COPY

Use Of In-Situ Gamma Spectrum Analysis To Support Final Status Surveys For Compliance With License Termination Criteria

YA-REPT-00-011-05

Approvals	**(Print & Sign Name)**		
Preparer: Greg Astrauckas/	[signature]	Date:	6/1/05
Reviewer: Dann Smith, CHP/	[signature]	Date:	6/1/05
Approver (Cognizant Manager): G. M. Babineau/	[signature]	Date:	6/1/05

Rev. Original

Technical Report YA-REPT-00-011-05, Rev. Original

Use Of In-Situ Gamma Spectrum Analysis To Support Final Status Surveys For Compliance With License Termination Criteria

TABLE OF CONTENTS

1.0 Report 2

1.1 Introduction 2

1.2 Discussion 2

1.2.1 System Description 2
1.2.2 General Application 3
1.2.3 Procedures and Guidance Documents 4
1.2.4 Environmental Background 5
1.2.5 Quality Control 5
1.2.6 Data Collection 6
1.2.7 Efficiency Calibration 7
1.2.8 Data Management 7

1.3 Conclusions/Recommendations 8

Attachments

Attachment 1, ISOCS® Detector System Photos 9

1.0 REPORT

1.1 Introduction

The ISOCS® In-Situ Gamma Spectrum detector system manufactured by Canberra Industries is being employed to support the Final Status Surveys at Yankee Atomic's Yankee Rowe facility. This system uses an HPGe detector and specialized efficiency calibration software designed to perform in-situ gamma-spectroscopy assay of surfaces and materials. The ISOCS® system will primarily be employed to evaluate survey units for residual radioactivity concentrations in lieu of scan surveys. This technology is particularly beneficial where background influences are problematic due to the presence of stored spent fuel (ISFSI) or where natural radioactivity makes such evaluations difficult. Nuclide-specific evaluations enhance the ability to distinguish background radioactivity from radioactivity associated with the surface(s) being evaluated. This technical report is intended to outline the parameters and technical approach associated with implementing a MARSSIM-based Final Status Survey.

In addition to supporting the Final Status Survey (FSS), the ISOCS® system may be used to evaluate bulk materials or large surfaces for radionuclide concentrations in conjunction with characterization, investigation, and unconditional release surveys.

Validation of this technology is beyond the scope of this technical report. Canberra Industries has performed extensive testing and validation on both the MCNP-based detector characterization process and the ISOCS® calibration algorithms associated with the calibration software. The full MCNP method has been shown to be accurate to within 5% typically. ISOCS® results have been compared to both full MCNP and to 119 different radioactive calibration sources. In general, ISOCS® is accurate to within 4-5% at high energies and 7-11% at 1 standard deviation for low energies. Canberra's validation and verification document is available at the Yankee Rowe site. Additionally, the ISOCS® technology has been previously qualified in Yankee Atomic Technical Report YA-REPT-00-022-04, "Use Of Gamma Spectrum Analysis To Evaluate Bulk Materials For Compliance With License Termination Criteria."

1.2 Discussion

1.2.1 System Description

Two portable ISOCS® systems have been purchased from Canberra Industries. Each system employs a reverse-electrode HPGe detector rated at 50% efficiency (relative to a NaI detector). Resolution for these detectors is 2.2 keV @ 1332 keV.

For each system, the detector is mounted on a bracket designed to hold the detector / cryostat assembly and associated collimators. This bracket may be mounted in a wheeled cart or in a cage-like frame. Both the wheeled cart and frame permit the detector to be oriented (pointed) over a full range from a horizontal to vertical position. The frame's design allows the detector to be suspended above the ground for "viewing" fairly large areas (e.g. 300 sqft) in a single assay.

The InSpector electronic unit that drives the signal chain and the laptop computer that runs the acquisition software (Genie-2000) are mounted either in the frame or on the wheeled cart. These components are battery powered. Back-up power supplies (inverter or UPS) are available to support the duty cycle. A wireless network has been installed at the site so that the laptop computers used to run the systems can be completely controlled from any workstation at the facility. This configuration also enables the saving of data files directly to a centralized file server. Radio communication will be used to coordinate system operation.

Other ISOCS® detectors (e.g. standard electrode coaxial), if available, may be used to increase productivity. The key element regarding the use of other types of ISOCS® detectors is that specific efficiency calibrations will be developed to account for each detector's unique characteristics.

1.2.2 General Application

The primary application for the portable ISOCS® system is to evaluate FSS survey units for potential elevated activity ($DCGL_{emc}$). This evaluation is traditionally performed using hand-held instruments, however the background influence from the ISFSI or from natural terrestrial sources significantly impacts the sensitivity of these detectors.

The nuclide identification and background subtraction capability of the gamma spectrum technology allows surface or volumetric radioactivity to be confidently discerned from background influences. Moreover, the static attribute of the ISOCS® system and ability to adjust count times enables this technology to achieve MDA concentrations much lower and more defensible than a hand-held detector/rate meter being moved (i.e. scanning) over a surface.

