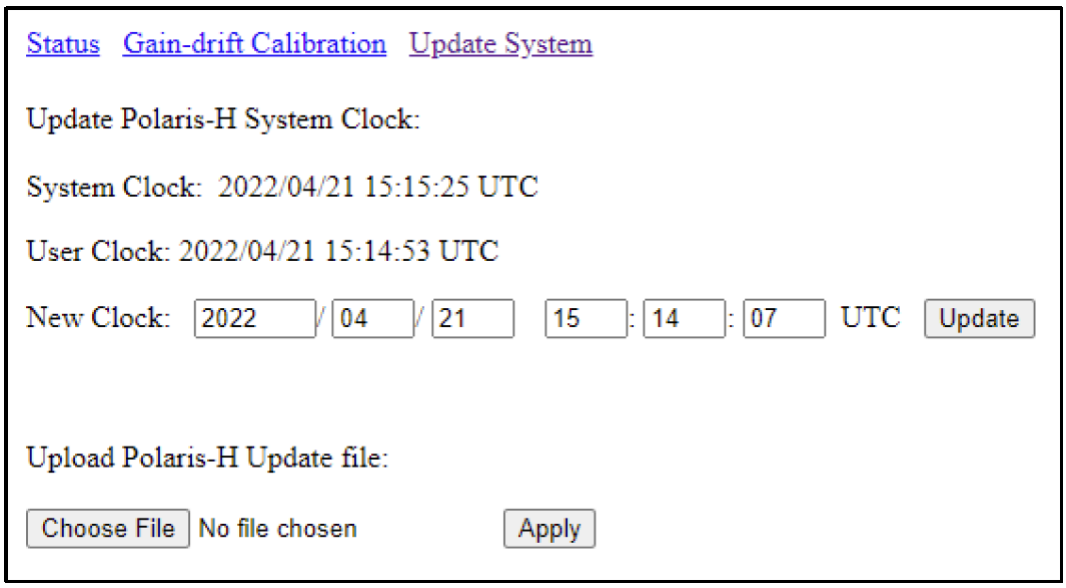


Figure 10: Updating the Detector Date and Time

Exhibit 1: Dose Rate Calibration Certificate Example

CALIBRATION CERTIFICATE

EnergySolutions Services, Inc.
1570 Bear Creek Road
Oak Ridge, TN 37830
Phone: (877) 462-4873
Email: ISFStaff@energysolutions.com

CUSTOMER INFORMATION	INSTRUMENT INFORMATION	
Customer Name: H3D, Inc.	**Manufacturer:** H3D, Inc.	
Address: 812 Avis Drive, Ann Arbor, MI 48108 USA	**Model:** TBD	**Serial Number:** TBD
Contact Name: Sean Kelly Jr.	**Detector:** CZT	**Serial Number:** TBD
PO/Project Number: TBD	**Order Number:** TBD	**Calibration Method:** Source

DOSE RATE CALBIRATION TEST DATA

Detector Range (mR/h)	Calibration Points		Instrument Response (mrem/hr)	
	Value ±5%* (mR/h)	Nuclide ID	As Found	As Left
0-200	0.1	Cs-137		
0-200	0.5	Cs-137		
0-200	1.0	Cs-137		
0-200	5.0	Cs-137		
0-200	10.0	Cs-137		
0-200	20.0	Cs-137		
0-200	50.0	Cs-137		
0-200	100	Cs-137		
0-200	150	Cs-137		
0-200	200	Cs-137		
Response ± 10% of Calibration Values			Passed ☐	Failed ☐

OTHER TEST DATA

M&TE		
M&TE Instruments	Serial No.	Cal Due Date
Temperature:		
Pressure:		
Humidity:		

Environmental Conditions	
Temperature (°C):	°C
Pressure (mmHg):	mmHg
Humidity (%):	%

Cs-137 Calibrators Used	
Source ID	Cal Due Date

ENERGY CALIBRATION CHECK

Cs-137 Energy Calibration Check	Sat ☐ Unsat ☐

RADIONUCLIDE IDENTIFICATION TEST

Radionuclide & Count Time	Am241 (30 seconds)	Cs-137 (30 seconds)	Co-60 (30 seconds)
Identification	Passed ☐	Passed ☐	Passed ☐

