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CCP-TP-190

Revision 1

CCP
Box Segmented Gamma System (BSGS)
Calibration Procedure

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RECORD OF REVISION

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1.0 PURPOSE

This procedure contains the operating instructions to calibrate the Box Segmented Gamma System (BSGS), using the Canberra Genie™ 2000 and Nondestructive Assay (NDA2000) Software. The BSGS and the Box Neutron Assay System (BNAS) combine data to produce one set of assay results.

1.1 Scope

This procedure specifies instructions to calibrate the BSGS, which includes starting up and using the Canberra Genie™ 2000 and NDA2000 software and calibration of the equipment. The BSGS and the BNAS combine data to quantify the activity of individual radionuclides present in 55-gallon drums, Standard Waste Boxes (SWBs), and Standard Large Box-2 (SLB-2) containers. The Multi-Group Analysis (MGA) software and four High Purity Germanium (HPGe) detectors are used for isotopics analysis. Each assay for each container type must meet the requirements of CCP-PO-002, *CCP Transuranic Waste Certification Plan*, for shipment to the Waste Isolation Pilot Plant (WIPP).

2.0 REQUIREMENTS

2.1 References

Baseline Documents

- Genie™ 2000 Spectroscopy Software – Operations, Canberra Industries Inc., *Software Reference Manual*
- *NDA2000 User's Manual*, Canberra Industries, Inc.
- ASTM C 1030, *Standard Test Method for Determination of Plutonium Isotopic Composition by Gamma-Ray Spectroscopy*, Annual Book of ASTM Standards, Vol. 12.01
- CCP-QP-005, *CCP TRU Nonconforming Item Reporting and Control*
- CCP-PO-003, *CCP Transuranic Authorized Methods for Payload Control (CCP CH-TRAMPAC)*
- CCP-QP-022, *CCP Software Quality Assurance Plan*

Referenced Documents

- CCP-PO-002, *CCP Transuranic Waste Certification Plan*
- CCP-QP-002, *CCP Training and Qualification Plan*
- CCP-QP-008, *CCP Records Management*
- CCP-QP-011, *CCP Notebooks and Logbooks*
- CCP-TP-189, *CCP Box Segmented Gamma System (BSGS) Operating Procedure*

2.2 Training Requirements

2.2.1 Personnel performing this procedure will be trained and qualified in accordance with CCP-QP-002, *CCP Training and Qualification Plan,* prior to performing this procedure.

2.3 Precautions and Limitations

2.3.1 Personnel working around the BSGS conveyor system and moving equipment must observe warning devices and postings.

2.3.2 Personnel working around the BSGS shall be aware of potential electrical hazards (i.e., high voltage (HV) power supplies, etc.).

2.3.3 Personnel shall be aware of the precautions to be exercised when working with or around radioactive sources and waste materials. Such precautions shall be in accordance with Host site requirements.

2.3.4 The system's HPGe detectors are cooled with liquid nitrogen (LN). LN may cause burns to exposed skin due to its extremely cold temperature. (Filling of the LN is addressed in CCP-TP-189, *CCP Box Segmented Gamma System [BSGS] Operating Procedure*.)

2.3.5 Quality control measurements involve the use of radioactive sealed sources. The physical position of the sources within the matrix container must be preserved to ensure repeatability.

2.4 Prerequisite Actions

2.4.1 Equipment Bay

[A] Ensure HPGe detectors have contained LN for at least four hours before the HV is applied.

[B] Verify that NO Emergency Stops are activated.

[C] Ensure that the security cage door is closed and locked.

[D] Inspect equipment and moving parts to ensure they are clear of any unauthorized personnel or obstructions.

2.4.2 Control Room

[A] Ensure the Temperature Stabilizer for the sodium iodide (NaI) detectors is displaying 40°C ± 0.5°C.

[B] Ensure the Equipment Bay door is closed and locked.

[C] Ensure the Light Stacks are operational.

[D] Ensure that the Programmable Logic Controller (PLC) cabinet is turned ON and operational (e.g., supplies system power, provides troubleshooting capability, etc.).

2.5 Equipment List

2.5.1 Four HPGe detectors with collimated cylindrical lead shielding

2.5.2 Transmission tower assembly with two tungsten shielded Cobalt-60 (Co-60) transmission sources

2.5.3 Two NaI detectors

2.5.4 Conveyor mechanism

2.5.5 Five Light Stacks (one in the control room and one on each exterior corner of the trailer) and Audible Device

2.5.6 55-gallon drum rotator pallet

2.5.7 Efficiency calibration line source standards obtained from suppliers maintaining a nationally accredited measurement program

2.5.8 Five 208-liter (55-gallon) calibration drums (empty, foam, homosote, particle-board, and sand matrices)

2.5.9 SWB and SLB-2 empty containers

2.5.10 Simulated matrix materials for SWB and SLB-2 containers

2.5.11 Electronics rack housing:

[A] Reference (quad) pulsers or equivalent

[B] Digital Spectrum Analyzer (DSA1000) units or equivalent

[C] Computer with other ancillary equipment such as printer, monitor, etc.

[D] Uninterruptible power supplies (UPSs)

2.5.12 Software

[A] NDA2000, Waste Assay

[B] Genie™ 2000, Gamma Acquisition and Analysis

2.6 Emergency Shutdown Instructions

2.6.1 Pressing any of the large red Emergency Stop buttons on the PLC, conveyor, or assay chamber will STOP operation of the BSGS conveyor system and will abort the BSGS operation.