To support the use of background subtraction, contributions from background sources are evaluated with the detector fully collimated and shielded, including the end of the detector. In addition to the collimators supplied with the detector system, which includes an end-cap shield, four ½" steel plates have been fabricated to further shield the detector face from photons which may be associated with the surface to be evaluated. Background spectra can then be collected and applied to the raw data spectra during post-acquisition analysis activities.

The detector's germane ability to distinguish natural activity from licensed radioactive material provides another distinct advantage over hand-held detectors. This attribute clearly minimizes investigative sampling while at the same time provides a real-time opportunity to efficiently mobilize remediation resources in a timely and focused manner. Reducing the collection of investigative samples has a positive cost-benefit with respect to the workload on the radiochemistry laboratory. Since the ISOCS® system is capable of providing concentration-based activity results, results of areas of elevated licensed activity can be included in the survey unit's statistical evaluation without the collection and analysis of additional material samples.

When the ISOCS® system is used to evaluate areas of elevated activity, the detector will generally be positioned (suspended) above the surface to be evaluated. Using the 90° collimators, the detector's distance from the surface to be evaluated is equal to the radius of the detector's field of view. For example, a position at 10 feet above the ground would cover approximately 300 ft^2. Placing the detector higher above the surface increases the effective radius of the area coverage. Because the effective volume of soil that is "viewed" decreases in thickness as the viewing radius increases, coverage is both surface and center weighted. The ISOCS efficiency calibration is designed to address such variations. Input parameters for the ISOCS calibration efficiencies can be selected so as to ensure that a 6-inch depth of soil is addressed in the analysis of the spectrum data.

1.2.3 Procedures And Guidance Documents

General use of the portable ISOCS® system is administrated by departmental implementing procedures which address the calibration and operation activities as well as analysis of the data. These procedures are listed as follows:

- DP-8869, "In-Situ (ISOCS) Gamma Spectrum Assay System Calibration Procedure."
- DP-8871, "Operation Of The Canberra Portable ISOCS Assay System."
- DP-8872, "ISOCS Post Acquisition Processing And Data Review."

Where the portable ISOCS® system is used for Final Status Surveys, the applicable Survey Plan will address specific configurations, radionuclide libraries, applicable $DCGL(s)_{emc}$, MDC requirements, and appropriate Data Quality Objectives.

A secondary application of the portable ISOCS® system is to assay surfaces or bulk materials for characterization or unconditional release evaluations. Use of the portable ISOCS® system for miscellaneous evaluations will be administrated under a specific guidance document (e.g. Sample Plan, etc.). Operating parameters such as physical configuration, efficiency calibrations, count times, and MDAs will be applied so as to meet the criteria in the associated controlling documents. Such documents will also address any unique technical issues associated with the application and may provide guidance beyond that of procedure AP-0052, "Radiation Protection Release of Materials, Equipment and Vehicles."

1.2.4 Environmental Background

If background subtraction is used, then an appropriate background spectra will need to be collected and saved. Count times for environmental backgrounds should approximate the count time associated with the assay. The collection of environmental background data will address the unique physical conditions, obstacles, and problems presented by the environment. Such attributes will be clearly documented. In areas where the background radioactivity is particularly problematic (e.g. ISFSI), the background will be characterized to the point of identifying gradient(s) such that background subtractions are either very appropriate or conservative.

1.2.5 Quality Control

Quality Control (QC) activities for the ISOCS® system ensure that the energy calibration is valid and detector resolution is within specifications. A QC file will be set up for each detector system to track, at a minimum, centroid position with respect to the assigned channel (4 channels per keV) and the FWHM. These attributes will be performed at or above 1332 keV. Additionally, the QC file may track activity calculations.

Quality Control counts will be performed on a shiftly basis prior to the system's use to verify that the system's energy calibration is valid. QC counts will employ a Na-22 / Eu-155 NIST traceable source. The Na-22 has a 1274.5 keV photon which will be the primary mechanism used for performance monitoring. If the energy calibration is found to be out of an acceptable tolerance (i.e. ±4 channels), then the amplifier gain shall be adjusted appropriately and a follow-up QC count will be performed. If the detector's resolution is found to be above the factory specification, then an evaluation shall be performed to determine if the detector should be removed from service and/or if the assay data is impacted. Such evaluations may include communications with the detector's manufacturer. Evaluations associated with QC counts shall be documented. Such documentation may be limited to a remark directly on the applicable QC report if the resolution does not render the system out of service. Otherwise the evaluation shall be also be separately documented so as to describe the impact of any assay results obtained since the last acceptable QC surveillance.

Where it is determined that background subtraction is necessary, a baseline QC background will be determined specific to that area or region before ISOCS® evaluations commence in that area. When background subtraction is required, a QC background surveillance will be performed before a set of measurements are made to verify the applicability of the background to be subtracted. Because of the background's variability across the site, several different QC background files will be required for various regions.