Instrument Condition Tests

Battery	Sat ☐ Unsat ☐
Display	Sat ☐ Unsat ☐
Button Operation	Sat ☐ Unsat ☐
Physical Condition	Sat ☐ Unsat ☐

COMMENTS

Note:

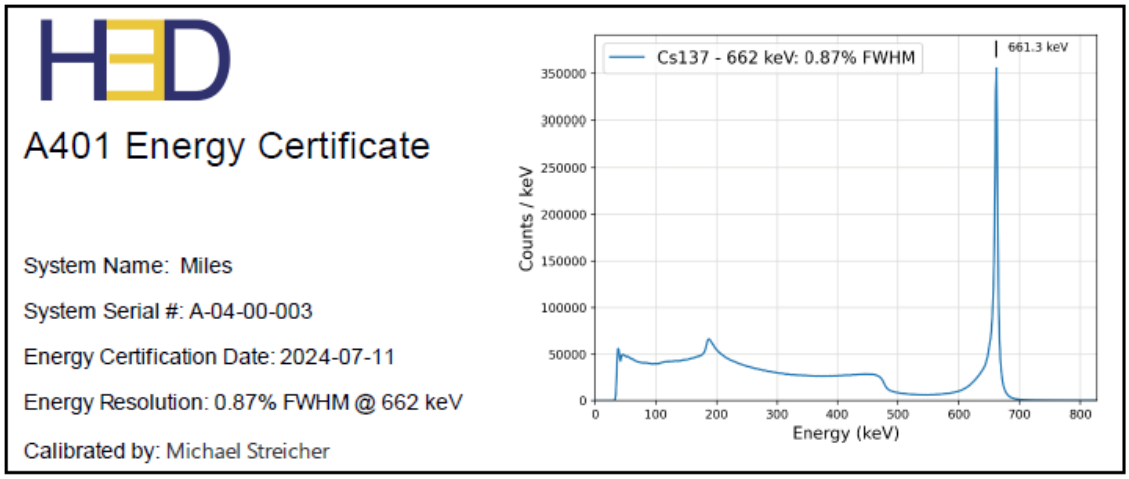
***Calibration Facility certifies its gamma calibrators to an uncertainty within 5%.**

STATEMENT OF CERTIFICATION

We Certify our program and procedures meet the requirements of ANSI N323AB-2013. We also Certify that the instrument listed above was calibrated in accordance with CP-IN-PR-101 and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further Certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument Calibrated By:	Reviewed By:	Date:
Certification Date:	**Certification Due Date:**	

Exhibit 2: Energy Calibration Certificate Example



WMG-P-127, CZT REACh™ M&C OP

Final Audit Report 2024-12-19

Created:	2024-12-19
By:	Sean Kelly Jr. (skelly@wmginc.com)
Status:	Signed
Transaction ID:	CBJCHBCAABAAnTuywWC4ZVE8FsEN4IWM6HXmPrTceBV1

History

Document created by Sean Kelly Jr. (skelly@wmginc.com)
2024-12-19 - 3:20:50 AM GMT

Document emailed to Sean Kelly Jr. (skelly@wmginc.com) for signature
2024-12-19 - 3:20:56 AM GMT

Email viewed by Sean Kelly Jr. (skelly@wmginc.com)
2024-12-19 - 3:21:08 AM GMT

Document e-signed by Sean Kelly Jr. (skelly@wmginc.com)
Signature Date: 2024-12-19 - 3:22:05 AM GMT - Time Source: server

Document emailed to Matthew Harper (mharper@wmginc.com) for signature
2024-12-19 - 3:22:06 AM GMT

Email viewed by Matthew Harper (mharper@wmginc.com)
2024-12-19 - 2:07:28 PM GMT

Document e-signed by Matthew Harper (mharper@wmginc.com)
Signature Date: 2024-12-19 - 2:07:48 PM GMT - Time Source: server

Document emailed to Heather Sullivan (hsullivan@wmginc.com) for signature
2024-12-19 - 2:07:49 PM GMT

Email viewed by Heather Sullivan (hsullivan@wmginc.com)
2024-12-19 - 2:10:25 PM GMT

Document e-signed by Heather Sullivan (hsullivan@wmginc.com)
Signature Date: 2024-12-19 - 2:10:41 PM GMT - Time Source: server

Agreement completed.
2024-12-19 - 2:10:41 PM GMT