2.6.2 Pressing any of the large red Emergency Stop buttons, located on the exterior of the control room, adjacent to the conveyor, will STOP operation of the BSGS conveyor system and will abort the BSGS operation.

2.6.3 Stepping on the Emergency Stop toe pads on the floor next to the NaI detector assembly of the BSGS assay chamber will STOP operation of the BSGS conveyor system and will abort the BSGS operation.

2.6.4 Unlocking the door between the Control Room and the Equipment Bay will STOP operation of the BSGS conveyor system and will abort the BSGS operation.

3.0 RESPONSIBILITIES

3.1 Nondestructive Assay (NDA) Operator

3.1.1 Operates the BSGS.

3.1.2 Notifies the NDA Lead Operator (LO) or NDA Expert Analyst (EA) of abnormal or nonconforming conditions.

NOTE

The NDA Operator and the NDA LO may be the same individual. The LO may perform NDA Operator test and functions at any time.

3.2 NDA Lead Operator (LO)

3.2.1 Provides supervision of the overall operation of the BSGS.

3.2.2 Investigates and resolves non-routine occurrences.

3.3 NDA Expert Analyst (EA)

3.3.1 Evaluates the BSGS assay data, and prepares NDA EA review paperwork and updated assay results, as applicable.

3.3.2 Prepares and issues the Calibration Verification Reports, as applicable.

3.3.3 Oversees the technical performance of the BSGS.

3.3.4 Prepares and issues the Calibration and Validation Report, as applicable.

3.3.5 Submits the appropriate BSGS prepared reports, as applicable.

3.4 NDA Services Technical Director

3.4.1 Reviews and approves the Calibration and Validation Report.

3.5 Facility Records Custodian

3.5.1 Receives, processes, and transmits records generated by this procedure in accordance with CCP-QP-008, *CCP Records Management*.

4.0 PROCEDURE

NOTE

Startup of the BSGS will be performed in accordance with the CCP-TP-189. Where sequential order is **NOT** important, steps may be performed in a sequence other than that stated in this procedure as directed by an NDA EA. This operation assumes familiarity with Canberra Industries, Inc., software, including Genie™ 2000 and NDA2000.

4.1 Detector and Source Positions

NOTE

The vertical positions of the HPGe and NaI detectors and the transmission sources are container dependent so that the top and the bottom detectors (sources) are looking (shining) at the center of the top and bottom segments for a given container type.

NDA OPERATOR

4.1.1 Detector Positioning

CAUTION

The top and bottom HPGe detectors in the two towers MUST be positioned at the same (detector axis) vertical height as the top and bottom NaI detectors, except for the SLB-2 containers where the sources/NaI detector positions MUST be adjusted to avoid ribs in the SLB-2 container for the transmission assembly.

NOTE

For each container type, the vertical positions of the transmission source and the NaI and HPGe detector are established by aligning the lower edge of the source and detector carriages with the values on the tower vertical scales listed in Table 1, Detector and Source Vertical Scales by the Tower Vertical Scale.

[A] For each container type listed in Table 1, position the top and bottom Co-60 transmission sources manually via the PLC so that they are accurately aligned with the corresponding NaI detectors.

Table 1. Detector and Source Vertical Scales by the Tower Vertical Scale (mm)

	55-gallon drum w/rotator	SWB	SLB-2
Bottom Source	862.0	611.0	935.0
Top Source	1223.0	1081.0	1655.0
Bottom NaI	942.0	691.0	1015.0
Top NaI	1303.0	1161.0	1735.0
HPGe No. 1	891.0	631.0	944.0
HPGe No. 2	1247.0	1101.0	1744.0
HPGe No. 3	885.0	625.0	938.0
HPGe No. 4	1241.0	1095.0	1738.0

NDA EA or LO

4.2 Gamma Energy and Shape (Full Width at Half Maximum [FWHM]) Calibration

NOTE

Once the data acquisition electronics are set, the energy and shape FWHM calibration can be performed. The energy calibration is performed for HPGe and NaI detectors using mixed gamma sources traceable to suppliers maintaining a nationally accredited measurement program.

4.2.1 Load the line sources onto the source holder.

4.2.2 Place the source holder with the line sources on it in the center of the conveyor platform.

4.2.3 From the desktop, open Gamma Acquisition & Analysis and the detector data sources.

4.2.4 Acquire a spectrum for a preset real time of 300 seconds for each detector.

4.2.5 Declare the Source Certificate for the line sources by performing the following:

[A] Select Calibrate on the Gamma Acquisition & Analysis menu.

[B] Select Energy Full.

[C] Select By Nuclide List.

[D] Select the nuclides that are present in the line sources from the nuclides list, **AND** click OK.

4.2.6 Proceed to the Energy Calibration – Full Menu, **AND** click Auto.

NOTE

The peak energy, channel number, and the FWHM will be populated for each selected nuclide of interest.

4.2.7 Click Show to open the Energy Calibration Curves window, **AND** review the energy and shape calibration values.

[A] **IF** there are outliers observed in the calibration curves, **THEN** ensure that the pole zero settings are properly adjusted for each of the HPGe Detectors, **AND** repeat steps 4.2.1 through 4.2.7.

[B] **IF** there are NO outliers observed in the calibration curves, **THEN** save the calibrations for each detector by clicking OK.

4.2.8 Click OK to Close the Energy Calibration – Full window.

4.2.9 Save the energy and shape FWHM calibration results by performing the following:

[A] Select File.

