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U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-001

Attention: Mr. John Hickman, Project Manager
Decommissioning Directorate
Division of Waste Management and Environmental Protection
Office of Nuclear Material and Safeguards

Subject: Response to Request for Final Status Survey-Related Procedures

This letter transmits copies of DP-8869,"*In-situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure*" and DP-8871, "*Operation of the Canberra Portable ISOCS System*" requested by phone on December 6, 2005, and subsequently provided to you via email. Should you have any questions regarding this matter, please contact me at (301) 916-3995.

Very truly yours,

YANKEE ATOMIC ELECTRIC COMPANY

Alice C Ca

Alice C. Carson
Licensing Manager

acc/acc
Enclosures: as stated

cc: Mr. J. Kottan, USNRC, Region I Inspector
Mr. D. Everhart, USNRC, Region I Inspector

NMSS01

Proc. No. DP-8869
Rev. No. 1
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IN-SITU (ISOCS) GAMMA SPECTRUM ASSAY SYSTEM CALIBRATION PROCEDURE

SCOPE

This procedure provides guidance for electronic set-up, energy calibration and efficiency calibration activities of HpGe detector systems, manufactured by Canberra Industries, used to perform in-situ gamma spectrum assays. This procedure is applicable to both single and multiple detector systems.

ENCLOSURES

| DP-8869 – Pgs. 1-17
DPF-8869.1 – Pg. 1
| DPF-8869.2 – Deleted
DPF-8869.3 – Pg. 1
DPF-8869.4 – Pg. 1

REFERENCES

1. DP-8856, "Preparation of Survey Plans"
2. AP-0221, "Plant Record Management"
3. Canberra Genie-2000 Operations Manual
4. Canberra NDA-2000 Users Manual
5. Canberra NDA-2000 Technical Reference Manual
6. Canberra Model S573 ISOCS Calibration Software User's Manual
7. Canberra training material for Genie-2000 Basic Operation (SU-470-4)
8. Canberra training material for ISOCS Measurements Using the InSpector (SU-474-4)
9. Canberra training material for NDA-2000 Basic Operation (SU-530)
10. Detector Specification and Performance Data documents as provided by Canberra
11. Notes on the Setup and Calibration of the Box Counter for Yankee Nuclear as provided by Canberra (Ack# 0401845)
12. DP-8870, "Operation of the Canberra Bulk Material Assay System"

DEFINITIONS

Cognizant Radiological Engineer – A Radiological Engineer who has been assigned responsibility for the calibration of the detector system.

Container – An object used to hold material during assay operations. In the context of assays of bulk materials a container is generally the cargo body of a truck or a roll-off.

Counter – A software designation for either a single detector or multiple detectors (e.g. six-detector array) set up to operate as an integrated assay system.

Geometry – A collection of the counting system's physical attributes (e.g. container dimensions, construction attributes, material density, detector position, etc.) which impact assay results.

Source Certificate File – A data file used by the Canberra software which represents a radioactive source, including nuclides, energies, and activity levels.

DISCUSSION

The use of ISOCS to assay bulk materials is an element of the Final Status Survey Program. Each application of this technology is administered by the development and issuance of a specific Survey Plan in accordance with procedure DP-8856, "Preparation Of Survey Plans." While energy calibrations of ISOCS systems do not reference a Survey Plan, efficiency calibrations are designed to incorporate parameters specified in an applicable Survey Plan.

System set-up and calibration activities are performed by Radiological Engineers with either previous experience or training in the calibration of gamma spectrum analysis systems. Training is documented in accordance with the Final Status Survey Training Program.

Energy calibration, including electronic set-up, is the same for all applications of in-situ gamma assay. In addition to guidance, this procedure prescribes recommended parameter values for electronic and energy calibration, however alternative values may be employed under the direction of a cognizant Radiological Engineer. Actual values used are documented on the associated calibration form (DPF-8869.1).

Efficiency calibration is required for each container type (size, shape & construction), material density, and detector configuration combination and is detector-specific. Efficiency calibrations are performed using Canberra's ISOCS modeling software which mathematically determines counting efficiencies without the use of radioactive sources. Parameters associated with efficiency calibrations (container attributes, material density, MDA requirements, etc.) are declared and documented in sample plans developed for each material to be assayed. Such sample plans are prepared in accordance with procedure DP-8856, "Preparation of Survey Plans" [1] and referenced during efficiency calibrations.

This procedure contains several notes, some of which are intended to provide recommendations when developing ISOCS geometry models and associated efficiency files for multi-detector configurations. The suggestions provided by these notes are based on practical experience as well as input from Canberra Industries during specific training sessions and Factory Acceptance Testing.

PREREQUISITES

1. Personnel performing energy calibrations and efficiency calibrations have either previously received training or possesses prior experience calibrating gamma spectrum systems. Training is documented in accordance with procedure DP-8868, "Final Status Survey Training Program."

2. Personnel performing efficiency calibrations associated with in-situ geometry modeling (ISOCS) shall have received training specific to such calibration.

3. Genie-2000 and NDA-2000 (for multi-detector systems) software has been installed, set-up, and configured for operation in accordance with references [3] and [4].

4. Multi-channel analyzer(s) have been defined, configured and loaded into the Genie-2000 runtime database in accordance with reference [3].

5. Radioactive sources used for energy calibration should be NIST traceable and contain Cs-137 and Co-60. Alternate nuclides may be substituted under the direction of a cognizant Radiological Engineer provided that at least two gamma energies are available which approximate or bound the primary energies of the nuclides of concern and NIST traceability for these nuclides can be verified.

6. A source certificate file has been created describing the source used during energy calibrations in accordance with reference [3].

7. Detectors are cooled with liquid nitrogen to operational parameters prior to applying high voltage to the detectors.

8. ISOCS efficiency calibrations shall reference applicable sample or survey plans for specific input parameters and shall correlate to the physical characteristics of the sample or material to be assayed.

9. Containers have been defined, as necessary, in accordance with procedure DP-8870, "Operation of the Canberra Bulk Material Assay System" [12] before ISOCS efficiency calibrations are performed for use with the Truck Monitor.

PROCEDURE

A. GENERAL

1. After a system is initially set up, initiate a system description file (e.g. loose-leaf binder) to include detector manufacturer specification sheets as a minimum. For multi-detector systems, a description of the system and detector-to-analyzer assignments should be provided.