In addition to the routine QC counts, each assay report will be reviewed with respect to the K-40 to verify that the 1461 keV peak centroid is at channel 5843 (±4 channels). If it is noted that this centroid is beyond the 4 channel boundary, then the assay report will be further reviewed to ascertain if any nuclide misidentifications are associated with the report. If no misidentifications are observed, then the report will be annotated with the results of the review and the results will be deemed acceptable. This review both precludes the necessity for specific after-shift QC surveillances and provides a "real-time" QC surveillance on the system to identify significant performance degradation. It also will minimize investigation efforts associated with previously collected data should the system completely fail a before-use QC count.

1.2.6 Data Collection

Data collection to support FSS activities will be administered by a specific Survey Plan. Survey Plans may include an index of measurement locations with associated spectrum filenames to ensure that all the required measurements are made and results appropriately managed. Personnel specifically trained to operate the system will perform data collection activities.

Data collection activities will address environmental conditions that may impact soil moisture content. Logs shall be maintained so as to provide a mechanism to annotate such conditions to ensure that efficiency calibration files address the in-situ condition(s). In extreme cases (e.g. standing water, etc.) specific considerations will be made before measurements are made.

The actual height of the detector will be based on the Survey Unit's grid spacing, the surface area bounded by the fixed measurement locations, and the applicable area factor / $DCGL_{emc}$. Since the area coverage is related to the detector's field of view, the number of required measurements in a Survey Unit will be determined by the height of the detector above the surface and the degree of overlap between adjacent measurement locations. The degree of overlap will be addressed by the applicable Survey Plan since this overlap relates to how much of a survey unit may be missed by any cluster of adjacent measurements.

The resultant MDA will be evaluated with respect to the applicable $DCGLs_{emc}$; count times will be adjusted as necessary. The detector's distance (height) and measurement locations will be selected so as to achieve a 100% coverage of the survey unit. This objective will require overlapping the detector's field-of-view from one assay to another. Due to the dynamics between the sample density, the area associated with the $DCGL_{emc}$; and the count time necessary to achieve the required MDA, measurement locations may need to employ a grid system different from that used to support the fixed-point sampling. These factors will be addressed in the applicable Final Status Survey Plan.

1.2.7 Efficiency Calibration

The central feature of the portable ISOCS® technology is to support in-situ gamma spectroscopy via the application of mathematically derived efficiency calibrations. Due to the nature of the environment and surfaces being evaluated (assayed), input parameters for the ISOCS® efficiency calibrations will be reviewed on a case-by-case basis to ensure the applicability of the resultant efficiency. Material densities applied to efficiency calibrations will be documented. In practice, a single efficiency calibration file may be applied to the majority of the measurements.

The geometry most likely to be employed will be a circular plane. ISOCS® evaluations will generally be limited to a depth of 6 inches and assume uniformly distributed activity. Other geometries (e.g. exponential circular plane, rectangular plane, etc.) will be applied as the physical attributes of the area or surface being evaluated warrants. Radiological engineers assigned to develop efficiency calibrations have received training with respect to the ISOCS® software. Documentation of efficiency calibrations will qualify their application, including inherent limitations and bounding conditions.

1.2.8 Data Management

Data management will be implemented in various stages as follows:

- Raw Spectrum Data – The portable ISOCS® systems will be used to methodically collect raw spectrum data from one location to another. Analysis activities generally will not be applied to the spectrum as a function of the data acquisition process.

  An index for each Final Status Survey Plan will be developed to cross-reference in-situ assay locations with a file naming convention. A priori count times will be determined based on a preliminary evaluation of the parameters. Raw spectrum files will be written directly to a central file server over a wireless connection. At the completion of the collection of the spectrum, a peak analysis report will be printed so that the K-40 centroid can be reviewed and system performance can be verified.

- Data Analysis – After the spectrum's raw data is written to the file server, a qualified Radiological Engineer will copy the file to a working directory where subsequent data reduction activities will be applied. Note that the raw data file will remain unchanged by subsequent analysis activities. The data analysis process includes application of appropriate background, nuclide libraries, and efficiency calibrations. Data reviews verify assay results with respect to the applicable $DCGL_{emc}$ and MDCs achieved. Data reviews may include monitoring system performance utilizing K-40. When the data analysis is completed, the analyzed data file will be archived to a unique directory located on a central file server.

- Data Reporting – The results of data files whose reviews have been completed and are deemed to be acceptable will be uploaded to a central database for subsequent reporting and statistical analysis.

- Data Archiving – Routinely (daily) the centralized file server(s) where the raw and analyzed data files are maintained will be backed up to tape. A specific back-up plan, including disaster recovery, will be implemented to support this activity.

1.3 Conclusions/Recommendations

The portable ISOCS® HPGe gamma spectrum assay system is a cost-effective technology well-suited to replace the traditional scanning survey technique used to evaluate areas for elevated radioactivity. The static manner in which this system is operated eliminates many of the variables and limitations inherent to hand-held detector being moved over a surface as a technician listens to a rate meter's audible response for indications of elevated activity. Not only does the portable ISOCS® system provide a lower and more defensible detection sensitivity, it can be used in areas where background radiation levels would prohibit the use of NaI detectors for evaluating gross activity. Furthermore, the concentration-based results from the gamma spectrum assay system might be applied to the statistical evaluation of the survey unit.

Attachment 1
Portable ISOCS® Detector System Photos