[B] Select Save.

4.2.10 Store the energy and shape FWHM calibration results by performing the following:

[A] Select Calibration.

[B] Select Store and perform the following:

[B.1] Select the appropriate calibration file in the Store menu.

[B.2] Select Store.

4.2.11 Exit Gamma Acquisition & Analysis.

NDA EA or LO

4.3 Pulser Reference Peak Calibration

NOTE

The reference pulser is used to correct data for live time losses. The Reference Peak Calibration for the pulser is performed on each detector after the corresponding pulse processing electronics have been properly gain adjusted, pole-zeroed, the energy and shape calibrations have been completed, and the pulser peak amplitude and frequency settings have been adjusted to the appropriate values.

4.3.1 Set the prescribed pulser gain and frequency using the Dual In-line Package (DIP) switches A and B present on the pulser circuit board of the Reference Pulser in accordance with the Reference Pulser Operations Manual, as required.

4.3.2 Ensure that the background levels registered on the transmission and emission detectors are as low as reasonably achievable (ALARA).

NOTE

The transmission source could be a source of background if not properly shielded from the NaI and HPGe detectors.

4.3.3 Ensure all shutters/attenuators are in their closed/in positions.

NOTE

The system has a ≈ 10 cm thick square lead block in front of the sintered tungsten shutter/attenuator. As a result, the background due to the transmission source, when the shutter/attenuator is in closed/in position, is not peaked in HPGe detectors. Some Compton background may become present in the detectors on the opposite side of the transmission sources.

4.3.4 From the desktop, open Gamma Acquisition & Analysis and the detector data sources.

NOTE

The reference peak count should be within one percent of the true pulser rate.

4.3.5 Acquire a spectrum for a preset real time of 300 seconds.

4.3.6 Save the spectrum to the detector data source by performing the following:

[A] Select File.

[B] Select Save.

4.3.7 Exit Gamma Acquisition & Analysis.

4.3.8 From NDA2000, open the Reference Peak Calibration Utility, **AND** open the detector data sources one by one to display each respective spectrum.

NOTE

The pulser peak must be the only peak of any significance observed in the spectrum.

4.3.9 Verify that Peak Locate and Peak Analysis have been included in the Current Steps of the analysis sequence by performing the following:

[A] Select Analyze.

[B] Select Edit.

4.3.10 **IF** the Peak Locate and Peak Analysis steps are not displayed in the Current Steps list,
THEN add them to the analysis sequence by performing the following:

[A] Select the applicable analysis sequence step from the Step Selection list box.

[B] Click Insert Step.

[C] Repeat steps 4.3.10[A] and 4.3.10[B], as necessary.

[D] Click Save.

[E] Click Exit to close the ASE window.

4.3.11 Analyze the spectrum by performing the following:

[A] Click Analyze.

[B] Select Execute.

NOTE

The energy, peak area, and the uncertainty of all the peaks that are found in the spectrum, will be reported on the screen.

4.3.12 Click on the Select As Reference checkbox to select the Reference Peak Information, **AND** save the results to complete the calibration by performing the following:

[A] Click File.

[B] Click Save.

4.3.13 Repeat steps 4.3.8 through 4.3.12 for all the HPGe detectors in the system.

4.3.14 Exit Reference Peak.

4.3.15 Record the Pulser rate and the Pulser peak position for each detector in the NDA Operational Logbook, in accordance with CCP-QP-011, *CCP Notebooks and Logbooks*, for future reference.

NDA EA or LO

4.4 Transmission Calibration

NOTE

A transmission calibration is performed by positioning each respective empty container in between the NaI detectors and the Co-60 transmission sources. Subsequent measurement of the container wall attenuated count rates at 1173 kilo electron Volts (keV) and 1332 keV is performed for each respective container geometry.

NOTE

The high intensity empty container measurement cannot be directly performed since the high count rate will saturate the NaI detectors and lead to deleterious effects such as peak shape distortion. Instead, the transmission measurements are performed in the low and high intensity modes through a matrix of moderate density. The matrix density must be such that a good counting precision can be obtained for the low intensity mode, albeit with an extended counting time, while the matrix attenuated count rates in the high intensity mode can be reduced to low enough levels.

In the following sections, the transmission calibration procedure for each container type is described in detail.

4.4.1 55-gallon Drum Container Transmission Calibration

NOTE

The procedure listed below in this section requires acquiring transmission data in the low and high intensity modes through a moderate density matrix such as the particle board (≈ 0.6 – 0.8 grams per cubic centimeters [g/cm^3]) as well as the low intensity mode for an empty drum. For the empty drum and the low transmission beam intensity mode, the preset real time is 60 seconds. For the low and high intensity transmission beam mode, with the particle board drum, the preset real times are 600 and 60 seconds, respectively. The count times are chosen so that the relative counting statistics in the 1332 keV peak will be less than two percent per segment (detector).

NOTE

The transmission calibration for the empty drum at high intensity mode is done off-line and the results entered into NDA2000 transmission calibration.

[A] Adjust the height of the two NaI detectors and the four HPGe detectors to be at the correct height for 55-gallon drums, in accordance with Table 1 of Section 4.1.

[B] Adjust the two Co-60 transmission sources to be at the same height as the opposing NaI detectors.

[C] Ensure the QC Check Background has been successfully completed, in accordance with CCP-TP-189.

[D] Perform a NaI Standardization, in accordance with CCP-TP-189.