2. Many of the steps in this procedure apply to a single detector and are to be executed (repeated) as necessary for multi-detector systems.

3. Energy calibrations are required before first-time use, on an annual basis, and as otherwise deemed necessary by a cognizant Radiological Engineer.

4. Enclosed forms are examples. Substitutions are permitted provided that procedurally addressed documentation requirements are supported.

B. CALIBRATION AND ELECTRONIC SET-UP

1. Start a session of Genie-2000's Gamma Acquisition and Analysis (GAA) module.

2. Open up a detector datasource for the detector to be calibrated. More than one detector may be opened at one time.

   NOTE: Recommended calibration set-up parameters are presented in Table 1 below. Alternate values may be employed as determined appropriate by a cognizant Radiological Engineer. Alternate values shall be documented on DPF-8869.1.

Energy Units	KeV
Tolerance Units	FWHM
Energy Cal Tolerance	1.5
Efficiency Match Tolerance	1.0
Tail Curve	LOW
Continuum Mode	STEP
Continuum Range / Units	4 FWHM

TABLE 1, CALIBRATION SET-UP VALUES

3. Review the calibration set-up parameters (menu = Calibrate | Setup...) and make changes as necessary.

   a. Calibration parameters need to be identical for all detectors in a multi-detector system.

b. If any changes are made to calibration set-up values, be sure to save the changes to the detector's configuration (menu = File | Save).

4. Record the applicable calibration set-up parameters in Table 1.1 of DPF-8869.1.

5. Record the detector ID / designator along with its manufacturer's serial number in Table 1.2 of DPF-8869.1. Document (check mark) that the calibration set-up parameters have been inspected and are appropriate.

6. Perform an electronic set-up of the detector's MCA as follows:

   a. Open up the software interface (dialog box) for the MCA electronics (menu = MCA | Adjust...).

   b. Verify (and adjust as necessary) the detector's high voltage setting against the manufacturer's specification as documented in reference [10]. Record the high voltage setting.

   c. Turn on the high (bias) voltage to the detector.

   d. Place the source to be used for the energy calibration close to the detector face, at or inside the plane of the detector collimator's opening so as to provide an adequate count rate to check pole zero settings.

   e. Verify the pole zero setting is satisfactory.

      1) Refer to the Genie-2000 user's manual and the DSA-1000 hardware manual as necessary.

      2) Record the pole zero setting.

   f. Set the amplifier gain via the software interface as follows:

      1) Clear any previous spectrum which may be displayed in the data acquisition window.

         __NOTE__: The following steps presume that a channel-to-energy relationship of 4:1 is employed. Alternative ratios shall be reflected on DPF-8869.1.

2) Place the spectrum cursor at the position of channel 5330. which is where 1332 keV should be located. If necessary. use the expand window to help position the cursor at the correct channel.

3) Start a new count. Count time should be at least 300 seconds.

4) During the collect. adjust the fine gain and the super fine gain settings as necessary so as to "shift" the position of the 1332.5 keV peak's centroid to line up with channel 5330.

5) Clear (and re-start if necessary) the collect after each gain adjustment & observe the influence of the gain adjustments as the spectrum continues to collect.

6) Repeat as necessary so that the 1332.5 KeV peak centroid physically corresponds to channel 5330.

7) When the 1332.5 KeV peak's centroid is positioned at channel 5330. record the course. fine and super fine gain settings.

8) Save the gain settings to the detector's configuration (menu = File | Save).

9) When the amplifier gain settings are completed. close the MCA Adjust dialog box.

C. <u>ENERGY CALIBRATION</u>

<u>NOTE</u>: Table 2 employs an energy-to-channel relationship of 0.25. correlating to 4 channels per KeV. This is to help simplify system performance monitoring with respect to gain shifts. etc. Careful consideration should be made before using an alternative energy-to-channel relationship.

1. Desired energies and channels for energy calibration are listed in Table 2.

NUCLIDE	ENERGY (KeV)	CHANNEL
Am-241	59.5	238
Cs-137	661.6	2646
Co-60	1332.5	5330

TABLE 2, ENERGY CAL CHANNELS

2. Start a full energy calibration (menu = Calibrate | Energy Full | By Certificate File). This will open a dialog box where a source certificate file is selected.

3. Select (& open) the source certificate file representing the source being used.

4. After the certificate file is opened, a dialog box (name = Energy Calibration – Full) will display a listing of the energies to be employed during the calibration.

5. Select the lowest energy in the list.

6. Place the spectrum cursor at the peak centroid of the associated nuclide regardless of the currently associated channel.

7. Press (click) the CURSOR button on the dialog box.

8. Highlight the next applicable peak in the list box and repeat steps C. 2. through C. 7. above until all desired energies have been addressed.

9. Press (click) the SHOW button to display the Energy Calibration Curves dialog box.

10. Print both the Energy and Shape curves.

11. Close the "Curve" dialog box.

12. Inspect the calibration curves for acceptability. If problems are noted, then re-perform the energy calibration as necessary.

13. Complete the Energy Calibration by pressing (clicking) the OK button on the Energy Calibration-Full dialog box.

14. Save the calibration to the detector's configuration (menu = File | Save).

15. Print out a report of the energy calibration (menu = Analyze | Reporting | Standard) via the Standard Report dialog box.

16. Set the section to "EnergyCal" and select the printer as an output.

17. To print the report, press (click) the EXECUTE button.

18. Verify that each of the energies is at the anticipated channel, ±4 channels. If the results are not satisfactory, repeat the energy calibration procedure above or contact technical support (e.g. cognizant radiological engineer, Canberra, etc.). Remove the equipment from service if necessary.

19. When the energy calibration is acceptable, record the centroid channel corresponding to the energy in Table 1.3 of DPF-8869.1.

20. Repeat steps C. 2. through C. 19. for each detector, as applicable.

21. When energy calibrations are completed as satisfactory and any qualifications are identified then:

    a. Sign & date DPF-8869.1.

    b. Note any applicable remarks on DPF-8869.1.

    c. File the completed DPF-8869.1 in the applicable system binder.

D. ISOCS EFFICIENCY CALIBRATION

NOTE: A multi-detector system assaying a particular material will generally involve more than one associated efficiency calibration due to the relative detector positions with respect to the container.