[E] Ensure the drum rotator is centrally located on the BSGS conveyor platform.

[F] Ensure the empty 55-gallon drum is loaded onto the centrally located drum rotator.

[G] Ensure the Drum Rotator is turned on and is operational.

[H] Perform the Transmission Calibration using NDA2000 Operations as follows:

[H.1] Select Assay.

[H.2] Select Routine Assay.

[H.3] Select Calib – Transmission.

[I] Ensure the following information is displayed on the Assay – Routine screen:

[I.1] Container Type: (e.g., 55 US Gal. Drum)

[I.2] Geometry: Default Geometry

[I.3] Disable Load/Unload: Unchecked

[I.4] Count Time: (e.g., 60 s)

[I.5] Live: Unselected

[I.6] Real: Selected

[I.7] Source: Attenuators Closed

[I.8] Mode: Normal Scan

[I.9] Automatic: Selected

[I.10] Fixed: Unselected

[J] Select Start Assay.

[K] Enter the following information in the Item Information screen:

[K.1] Item ID: (e.g., TCAL_55g_MT)

[K.2] Description 1: N/A

[K.3] Description 2: (e.g., Trans CAL, 55-gallon Empty drum, Attenuators Closed)

[K.4] Location: (e.g., SRS, E Area)

[K.5] Comment: (e.g., N/A)

[K.6] Matrix Type: Default

[K.7] Percent Full: 100%

[K.8] Gross Weight: (as appropriate)

[K.9] Density: (automatically calculated by NDA2000)

[L] Select Done.

[M] Check the count rate to verify the attenuator positions.

[N] **WHEN** the Count is finished,
THEN ensure the 55-gallon Empty drum is unloaded, if required.

[O] Ensure the 55-gallon Particle Board drum is loaded on the pallet.

[P] Repeat steps 4.4.1[H] through 4.4.1[M] for the 55-gallon Particle Board drum with the Attenuators Closed for 600 seconds, with the following exceptions:

[P.1] In the Item ID field, enter: TCAL_55g_PB1.

[P.2] In the Description field, enter: Trans CAL, 55-gallon Particle Board drum, Attenuators Closed.

[Q] Repeat steps 4.4.1[H] through 4.4.1[M] for the 55-gallon Particle Board drum with the Attenuators Open for 60 seconds, with the following exceptions:

[Q.1] In the Item ID field, enter: TCAL_55g_PB2.

[Q.2] In the Description field, enter: Trans CAL, 55-gallon Particle Board drum, Attenuators Open.

[R] Print these NDA2000 report files and place them in a binder at the operator's station for reference.

[S] Ensure the 55-gallon Particle Board drum is unloaded from the pallet.

[T] Ensure the drum rotator is unloaded from the conveyor.

4.4.2 Standard Waste Box (SWB) Transmission Calibration

NOTE

This procedure is the same as for the 55-gallon drum geometry. The difference is, in the case of the 55-gallon drum, the transmission data were collected only at one conveyor position, whereas for the SWB, transmission data are collected at three scanning positions along the length of the container. The count times are chosen so that the relative counting statistics in the 1332 keV peak will be less than two percent per segment (detector).

NOTE

Transmission calibration measurements are performed in the low and high intensity modes through the ≈ 0.6 g/cc Cardboard, Polyethylene, and Plywood (CPP) matrix (≈ 20% cardboard, ≈ 30% polyethylene and ≈ 50% plywood). The preset real time is 1200 seconds (per scanning position) at low intensity (Attenuators Closed), and 180 seconds (per scanning position) at high intensity (Attenuators Open).

NOTE

The transmission calibration for the SWB at high intensity mode is done off-line and the results entered into NDA2000 transmission calibration.

[A] Adjust the height of the two NaI detectors and the four HPGe detectors to be at the correct height for the SWB container type, in accordance with Table 1 of Section 4.1.

[B] Adjust the two Co-60 transmission sources to be at the same height as the opposing NaI detectors.

[C] Ensure the QC Check Background has already been completed in accordance with CCP-TP-189.

[D] Perform a NaI Standardization measurement in accordance with CCP-TP-189.

[E] Ensure the Empty SWB is loaded and centered on the BSGS conveyor platform.

[F] Perform the Transmission Calibration using NDA2000 Operations as follows:

[F.1] Select Assay.

[F.2] Select Routine Assay.

[F.3] Select Calib – Transmission

[G] Ensure the following information is displayed on the Assay – Routine screen:

[G.1] Container Type: (e.g., SWB)

[G.2] Geometry: Default Geometry

[G.3] Disable Load/Unload: Unchecked

[G.4] Count Time: (e.g., 180 s)

[G.5] Live: Unselected

[G.6] Real: Selected

[G.7] Source: Attenuators Closed

[G.8] Mode: Normal Scan

[G.9] Automatic: Selected

[G.10] Fixed: Unselected

[H] Select Start Assay.

[I] Enter the following information in the Item Information screen:

[I.1] Item ID: (e.g., TCAL_SWB_MT)

[I.2] Description 1: N/A

[I.3] Description 2: (e.g., Trans CAL, SWB Empty Container, Attenuators Closed)

[I.4] Location: (e.g., SRS, E Area)

[I.5] Comment: (e.g., N/A)

[I.6] Matrix Type: Default

[I.7] Percent Full: 100%

[I.8] Gross Weight: (as appropriate)

[I.9] Density: (automatically calculated by NDA2000)

[J] Select Done.