NOTE: If a multi-detector array is being addressed, and all detectors in the array exhibit similar responses within ±10% for energies of concern, then the same detector (serial number) may be assigned to all geometry models in the array. For the Truck Monitor, detector SN 7828 has been identified during Factory Acceptance Testing as meeting this condition for energies above 100 keV [11]. This provision is intended to support detector substitutions in the event a detector in the array is rendered out of service.

1. If the ISOCS efficiency calibration is for the Truck Monitor, then determine the detector off-sets and physical positions referencing the applicable form DPF-8870.1 [12], including any attached drawings and notes as necessary.

2. If desirable, prepare a hard-copy of the ISOCS geometry template for each detector or detector position, as applicable.

    a. Print the applicable geometry worksheet (PDF file). Blank worksheets are located at \GENIE2K\ISOCS\UTILITIES.

NOTE: Typically, a simple box is used for trucks of bulk material or debris and a circular plane is used for open area land surveys. Other more appropriate templates may be used as determined by a Radiological Engineer.

NOTE: If a multi-detector array is being addressed, then one geometry template may be used to represent several similar (due to symmetry) detector positions.

NOTE: If multiple densities are being addressed, it is not necessary to complete a separate hard-copy geometry template for each density, however the hard-copy template should be annotated specifying each density.

b. Detector and collimator parameters are based on the equipment being used.

c. Record the Geometry Description (16) to reflect the container.

d. Record the source material applicable density in the Comments (50) section.

e. In the case of the multi-detector systems (i.e. Truck Monitor), record dimensions regarding the geometry as follows:

1) Record the container dimensions (inches), material identifier and density (g/cc).

2) Record the source layer data.

a) The total height of the source layer(s) should be equal to the height of the container so as to reflect a full load.

b) Specify the source material (e.g. concrete, soil, etc.) and density (g/cc).

c) Specify the relative "source concentration" of the source layer, which should be 1 unless the distribution of the radioactivity is stratified (i.e. there is more than one source layer).

3) Record absorber 1 as representing the Truck Monitor's wall where the thickness = 1.57 inches. Select the material (material identifier = "wall") from the material editor. A (default) density of 0.42 g/cc should be applied for the truck monitor enclosure's wall.

4) Record absorber 2 as representing the aluminum plate at the detector face where the thickness = 0.03 inches [11]. Select the material (aluminum) from the material editor using a (default) density of 2.7 g/cc.

5) Record the source-to-detector dimensions (in inches) with respect to the center of the reference plane.

f. For calibration efficiencies applied to single (portable) detectors being setup for open-land assays, record the parameters as follows:

1) The description text should describe the geometry (e.g. open land, etc.).

2) Comment text should minimally address detector orientation at a minimum.

3) Record the "container" wall thickness as zero.

4) Record source layer information. Represent the stratification of the radioactivity via the use of the relative concentration parameter. Specify the material (soil) and density (g/cc) via the material editor.

5) Record parameters associated with any applicable absorbers.

6) Record detector off-set parameters with respect to the center of the "object's" reference plane.

3. Create geometry files via the Geometry Composer module. This process calculates efficiency values (data points) for specific energies.

a. Start the Geometry Composer software module.

b. Select the applicable ISOCS geometry template (menu = File | New...). If a geometry file (*.GEO) similar to the geometry being addressed already exists, then such a file may be used as a template (i.e. edited & renamed) so as to minimize redundant data entry.

c. Enter the parameters into the ISOCS software template referencing the applicable geometry template worksheet.

d. If a unique material / density is encountered, then use the Material Editor to create a specific entry for the material.

e. Press (click) the OK button when all parameters have been entered. This will result in the displaying of a report reflecting the geometry's attributes.

f. Verify the validity of the geometry's definition (menu = Efficiency Curve | Check Geometry Validity). Correct any "flagged" issues.

g. Identify the sample and detector environmental conditions during extreme or unusual operating conditions as necessary (menu = Edit | Environment).

h. Define the parameters to be applied during efficiency calculations (menu = Edit | Efficiency Parameters).

   1) Specify energies to be addressed during efficiency calculations. Generally, one of the pre-defined energy lists (e.g. "Mixed gamma + Am") is appropriate.

i. Press (click) the OK button to process the geometry file.

j. Save the geometry file (menu = File | Save).

   1) File names should reflect the container, the detector, the material, and the density.

   2) Record (list) assigned filenames on DPF-8869.3.

   3) Alternate file naming conventions should be deciphered/documented on documentation (forms, memos, etc.) associated with the efficiency calibration.

k. Generate efficiency data points for the geometry (menu = Efficiency Curve | Generate Efficiency Data Points). This process results in the creation of an (*.ECC) efficiency file automatically applying the same filename assigned to the geometry file.

l. Print a copy of the geometry report.

m. If a multi-detector system is being addressed, then:

1) Repeat steps D. 4. a. through D. 5. k. to create a geometry file and generate efficiency data points for each detector in the system.

2) Generate a set of multi-efficiency data points that represent the collective efficiency of all detectors in the system (menu = Efficiency Curve | Run Multi-Efficiency).

3) Select the Sum Calibration mode.

4) Set the Mass or Area Multiplier to "None" unless a specific multiplier is applicable.

5) Select "Add ECC File" and open the first efficiency file to be summed.

6) Repeat step D. 5. l. 5) above until a file has been added for each detector in the system.

7) Enter description text for the summed efficiency file.

8) Press (click) the CALCULATE button to sum the selected files.

9) Review the sum results and print a report of the summed efficiencies. Report style 2 generally fits best on one page.

10) Close the dialog box, which will cause a prompt for the file to be saved. Save the file using an applicable filename to reflect the summed efficiencies (e.g. SUM_RO_CONC_114).

11) Record the filename assigned to the summed efficiency file on DPF-8869.3.

4. Build efficiency curves from the data points generated by the Geometry Composer.

a. In Genie-2000, open up the efficiency calibration dialog box (menu = Calibrate | Efficiency | By ISOCS/LabSOCS...). Note that this menu selection will be grayed-out unless a detector datasource is loaded.

b. Select the appropriate geometry efficiency (*.ECC) file. If necessary, browse via the path ...ISOCS\DATA\GEOMETRY\IN-SITU\....

c. Press (click) the NEXT button, which will present efficiency-type options.

d. If appropriate, set the Optional Efficiency Factor to "Efficiency * Mass" (referred to as massimetric). This is generally applicable to large sample volumes where results are to be expressed in terms of activity / mass (pCi/gm). Other optional factors may be alternatively applied as appropriate.

e. Open the Efficiency Results dialog box by to display the calculated efficiency for each energy by pressing (clicking) the NEXT button.

f. Press (click) the SHOW button to generate the efficiency curve.

g. Adjust the Curve Model, Scale and Polynomial Order as necessary to obtain a good curve fit to the data points. The recommended curve-type is "interpolated".

h. When the curve fit is acceptable, the efficiency curve MAY BE (optionally) printed by pressing (clicking) the PRINT button. Printouts of efficiency curves should be annotated with the applicable efficiency filename.

i. Return to the efficiency results dialog box by pressing (clicking) the OKAY button.

j. Enter description text for the efficiency (limited to approximately 70 characters). Text should reflect the detector, material and applicable density.

k. Press (click) the REPORT button, which will display a report listing the ISOCS efficiency results. Print this report and then return to the efficiency results dialog box by pressing (clicking) the OKAY button.

l. Press (click) the STORE button to save the ISOCS efficiency file. Use the same filename applied to the associated geometry file. If the efficiency is massimetric then augment the filename to reflect this quality.

m. Close the Efficiency Results dialog box by pressing (clicking) the FINISH button.

n. For a multi-detector system, repeat steps D. 4. a. through D. 4. m. above to build an efficiency curve for each detector, including any applicable summed efficiency file.

o. If a multi-density efficiency file is to be developed, then repeat steps D. 4. a. through D. 4. n. for each density.

5. Load efficiency calibration files into the software and associate to specific detectors prior to use.

a. For a single detector system (e.g. portable unit) assign an efficiency calibration file to the detector's configuration as follows:

1) Start a session of the Genie-2000 Gamma Acquisition and Analysis (GAA) module.

2) Load the applicable detector datasource.

3) Open a dialog box listing the available calibration files (menu = Calibrate | Load).

4) Select the appropriate calibration file (*.CAL).

5) Verify that the "Efficiency" check box is selected.

6) Press (click) the LOAD button. The dialog box will close.

7) Save the detector datasource (menu = File | Save).

b. For a multi-detector system, load efficiency curves into the NDA-2000 software as follows:

1) Open the NDA-2000 Calibrations module.

2) Select the applicable counter (menu = File | Select Counter).

3) Set the type of calibration to "Efficiency".

4) Open the Efficiency Calibration dialog box (menu = Calibration Operations | Perform Calibration).

5) Designate the applicable Container and Geometry which will be associated to these calibration files and press (click) the NEW EFFICIENCY CALIBRATION button.

6) Enter the appropriate calibration description and press (click) the NEXT button. This will present a Count dialog box which is not used for ISOCS efficiencies.

7) Make an entry on the NDA Efficiency Log (DPF-8869.4) for each ISOCS efficiency being loaded into NDA. Include the container, density (range) and material associated with the geometry.

8) Press (click) the NEXT button again to display the Plot dialog box.

NOTE: Individual efficiency files (*.CAL) are assigned to each physical analyzer (e.g. detector) in the system, including a virtual "analyzer" representing the summed detectors.

9) Select an analyzer from the drop-down list located at the lower right quadrant of the Plot dialog box.

10) Press (click) the LOAD FILE button to display a dialog box where the calibration (*.CAL) files can be accessed in the GENIE-2K\CALFILES directory.

11) Select (Open) the calibration file appropriate to the analyzer being addressed. Enter the applicable density (units = g/cc) when prompted and then press (click) the LOAD button to load the file.

12) Set the calibration model (interpolated recommended) and polynomial order, as necessary, to obtain a good curve fit.

13) If creating a multi-efficiency calibration (i.e. a range of densities), then repeat steps D. 5. b. 1) through D. 5. b. 11) above for each calibration file to be loaded on the combined curve for the selected analyzer.

14) If multi-density efficiencies are being processed, then set the View's radio button to OverPlot.

15) When files have been loaded for the selected analyzer(s) (detectors), press (click) the PRINT button to print the final calibration chart.

16) Repeat steps D. 5. b. 1) through D. 5. b. 14) above for each analyzer(s) (detector) in the system, including the summed detector analyzer.

17) Press (click) the FINISH button when all efficiency calibration files when all desired densities have been loaded to all analyzers (detectors) in the counter.

18) Print a report of the efficiencies loaded into NDA-2000 by pressing (clicking) the REPORT button on the Efficiency Calibration dialogue box.

19) Close the dialogue box when finished by pressing (clicking) the EXIT button.

NOTE: After efficiencies are loaded into the NDA-2000 software, the efficiency must be "approved" (i.e. registered) before the software will employ the efficiency in analysis routines.

20) Approve loaded efficiencies before use (menu = Calibration Operations | Approval).

NOTE: If a single ISOCS calibration efficiency is to be applied to more than one material stream, then a separate geometry may need to be defined for the additional stream(s) in accordance with procedure DP-8870 [12].

21) Assign the default efficiency for the container/geometry combination (menu = Calibration Operations | Set Default).

22) Update the NDA Efficiency Log (DPF-8870.4) as appropriate.

RECORDS

Calibration records will be filed and processed in accordance with procedure AP-0223 "Document Control."

A reference file should be maintained for each detector system which describes the system (e.g. specification documents), and contains (copies of) energy and efficiency calibrations as well as a summary (charts, etc.) of performance monitoring (QC) activities.

Aside from the applicable forms to this procedure, documentation should include software-generated reports as follows:

- Energy calibrations should include an Energy Calibration Report for each detector.

- Efficiency calibrations should include, for each detector: 1) Geometry Composer Reports, 2) Efficiency Calibration Curve (optional), and 3) ISOCS / LABSOCS Results.

Calibration records are to be handled in accordance with reference [2].

Copies of efficiency calibration documentation (procedure forms and software reports) should be attached to applicable Sample Plan(s).