[K] Check the count rate to verify the attenuator positions.

[L] **WHEN** the Count is finished,
THEN ensure the empty SWB is unloaded, if required.

[M] Ensure the SWB with CPP matrix is loaded centrally onto the conveyor.

[N] Repeat steps 4.4.2[F] through 4.4.2[K] for the SWB with CPP matrix with the Attenuators Closed for 1200 seconds (per scanning position), with the following exceptions:

[N.1] In the Item ID field, enter: TCAL_SWB_CPP1.

[N.2] In the Description field, enter: Trans CAL, CPP SWB, Attenuators Closed.

[O] Repeat steps 4.4.2[F] through 4.4.2[K] for the SWB with CPP matrix with Attenuators Open for 180 seconds (per scanning position), with the following exceptions:

[O.1] In the Item ID field, enter: TCAL_SWB_CPP2.

[O.2] In the Description field, enter: Trans CAL, CPP SWB, Attenuators Open.

[P] Print these NDA2000 report files and place them in a binder at the operator's station for reference.

[Q] Ensure the SWB is unloaded.

4.4.3 SLB-2 Transmission Calibration

NOTE

This procedure is the same as for the 55-gallon drum geometry. The difference is, in the case of the 55-gallon drum, the transmission data were collected only at one position whereas for the SLB-2, transmission data are collected at five scanning positions along the length of the container. The count times are chosen so that the relative counting statistics in the 1332 keV peak will be less than two percent per segment (detector).

NOTE

Transmission calibration measurements are performed in the low and high intensity modes through ≈ 0.5 – 0.7 g/cm^3 density plywood matrix. The preset real time is 720 seconds (per scanning position) at low intensity (Attenuators Closed), and 180 seconds (per scanning position) at high intensity (Attenuators Open).

NOTE

The transmission calibration for the SLB-2 at high intensity mode is done off-line and the results entered into NDA2000 transmission calibration.

[A] Adjust the height of the two NaI detectors and the four HPGe detectors to be at the correct height for the SLB-2 container type in accordance with Table 1 of Section 4.1.

[B] Adjust the two Co-60 transmission sources to be at the same height as the opposing NaI detectors.

[C] Ensure the QC Check Background has already been completed in accordance with CCP-TP-189.

[D] Perform a NaI Standardization measurement in accordance with CCP-TP-189.

[E] Ensure the Empty SLB-2 is loaded and centered on the BSGS conveyor platform.

[F] Perform the Transmission Calibration using NDA2000 Operations as follows:

[F.1] Select Assay

[F.2] Select Routine Assay.

[F.3] Select Calib – Transmission.

[G] Ensure the following information is displayed on the Assay – Routine screen:

[G.1] Container Type: (e.g., SLB-2)

[G.2] Geometry: Default Geometry

[G.3] Disable Load/Unload: Unchecked

[G.4] Count Time: (e.g., 180 s)

[G.5] Live: Unselected

[G.6] Real: Selected

[G.7] Source: Attenuators Closed

[G.8] Mode: Normal Scan

[G.9] Automatic: Selected

[G.10] Fixed: Unselected

[H] Select Start Assay.

[I] Enter the following information in the Item Information screen:

[I.1] Item ID: (e.g., TCAL_SLB2_MT)

[I.2] Description 1: N/A

[I.3] Description 2: (e.g., Trans CAL, SLB-2 Empty Container, Attenuators Closed)

[I.4] Location: (e.g., SRS, E Area)

[I.5] Comment: (e.g., N/A)

[I.6] Matrix Type: Default

[I.7] Percent Full: 100%

[I.8] Gross Weight: (as appropriate)

[I.9] Density: (automatically calculated by NDA2000)

[J] Select Done.

[K] Check the count rate to verify the attenuator positions.

[L] **WHEN** the Count is finished,
THEN ensure the empty SLB-2 is unloaded, if required.

[M] Ensure the SLB-2 with Plywood matrix is loaded centrally onto the conveyor.

[N] Repeat steps 4.4.3[F] through 4.4.3[K] for the SLB-2 with Plywood matrix with the Attenuators Closed for 720 seconds (per scanning position), with the following exceptions:

[N.1] In the Item ID field, enter: TCAL_SLB2_PW1.

[N.2] In the Description field, enter: Trans CAL, SLB-2 Plywood, Attenuators Closed.

[O] Repeat steps 4.4.3[F] through 4.4.3[K] for the SLB-2 with Plywood matrix with Attenuators Open for 180 seconds (per scanning position), with the following exceptions:

[O.1] In the Item ID field, enter: TCAL_SLB2_PW2.

[O.2] In the Description field, enter: Trans CAL, SLB-2 Plywood, Attenuators Open.

[P] Print these NDA2000 report files and place them in a binder at the operator's station for reference.

[Q] Ensure the SLB-2 is unloaded.

NDA EA or LO

4.5 Multi-Curve Emission Efficiency Calibration

NOTE

Efficiencies for each HPGe detector and for the sum of all HPGe detectors are determined using a set of line sources traceable to suppliers maintaining a nationally accredited measurement program. These are typically radionuclides such as Am-241, Ba-133, Co-57, Cs-137, and Co-60.

NOTE

During the efficiency based multi-curve emission calibration measurements, the 55-gallon matrix drum of interest must be centered on the rotator pallet centered on the BSGS conveyor platform (i.e., the HPGe detector axis is along the drum diameter).