FINAL CONDITIONS

1. Energy calibrations result in centroid peaks located within ±4 channels of the anticipated channel.

2. Calibration stickers have been affixed to detectors following successful energy calibration.

IN-SITU GAMMA SPECTRUM ASSAY SYSTEM
ENERGY CALIBRATION WORKSHEET

DATE @ TIME: ____________________

SOURCE ID: ____________________

CALIBRATION SET UP PARAMETERS

Energy Units	keV
Tolerance Units	FWHM
Energy Cal Tolerance	1.5 FWHM
Efficiency Match Tolerance	1.0 FWHM
Tail Curve	LOW
Continuum Mode	STEP
Continuum Range / Units	4 FWHM

ELECTRONIC SETTINGS FOR ENERGY CALIBRATION

					GAIN SETTINGS		
DETECTOR POSITION (e.g. tower, etc)	DET S/N	MCA S/N	HIGH VOLTAGE	POLE ZERO	COURSE	FINE	SUPER FINE

ENERGY CALIBRATION RESULTS

ENERGY (KeV)	ASSIGNED CHANNEL	AS-CALIBRATED CENTROID CHANNEL [1]	FWHM (keV)[2]
59.5	238		
661.6	2646		
1332.5	5330		

1 – ACCEPTANCE = ASSIGNED CHANNEL ±3 CHANNELS
2 – ACCEPTANCE = AT OR BELOW DETECTOR'S FACTORY SPECIFICATION

REMARKS:

CALIBRATION DUE (MONTH/YEAR): ____________________

CALIBRATION PERFORMED BY: ________________________________ DATE: __________

ISOCS EFFICIENCY FILENAME WORKSHEET

APPLICABLE CONTAINER ID: ______________________

APPLICABLE GEOMETRY DESIGNATION: ______________________

SOURCE MATERIAL: ______________________

APPLICABLE DENSITY & COMMENTS	ISOCS EFFICIENCY FILENAMES	GEOMETRY (*.GEO) FILE	EFF POINTS (*.ECC) FILE	GEOMETRY COMPOSER RPT	MULTI-EFFICIENCY RPT	CALIBRATION (*.CAL) FILE	EFF. CALIBRATION CURVE	ISOCS EFF. RESULTS RPT	LOADED INTO NDA

EFFICIENCIES PREPARED BY: ______________________ DATE: __________

EFFICIENCIES REVIEWED BY: ______________________ DATE: __________
COGNIZANT RADIOLOGICAL ENGINEER

NDA ACTIVITIES (PERFORMED BY COGNIZANT RADIOLOGICAL ENGINEER)

ASSIGNED NDA EFFICIENCY NAME: ______________________

DATE LOADED TO NDA: __________ BY: ______________________

DATE EFFICIENCY APPROVED IN NDA: __________ BY: ______________________

DATE EFFICIENCY SET AS A DEFAULT: __________ BY: ______________________

TRUCK MONITOR ISOCS EFFICIENCY LOG

EFFICIENCY DESIGNATION	CONTAINER	GEOMETRY	DENSITY (RANGE)	REMARKS	DATE ENTERED INTO NDA	INITIALS

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OPERATION OF THE CANBERRA PORTABLE ISOCS ASSAY SYSTEM

SCOPE

This procedure governs the operation and maintenance of the Canberra portable gamma spectrum assay system. This procedure works in partnership with DP-8869 "*In-Situ* (ISOCS) Gamma Spectrum Assay System Calibration Procedure."

ENCLOSURES

DP-8871 - Pgs. 1–11

DPF-8871.1 - Pg. 1

DPF-8871.2 - Pg. 1

DPF-8871.3 - Pg. 1

DPF-8871.4 - Pg. 1

Attachment A - Pg. 1

Attachment B - Pg. 1

Attachment C - Pg. 1

REFERENCES

1. DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure"
2. Job Hazard Assessment, "Filling Detectors/Dewars with Liquid Nitrogen Activity"
3. Yankee Nuclear Power Station License Termination Plan
4. Canberra Genie-2000 V3.0 Operations Manual
5. Canberra training material for Genie-2000 Basic Operation (SU-470-4)
6. Model ISOXSHLD ISOCS Shield System Hardware Manual
7. DP-8856, "Preparation of Survey Plans"

8. DP-8872, "ISOCS Post Acquisition Processing And Data Review"

9. DP-8868, "Final Status Survey Training Program"

DEFINITIONS

Cognizant Radiological Engineer – A Radiological Engineer who has been assigned responsibility for the calibration of the detector system.

Source Certificate File – A data file used by the Canberra software which represents a radioactive source, including nuclides, energies, and activity levels.

Count – The process of collect gamma spectrum data.

DISCUSSION

This procedure provides guidance for the operation and maintenance of this system, including QC activities. The level of detail in this procedure presumes a significant degree of familiarity with the equipment and software as obtained through training and/or experience.

Operation of the portable ISOCS assay system is under the direction of qualified Radiological Engineers. Energy and efficiency calibrations are performed in accordance with procedure DP-8869, "*In Situ* (ISOCS) Gamma Spectrum Assay System Calibration Procedure." Use of the portable assay system should be under the administrative guidance of a Sample Plan or a Final Status Survey Plan. Plans provide information regarding nuclide library, acceptable MDA values, and applicable acceptance criteria.

The portable ISOCS assay system consists of a uniquely characterized HPGe detector, an InSpector2000 multi-channel analyzer, a laptop computer with Genie-2000 software installed. The system is designed to perform in situ gamma spectroscopy of large containers, surfaces, and open land areas.

PRECAUTIONS

1. Liquid nitrogen is VERY cold (approx. -200°F) and can easily cause severe frostbite. Wear eye protection when working with liquid nitrogen. Use gloves when working with cold piping and valves or where liquid nitrogen may contact the skin.

2. Nitrogen displaces oxygen and may cause asphyxiation. Do not occupy areas where an oxygen monitor is observed in the alarm state.

3. If the cryostats are being filled with LN2 in an enclosed area (room, etc.) then personnel access doors (if present) shall be open while filling unless BOTH an alarming oxygen monitor is operational in the enclosure AND the cryostats are vented to the outside of the enclosure.

4. Sources shall be controlled in accordance with Radiation Protection procedures and should be secured in locked storage when not in use or attended.

PRE-REQUISITES

1. Personnel working with liquid nitrogen shall have reviewed (and signed-off on) the associated Job Hazard Assessment for Liquid Nitrogen [2].

2. Personnel shall have received training that is applicable to the assigned task(s) in accordance with DP-8868, "Final Status Survey Training Program" [9].

3. The assay system has been set-up and an energy calibration has been performed in accordance with DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure" [1].

4. Although this procedure provides guidance associated with setting the parameters in a QA file, a QA file shall be set-up and implemented prior to using the portable ISOCS system for Final Status Survey measurements.

PROCEDURE

A. GENERAL

1. If an oxygen monitor is observed in the alarm state, immediately exit the area and notify the ISFSI Shift Supervisor at x2235.

2. Guidance in this procedure generally follows a linear format. However, some steps may occasionally be determined as unnecessary or may be performed out of sequence as practical.

3. A system binder (book) should be maintained for each detector system to include information such as a copy of the current energy calibration, source certificate files, Gain Adjustment Logs, Maintenance Reports, etc. Applicable Daily Checklists (DPF-8871.1) may also be maintained in the system binder.

4. A narrative-style logbook should be maintained for purposes of documenting unique attributes of system performance or QC activities.

5. This procedure contains forms that are considered examples. Alternate or modified forms may be employed provided that information specifically required by the text of the procedure is addressed. Alternate or modified forms should be annotated with the appropriate document and revision identifier.

6. Data acquisition and analysis steps associated with FSS data are executed via Analysis Sequence Files defined by a cognizant Radiological Engineer. However, a cognizant Radiological Engineer may manually collect and analyze data without use of an ASF on a case-by-case basis.

B. FILLING CRYOSTATS WITH LIQUID NITROGEN

1. If an oxygen monitor is observed in the alarm state, immediately exit the area and notify the ISFSI Shift Supervisor at x2235.

2. The system should not be operated while a detector cryostat is being filled with liquid nitrogen because the data results will most likely be erroneous.

3. Recommended guidance concerning filling the detector cryostats with liquid nitrogen is presented in Attachment A of this procedure.

4. Notify a cognizant Radiological Engineer if any unusual conditions are encountered.

5. Attachment A may be posted for reference by personnel filling detector cryostats with liquid nitrogen.

C. QUALITY CONTROL

1. General

a. Quality Control files shall be setup by a cognizant Radiological Engineer before QC activities can be performed.

b. QC-related count times should be at least 600 seconds.

c. Cognizant Radiological Engineers shall routinely review completed Daily Checklists (DPF-8871.1). Reviews are documented via a dated signature on the Daily Checklist.

2. Detector Performance Monitoring

a. Routine QC source checks should be performed with the Eu-155 / Na-22 sources (nominally 1 μCi each) provided by Canberra.

b. QC source checks should consist of the following attributes:

1) The centroid channel should be tracked at 86.5 keV (± 2 channels) and 1274.5 keV (± 4 channels).

2) The Full Width Half Max (FWHM) should be monitored at 1274.5 keV. Acceptance criteria should be selected to provide preliminary indications when the detector's specifications may be exceeded (e.g. slightly below the detector's specification).

3) Source activities at 86.5 keV and 1274.5 keV should be tracked. Acceptance criteria should be selected to flag results that exceed ±10% of the mean activity value of the source.

c. QC source counts shall be performed shiftly prior to use.

NOTE: Because each assay reports for the presence of K-40, post shift QC source counts are not required to verify system operability.

d. Optionally, QC source counts may be performed post shift on a case-by-case basis as determined by a cognizant Radiological Engineer.

e. QC source counts shall be performed as follows:

1) Position the designated QC source in front of the detector at the prescribed position.

2) Start the Genie2000 software as described in Section E of this procedure unless the software is already running.

3) Start the QC source count via a pre-defined Analysis Sequence File (ASF). (Menu = Analyze | Execute Sequence >).

4) If an Analysis Sequence file is either not available or for some reason is not desired to be used, then a QC source count may be manually executed under the direction of a cognizant Radiological Engineer.

5) When the count is complete:

a) Review the results.

b) Annotate (check mark) the applicable Daily Checklist (DPF-8871.1) when QC activities are satisfactory.

c) If a flagged result was encountered, notify a cognizant Radiological Engineer for resolution. Such resolutions shall be documented on the appropriate Daily Checklist (DPF-8871.1), including any applicable follow-up actions.

3. Background Surveillances

a. QC surveillances for background are not performed unless background subtraction is to be applied to in-situ gamma spectroscopy results.

b. When background subtraction is applied to assay results then QC background surveillances shall be performed under the direction of a cognizant Radiological Engineer as appropriate.

c. A cognizant Radiological Engineer will establish acceptance criteria for QC background surveillances on a case-by-case basis.

d. QC background results shall be reviewed by a cognizant Radiological Engineer.

e. Flagged results for QC background surveillances used to support Final Status Survey activities shall be addressed in the applicable FSS Field Log(s).

D. SYSTEM DEPLOYMENT / STORAGE

1. Recommended guidance concerning system configuration for deployment in the field is presented in Attachment B of this procedure.

2. Notify a cognizant Radiological Engineer if any unusual conditions are encountered.

3. Attachment B should be available for reference by personnel removing the systems from the storage location.

4. Attachment C should be available by personnel when placing the systems into storage (e.g. overnight) between uses.

E. SYSTEM STARTUP

1. As necessary, start the Genie2K software (i.e. Gamma Acquisition and Analysis Module).

2. Open the appropriate detector (Menu = File | Open Datasource…)

a. Note the distinction between the two possible types of sources: detector verses file. Select the DETECTOR radio button.

b. Select the appropriate detector and press (click) the OPEN button. Note that the detector designations (i.e. naming convention) may include color identifiers to minimize confusion.

3. Verify that the detector high voltage is turned on. If the high voltage is not turned on, then the high voltage will need to be turned on prior to performing a count. When the high voltage has reached the prescribed set point, the system is ready for use.

F. AMPLIFIER GAIN ADJUSTMENTS

1. Amplifier gain adjustments shall be performed only as directed by a cognizant Radiological Engineer.

2. In the Genie-2000 environment, open the detector datasource requiring amplifier gain adjusting (menu = File | Open Datasource).