4.5.1 55-Gallon Drum Efficiency Calibration

[A] Adjust the height of the HPGe detectors, the NaI detectors, and the sources to be at the correct height for 55-gallon drums in accordance with Table 1 of Section 4.1.

[B] Ensure the QC Check Background has already been completed in accordance with CCP-TP-189.

[C] Perform a QC Daily Performance Check measurement in accordance with CCP-TP-189.

[D] Ensure the drum rotator pallet is loaded and centered on the BSGS conveyor platform.

[E] Obtain and insert the mixed gamma line sources into the corresponding drum tube number, as directed by the NDA EA or NDA LO.

[F] Record the line source positions in the NDA Operational Logbook in accordance with CCP-QP-011.

[G] Ensure the empty 55-gallon drum is loaded on to the rotator on the pallet that is located centrally on the BSGS conveyor platform.

[H] Ensure the drum rotator is turned on and is operational.

[I] Perform the Efficiency Calibration using NDA2000 Operations as follows:

[I.1] Select Assay.

[I.2] Select Routine Assay.

[I.3] Select Calib – Efficiency.

[J] Ensure the following information is displayed on the Assay – Routine screen:

[J.1] Container Type: (e.g., 55 US Gal. Drum)

[J.2] Geometry: Default Geometry

[J.3] Disable Load/Unload: Unchecked

[J.4] Count Time: (e.g., 3600 s)

[J.5] Live: Unselected

[J.6] Real: Selected

[J.7] Mode: Normal Scan

[J.8] Automatic: Selected

[J.9] Fixed: Unselected

Controlled
Copy

[K] Select Start Assay.

[L] Enter the following information in the Item Information screen:

[L.1] Item ID: (e.g., ECAL_55g_MT)

[L.2] Description 1: N/A

[L.3] Description 2: (e.g., Eff. CAL, 55-gallon Empty drum)

[L.4] Location: (e.g., SRS, E Area)

[L.5] Comment: (e.g., N/A)

[L.6] Matrix Type: Default

[L.7] Percent Full: 100%

[L.8] Gross Weight: (as appropriate)

[L.9] Density: (automatically calculated by NDA2000)

[M] Select Done.

[N] **WHEN** the Count is finished,
THEN ensure the respective 55-gallon calibration drum is unloaded, if required.

[O] Repeat steps 4.5.1[D] through 4.5.1[M] for the measurements for 55-gallon foam, homosote, particle board, and sand drums using the real times indicated by the NDA EA or NDA LO.

[P] Ensure the drum rotator pallet is unloaded from the conveyor.

4.5.2 SWB Efficiency Calibration

NOTE

For the empty SWB, the efficiency calibration emission data are collected at three scanning positions along the length of the container.

[A] Move the HPGe detectors, NaI detectors, and sources to the positions for the SWB container type in accordance with Table 1 of Section 4.1.

[B] Ensure the QC Check Background has already been completed in accordance with CCP-TP-189.

[C] Perform a QC Daily Performance Check measurement in accordance with CCP-TP-189.

[D] Place the mixed gamma line sources into the SWB as directed by the NDA EA.

[E] Record the line source positions in the NDA Operational Logbook in accordance with CCP-QP-011.

[F] Ensure the empty SWB container is loaded and centered on to the BSGS conveyor.

[G] Perform the Efficiency Calibration using NDA2000 Operations as follows:

[G.1] Select Assay.

[G.2] Select Routine Assay.

[G.3] Select Calib – Efficiency.

[H] Ensure the following information is displayed on the Assay – Routine screen:

[H.1] Container Type: (e.g., SWB)

[H.2] Geometry: Default Geometry

[H.3] Disable Load/Unload: Unchecked

[H.4] Count Time: (e.g., 1200 s)

[H.5] Live: Unselected

[H.6] Real: Selected

[H.7] Mode: Normal Scan

[H.8] Automatic: Selected

[H.9] Fixed: Unselected

[I] Select Start Assay.

[J] Enter the following information in the Item Information screen:

[J.1] Item ID: (e.g., ECAL_SWB_A)

[J.2] Description 1: N/A

[J.3] Description 2: (e.g., Eff. CAL, SWB Empty Container, Column A)

[J.4] Location: (e.g., SRS, E Area)

[J.5] Comment: (e.g., N/A)

[J.6] Matrix Type: Default

[J.7] Percent Full: 100%

[J.8] Gross Weight: (as appropriate)

[J.9] Density: (automatically calculated by NDA2000)

[K] Select Done.

[L] Repeat steps 4.5.2[G] through 4.5.2[K] for each of the three scanning positions (A, B, and C).

[M] **WHEN** each of the efficiency calibration assays is completed,
THEN ensure the SWB is unloaded.

4.5.3 SLB-2 Efficiency Calibration

NOTE

For the empty SLB-2, the efficiency calibration emission data are acquired at five scanning positions.

[A] Move the HPGe detectors, NaI detectors, and sources to the positions for the SLB-2 container type in accordance with Table 1 of Section 4.1.

[B] Ensure the QC Check Background has already been completed in accordance with CCP-TP-189.

[C] Perform a QC Daily Performance Check measurement in accordance with CCP-TP-189.

[D] Place the mixed gamma line sources into the SLB-2 as directed by the NDA EA.

[E] Record the line source positions in the NDA Operational Logbook in accordance with CCP-QP-011.

[F] Ensure the empty SLB-2 is loaded and centered onto the BSGS conveyor platform.