3. Position the QC check source at the face of the detector

4. Open the MCA adjust dialog box (menu = MCA | Adjust...).

   a. Verify that the detector's high (bias) voltage is turned ON.

   b. Inspect the amplifier gain settings.

5. Record the date, detector ID and as-found settings on an Amplifier Gain Log (DPF-8871.2).

6. Position the spectrum cursor at channel 5098.

7. Start a count for approximately 300 seconds (or longer).

8. While the spectrum is being collected, adjust the super fine (& fine, if necessary) amplifier gain settings so that the centroid for the 1274.5 keV peak corresponds to channel 5098.

9. Clear the spectrum (and re-start the count if necessary) after each gain adjustment, observing the influence of the gain adjustments.

10. When the 1274.5 keV peak's centroid is positioned at channel 5098, save the gain settings (Menu = File | Save) and record the "as-left" fine and super fine gain settings on an Amplifier Gain Log.

11. After amplifier gain adjustments are made, perform a follow-up QC source count in accordance with Section C of this procedure.

12. When follow-up QC source counts are satisfactory, annotate the Amplifier Gain Log appropriately.

G. NUCLIDE LIBRARIES

1. For FSS activities, a nuclide library shall be developed to address the gamma-emitting radionuclides listed in the License Termination Plan.

2. For non-FSS activities, nuclide libraries may be developed on a case-by-case basis under the direction of a Radiological Engineer.

3. Libraries may include naturally occurring nuclides so as to minimize unidentified peaks.

4. Nuclide libraries should be saved with filenames that clearly denote the application of the library along with a revision identifier.

5. Nuclide libraries shall be independently reviewed with respect to the list of radionuclides and for the half-life and energy/abundance values.

H. DATA ACQUISITION

1. Before data acquisition, field personnel (e.g. RP Technician) shall verify the detector is outfitted with the correct collimator as directed by the cognizant Radiological Engineer or by the applicable FSS Plan.

2. Position the detector at the desired location, height, and orientation.

3. Verify that the detector's high (bias) voltage is turned on, if necessary.

4. If FSS data is being collected, document each acquisition either on an In-Situ Gamma Spectrum Data Collection Worksheet (DPF-8871.3), or similar, or on a report generated by a FSS database (e.g. EDMS).

   a. At a minimum, the instrument identifier, date and time of acquisition, spectrum filename, and individual operating the system should be documented.

   b. Remarks should be documented to describe unique conditions, configurations or other attributes that may be relevant as directed by the cognizant Radiological Engineer.

5. Initiate a count by selecting the desired analysis sequence file (Menu = Analyze | Execute Sequence >).

   a. When prompted, input or edit the Sample Information in accordance with the applicable ISOCS Data Collection Worksheet (DPF-8871.3). Unique assay identifiers or descriptions, if used, should be entered as directed by the cognizant Radiological Engineer.

   b. When prompted, enter the filename (and path if necessary) where the spectrum's data file should be saved. The assay will automatically be saved with the specified filename at the end of the collection process.

6. If an Analysis Sequence File is either not available or for some reason is not desired to be used, then a count may be manually executed under the direction of a cognizant Radiological Engineer.

   a. Set the count time (Menu = MCA | Aquire Setup).

   b. Input appropriate information about the count (Menu = Edit | Sample Info...).

   c. Save the data file when the count is finished (Menu = File | Save As...).

I. POST ACQUISITION PROCESSING AND DATA REVIEW

<u>**NOTE:**</u> Post acquisition processing may be applied at the time of data acquisition via Analysis Sequence Files.

1. Data analysis routines are incorporated into an ASF used to collect the data, however post acquisition processing may be manually performed.

2. After a spectrum has been collected, data analysis routines shall be applied.

   a. The data file(s) should be copied to a working directory, as determined by the Radiological Engineer performing the data analysis.

   b. Although data analysis routines may be selected, customized, or modified by a Radiological Engineer, the following routines are suggested:

      - Peak Locate (Unidentified 2nd Difference)

- Peak Area (Sum/non-Linear LSQ fit)
- Efficiency Correction (standard) – select Interpolated
- Nuclide Identification (w/ Interference Correction)
- Reports – (e.g., Header, Peak Analysis, NID, etc. as desired)

c. The following parameters should be applied to the above routines, as applicable:

- Peak locate threshold = 3.0
- Peak search range = 200 – 8000 channels
- Identification tolerance = 1.25 FWHM
- All other parameters may be selected / specified by a Radiological Engineer.

3. Directly following the completion of each assay used for FSS activities, the individual colleting the data should review the results with respect to the K-40 result.

4. Spectrum data files may be manually analyzed or re-analyzed as follows:

   a) Open the data file to be processed (Menu = File | Open Datasource).

   b) Execute the desired analysis sequence file (Menu = Analyze | Execute Sequence >), ensuring that the efficiency calibration file applied to the data is correct.

5. Review the results. If necessary re-process the data, making any adjustments to the post acquisition processing routines.

6. After post acquisition processing activities are completed, the data file shall be saved to a specific directory where FSS data is stored.

7. Assay results may be transferred into the EDMS database for final processing and data analysis.

J. MAINTENANCE

1. If a component of the signal chain requires repair or non-routine maintenance, then a Maintenance Report (DPF-8871.4) shall be initiated and updated as necessary.

2. A separate Maintenance Report shall be initiated for each unique piece of equipment.

3. Maintenance Reports shall be closed out when corrective or follow-up actions are completed.

RECORDS

Spectrum data files (e.g. CAM files) used to support Final Status Surveys shall be maintained on a centralized fileserver.

Maintenance Reports (DPF-8871.4) and Amplifier Gain Logs (DPF-8871.2) "in progress" should be maintained with the applicable system binder. When the forms are completed, forward to document control in accordance with procedure AP-0223 "Document Control."

Copies of completed daily checklists (DPF-8871.1) should be maintained with the applicable system binder.

Forms and assay results generated via this procedure shall be filed and processed in accordance with procedure AP-0223 "Document Control."

FINAL CONDITIONS

1. The assay system is verified to be functioning properly before it is used to collect data.

2. Data is collected, reviewed and data files are saved.

ISOCS DETECTOR DAILY CHECKLIST

Check off (√) blocks to indicate that the applicable activities have been completed.

	SUN	MON	TUES	WED	THUR	FRI	SAT
DATE:							
FILL CRYOSTAT WITH LN2							
DIAGNOSTIC ON O[2] MONITORS							
AM QC SOURCE CHECK SAT							
PM QC SOURCE CHECK SAT							

DETECTOR IDENTIFIER	CURRENT ENERGY CAL DUE DATES [1]						

1 - Only latest due date needs to be reflected one time.

REMARKS:

REVIEWED BY:______________________________ DATE: ______________

COGNIZANT RADIOLOGICAL ENGINEER

AMPLIFIER GAIN LOG

		AS-FOUND GAIN SETTINGS		AS-LEFT GAIN SETTINGS		FOLLOW-UP SATISFACTORY QC SOURCE COUNT		
DATE	DETECTOR	FINE	SUPER- FINE	FINE	SUPER- FINE		REMARKS (FLAGGED REPORT, ETC)	INITIALS

IN-SITU GAMMA SPECTRUM DATA COLLECTION WORKSHEET

SURVEY AREA OR SURVEY UNIT: ______________________

GENERAL COMMENTS:

FSS FILENAME EXAMPLE = NOL-02-01-XXX-F-G (unless otherwise instructed), where XXX is the measurement location identifier

	DETECTOR / SYSTEM ID	DATE / TIME	DATA FILENAME OR IDENTIFIER	REMARKS	INITIALS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					

IN-SITU GAMMA SPECTRUM ASSAY EQUIPMENT MAINTENANCE REPORT

EQUIPMENT DESCRIPTION	SERIAL NUMBER	INITIATION DATE

PROBLEM
RESOLUTION
FINAL CONDITION
REMARKS

MAINT. REPORT CLOSED: ______________________________ DATE: __________
COGNIZANT RADIOLOGICAL ENGINEER

ATTACHMENT A
DETECTOR CRYOSTAT FILLING WITH LIQUID NITORGEN

This attachment presents recommended guidance for filling the ISOCS HPGe detectors with liquid nitrogen (LN2).

1. Personnel filling cryostats with liquid nitrogen shall have been trained and read the Job Hazard Assessment, "Filling Detectors/Dewars with Liquid Nitrogen Activity."

2. Liquid nitrogen is VERY cold (approx. -200°F) and can easily cause severe frostbite. Wear eye protection when working with liquid nitrogen. Use gloves when working with cold piping and valves or where liquid nitrogen may contact the skin.

3. Nitrogen displaces oxygen and may cause asphyxiation. If the cryostats are filled with liquid nitrogen in an enclosed area or room, then personnel access doors (if present) shall be open while filling unless BOTH an alarming oxygen monitor is operational in the enclosure AND the cryostats are vented to the outside of the enclosure.

4. If an oxygen monitor is observed in the alarm state, immediately exit the area and notify the ISFSI Shift Supervisor at x2235.

5. Detector cryostats should be filled every 3 – 4 days while in storage without being used or daily, prior to being deployed out in the field, as practical. However, this may be relaxed to every two days for convenience.

6. Verify (test) the operability of oxygen monitors, as available, prior to filling cryostats.

7. Generally, cryostats should be filled in the horizontal position. However it may be more appropriate to fill some detector configurations in the vertical position. In such cases a cognizant Radiological Engineer will provide direction.

8. Connect the liquid nitrogen supply line to the cryostat's fill port and verify that the vent port is free from restrictions such as build-up, etc.

9. If the detector is being filled in the vertical position, install a vent line to ensure that discharging LN2 does not either create a safety concern or contact the pre-amp.

10. Verify that the pressure on the liquid nitrogen supply bottle does not exceed 50 psi.

11. Open the liquid nitrogen supply valve on the supply bottle of liquid nitrogen.

12. When the cryostat is completely filled, liquid nitrogen can be observed to be flowing from the cryostat's vent.

13. When the filling operation is completed, turn off the supply valve and remove the rubber supply line from the cryostat's fill port (when pliable).

14. After the cryostat has been filled, annotate the applicable DPF-8871.1 (Daily Checklist).

ATTACHMENT B

ISOCS SYSTEM DEPLOYMENT CONFIGURATION

This attachment is intended to serve as an informal checklist to be reviewed prior to transporting the system to a field location. If any pre-deployment configuration attributes are in question, contact a cognizant Radiological Engineer for guidance or disposition. The following not all inclusive attributes should be considered or verified:

1. Verify satisfactory performance of a QC source check by referring to the current Daily Checklist (DPF-8871.1).

2. Verify that the cryostats have been filled appropriately by referring to the current Daily Checklist (DPF-8871.1).

3. Verify that the detector, collimator, and electronics are configured as directed by the cognizant Radiological Engineer(s).

4. Remove and store the QC check source as appropriate.

5. Verify that the detector is securely seated in the collimator frame assembly.

6. Outfit the cryostat's vent port with an overflow tube to prevent liquid nitrogen from contacting the preamp when power is applied to the preamp.

7. Cap the cryostat's fill port unless otherwise directed by a cognizant Radiological Engineer.

8. Rotate the detector to the vertical position and secure.

9. Replace the battery for the InSpector unit with a fully charged battery on a daily (or shiftly) basis unless the battery had been installed on the InSpector unit AND the unit was powered ON via line supply for more than 24 hours (e.g. weekends).

10. Disconnect the (line voltage) power supply for the laptop computer and connect the power lead from the portable battery pack (located in the bottom of the electronics cabinet) to the laptop. Connect the cigarette lighter plug to the portable battery pack. Verify that connections associated with the battery pack are secure.

11. Disconnect the power cord associated with the electronics cabinet.

ATTACHMENT C

ISOCS SYSTEM STORAGE CONFIGURATION

This attachment is intended to serve as an informal, not all inclusive, checklist as reference when the system is being placed into storage (i.e. overnight). If any attributes are in question, contact a cognizant Radiological Engineer for guidance or disposition.

1. Disconnect the portable battery pack's line into the laptop computer and plug in the line voltage connection into the laptop.

2. Unplug the cigarette lighter plug from the portable battery pack

3. Plug in the line voltage supply associated with the electronics cabinet.

4. If the detectors are stored in the horizontal position, then the QC source may be set in place to facilitate source checking activities.

5. Storage facilities should be locked as necessary to ensure that sources are in a locked configuration and the electronics cabinet (i.e. laptop computer) is secured.