[G] Perform the Efficiency Calibration using NDA2000 Operations as follows:

[G.1] Select Assay.

[G.2] Select Routine Assay.

[G.3] Select Calib – Efficiency.

[H] Ensure the following information is displayed on the Assay – Routine Screen:

[H.1] Container Type: (e.g., SLB-2)

[H.2] Geometry: Default Geometry

[H.3] Disable Load/Unload: Unchecked

[H.4] Count Time: (e.g., 720 s)

[H.5] Live: Unselected

[H.6] Real: Selected

[H.7] Mode: Normal Scan

[H.8] Automatic: Selected

[H.9] Fixed: Unselected

[I] Select Start Assay.

[J] Enter the following information in the Item Information Screen:

[J.1] Item ID: (e.g., ECAL_SLB2_A)

[J.2] Description 1: N/A

[J.3] Description 2: (e.g., Eff. CAL, SLB-2 Empty Container, Column A)

[J.4] Location: (e.g., SRS, E Area)

[J.5] Comment: (e.g., N/A)

[J.6] Matrix Type: Default

[J.7] Percent Full: 100%

[J.8] Gross Weight: (as appropriate)

[J.9] Density: (automatically calculated by NDA2000)

[K] Select Done.

[L] Repeat steps 4.5.3[G] through 4.5.3[K] for all the lower and upper level columns (1 through 8).

[M] Print these NDA2000 report files and place them in a binder at the operator's station for reference.

[N] **WHEN** each of the efficiency calibration assays is completed,
THEN ensure the SLB-2 is unloaded.

NDA EA or LO

4.6 Multi-Curve Efficiency Calibration based on In Situ Object Counting System (ISOCS)

NOTE

In the case of the SWB and SLB-2, efficiency calibration measurements are performed only for the empty containers. The summation of the multiple assays using a limited number of the Am-241, Ba-133, Co-57, Cs-137, and Co-60 mixed gamma line sources is used to simulate a uniform source distribution inside an empty container. Efficiencies from these individual calibration measurements are weighted and combined to yield the summed gamma efficiency for an empty container with uniform source distribution.

NOTE

Density effects (i.e., self-shielding due to attenuation in the matrix) are determined utilizing ISOCS to mathematically model a uniformly-active and uniformly-dense matrix. Using this combined calibration methodology, the matrix is assumed to be cellulose at low densities (less than or equal to 0.6 g/cc) and concrete at high densities (greater than 0.6 g/cc). Canberra ISOCS is used to model sources of a wide variety of shapes and sizes. Cylindrical or rectangular collimator types can also be defined for the detectors. The ISOCS software uses the response characterization for the specific HPGe detector as a look-up table to obtain peak efficiencies in vacuum at any given spatial location, and then factors in the attenuation factors due to absorbers that are external and internal to the source. In essence, the ISOCS software can generate peak efficiencies at any given gamma ray energy between 45 keV and 7 Mega electron Volts (MeV) for any given source-detector-collimator configuration. These efficiency data points are then used to generate a multi-density calibration curve.

NOTE

The four HPGe detectors in the BSGS are response-characterized individually using the ISOCS method. The detector collimator configuration is also very accurately modeled in ISOCS. The container dimensions, matrix definitions, the detector positions with respect to the container, aluminum absorber in front of the detector, and the source to detector distance, etc., have all been accurately entered into the ISOCS software to create the ISOCS geometry files (.geo and .gis files). A list of energies where the efficiency values are required is also defined.

4.6.1 Merging of ISOCS Detector CAL Files into Calibration

NOTE

For each of the ISOCS characterized HPGe detectors, batch routines are used to convert the ISOCS Model *.ecc files to ISOCS *.cal files, as required by Genie™ 2000. Thus, for the four HPGe detector arrangement, a corresponding *.cal file is created for each segment of the container and the sum of all segments for each assay. The calibration files created for different matrix densities are also merged to generate a gamma efficiency multi-curve calibration. The multi-curve efficiency calibration files are then to be loaded into NDA2000 through the NDA2000 calibration utility.

[A] For each ISOCS modeled container geometry (i.e. 55-gallon drum, SWB, and SLB-2), convert each of the composite four HPGe detector ISOCS *.ecc files to *.cal files using the Genie™ 2000 software calibration utility.

NOTE

Corresponding *.cal files are created for each segment, for each container type, and the sum of all segments for each gamma calibration assay.

[B] Load the resulting ISOCS *.cal files into the appropriate file locations as prescribed by the NDA2000 software manual using the NDA2000 software calibration utility.

NOTE

The calibration files created for different matrix densities are merged together in order to generate a gamma efficiency multi-curve calibration for each container type.

[C] Load the resulting multi-curve efficiency calibration files into the Calib subdirectory in NDA2000 using the NDA2000 calibration utility.

NDA Operator

4.7 Calibration Confirmation

NOTE

Calibration Confirmation shall be performed after each calibration or re-calibration using at least one non-interfering, representative waste container configuration. Matrices representative of the calibration density range may also be tested, as required.

A minimum of two standard strengths or loadings is required: one to cover the lower one-third of the operating range, and one to cover the upper one-third of the operating range. Standards are from a supplier maintaining a nationally accredited measurement program. Standards used for initial calibration will **NOT** be used for confirmation.

The NDA LO will provide the detailed information concerning the number and strength of the standards, the matrix container configurations, and the number of replicates required. Typically, six replicates will be performed and the results evaluated against the criteria in CCP-PO-002 for a ±30 percent accuracy and a precision of less than 14.0 percent. Changes from these typical values will be documented by the NDA LO.

4.7.1 Obtain the appropriate standard/matrix configuration as indicated by the NDA LO and document the configuration in the NDA Operational Logbook, in accordance with CCP-QP-011.

4.7.2 Ensure the standard(s) are located within the matrix container as indicated by the NDA LO.

4.7.3 Perform QC Background Check and instrument performance check as described in CCP-TP-189.

4.7.4 Perform replicates for each standard/matrix configuration as indicated by the NDA LO in accordance with the routine assay procedure described in CCP-TP-189.

NDA EA

4.7.5 Evaluate the confirmation measurement results against the criteria for confirmation measurements specified in the following table taken from CCP-PO-002, **AND** using a percent recovery limit of ±30 percent.

Table 2. Calibration Confirmation Criteria

Number of Replicates	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Max %RSD	1.8	6.6	10.0	12.3	14.0	15.2	16.2	17.1	17.7	18.3	18.8	19.3	19.7	20.0

4.7.6 **IF** the criteria are met,
THEN document the results in a Calibration and Validation Report.

4.7.7 **IF** the criteria are **NOT** met,
THEN evaluate the cause, correct, **AND** instruct the NDA LO to re-perform the measurements as needed, beginning with step 4.7.3 or 4.7.4, as appropriate.

4.8 Preparation of the Calibration and Validation Report

NDA EA

4.8.1 Upon completion of the Neutron and Gamma Calibrations, prepare a Calibration and Validation Report to include the following elements:

[A] Confirmation measurement results

[B] QA measurement control results and plots

[C] Calibration measurement results

[D] Weekly Interfering Matrix Standard Specifications and Limits

[E] Lower Limit of Detection (LLD) and Minimum Detectable Concentrations (MDC) results for WIPP-reportable radionuclides

[F] Demonstration of precision and accuracy

[G] Justification of the number of replicates and types of matrices

[H] Copies of the certificates of all radioactive sources used in the calibration and calibration confirmation

[I] Reporting thresholds for reportable radionuclides that are not measured

4.8.2 Print name, sign, and date the Calibration and Validation Report as the preparer.

4.8.3 Forward the Calibration and Validation Report to another NDA EA or the NDA Services Technical Director for review and approval.

Second NDA EA or NDA Services Technical Director

4.8.4 Review the Calibration and Validation Report.

4.8.5 **IF** the report is acceptable,
THEN print name, sign, and date to approve and submit the Calibration and Validation Report to the Facility Records Custodian.

4.8.6 **IF** the report is **NOT** acceptable,
THEN return the Calibration and Validation Report to the first NDA EA.

NDA EA

[A] Revise the Calibration and Validation Report and proceed to step 4.8.2.

Facility Records Custodian

4.8.7 Receive, process, and transmit the Calibration and Validation Report in accordance with CCP-QP-008.

NDA Operator

4.9 Calibration Verification

NOTE

Verification of the calibration is performed using at least one standard matrix configuration. At the direction of the NDA EA or NDA LO, this may be either a 55-gallon drum, a SWB, or a SLB-2. Calibration standards or secondary sources that have been correlated with the calibration standards can be used.

Calibration verification shall be performed after any one of the following occurs:

- major system repairs and/or modifications
- replacement of the measurement system's components (e.g., detector, supporting electronic components that have the capacity to affect data)
- significant changes to the system's software
- relocation of the system
- failure of QC measurements

The NDA LO will provide the detailed information concerning the number and strength of the sources, the matrix container configurations, and the number of replicates to be performed.

4.9.1 Obtain the appropriate standard/matrix configuration as indicated by the NDA LO and document the configuration in the NDA Operational Logbook in accordance with CCP-QP-011.

4.9.2 Locate the sources within the matrix as indicated by the NDA LO.

4.9.3 Perform background and instrument performance checks as described in CCP-TP-189.

4.9.4 Perform replicates for each standard/matrix configuration as indicated by the NDA LO in accordance with the routine assay procedure described in CCP-TP-189.

NDA EA

4.9.5 Evaluate the verification measurement results against the criteria for confirmation measurements specified in Table 2, Calibration Confirmation Criteria.

NOTE

Supporting data may include QA Last Results Reports, Long Reports, or radioassay data sheets.

4.9.6 **IF** the criteria are met,
THEN document the results and any supporting data as determined by the NDA EA in a Calibration Verification Report, **AND** GO TO step 4.9.8.

4.9.7 **IF** the criteria are **NOT** met,
THEN evaluate the cause, correct, **AND** instruct the NDA LO to re-perform the measurements as needed, beginning with step 4.9.3 or 4.9.4, as appropriate.

4.9.8 Submit the Calibration Verification Report to the Facility Records Custodian.

Facility Records Custodian

4.9.9 Receive, process, and transmit the Calibration Verification Report in accordance with CCP-QP-008.

5.0 RECORDS

5.1 Records generated during the performance of this procedure are maintained as quality assurance (QA) records in accordance with CCP-QP-008. The records are the following:

5.1.1 QA/Nonpermanent

[A] Calibration and Validation Report to include:

[A.1] QC Background Check (from CCP-TP-189)

[A.2] Daily Performance Check (from CCP-TP-189)

[A.3] Supporting data included as appendices and/or attachments

[B] Calibration Verification Report, as required, to include:

[B.1] Supporting data included as appendices and/or attachments