Department of Energy
Ohio Field Office
Fernald Area Office
P. O. Box 538705
Cincinnati, Ohio 45253-8705
(513) 648-3155

MAY 19 1998

DOE-0785-98

Mr. James A. Saric, Remedial Project Manager
U.S. Environmental Protection Agency
Region V-SRF-5J
77 West Jackson Boulevard
Chicago, IL 60604-3590

Mr. Tom Schneider, Project Manager
Ohio Environmental Protection Agency
401 East 5th Street
Dayton, OH 45402-2911

Dear Mr. Saric and Mr. Schneider:

TRANSMITTAL OF ADDENDUM TO THE SITEWIDE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACTION QUALITY ASSURANCE PROJECT PLAN

The purpose of this letter is to transmit, for your review and approval, an addendum to the Sitewide Comprehensive Environmental Response, Compensation and Liability Action (CERCLA) Quality Assurance Project Plan (SCQ) entitled "*In-Situ* Gamma Spectrometry Addendum to the SCQ". As agreed upon between the U.S. Environmental Protection Agency (U.S. EPA) and the Department of Energy, Fernald Environmental Management Project (DOE-FEMP), this addendum will be reviewed and approved separately from the rest of the SCQ. The content of the addendum was discussed and agreed upon at the Real-Time Technical Workgroup Meeting on January 21, 1998, as well as in the monthly meeting (March 10, 1998) among the U.S. EPA, Ohio Environmental Protection Agency (OEPA), and DOE-FEMP. Accordingly, the *in-situ* gamma spectrometry addendum to the SCQ contains three elements: 1) the most recent revision (May 1, 1998) of the "Real Time Instrumentation Measurement Program Quality Assurance Plan (QA)", document number 20300-PL-002; 2) the most recent revision (March 18, 1998) of the procedure "*In-Situ* Gamma Spectrometry Quality Control (QC) Measurements", document number ADM-16; and 3) Appendix H to the SCQ which gives a brief overview of the *in-situ* gamma spectrometry program at the FEMP, shows a crosswalk between elements of the SCQ and elements of the *in-situ* gamma spectrometry QA plan, and presents the basic elements of the *in-situ* gamma spectrometry QC procedure.

The QA plan (20300-PL-002) and the QC procedure (ADM-16) have previously been submitted to the U.S. EPA for review, and the U.S. EPA comments have been incorporated in the most recent revisions of these two documents. Additionally, copies of the DOE-FEMP responses to U.S. EPA comments were given to the U.S. EPA at the March 25, 1998, Real Time Technical Workgroup Meeting. Finally, at that same March 25, 1998, meeting a draft version of Appendix H was passed out for discussion purposes.

If you have any questions or concerns regarding this document, please contact Robert Janke at (513) 648-3124.

Sincerely,

Johnny Reising

FEMP:RJJanke

Johnny W. Reising
Fernald Remedial Action
Project Manager

Enclosure: As Stated

cc w/enc:

G. Jablonowski, USEPA-V, 5HRE-8J
R. Beaumier, TPSS/DERR, OEPA-Columbus
T. Schneider, OEPA-Dayton (total of 3 copies)
K. Miller, DOE-EML
M. Davis, ANL (total of 3 copies)
F. Bell, ATSDR
M. Schupe, HSI GeoTrans
R. Vandegrift, ODOH
F. Barker, Tetra Tech
H. Ellis, Tetra Tech
S. Pastor, Tetra Tech
AR Coordinator, FDF, 78

cc w/o enc:

N. Hallein, EM-42, CLOV
A. Tanner, DOE-FEMP
D. Carr, FDF, 52-2
R. Heck, FDF, 2
S. Hinnefeld, FDF, 2
D. Jensen, FDF, 90
EDC, FDF, 52-7

FD-1000
15 May 1998

Fernald Environmental Management Project

IN-SITU GAMMA SPECTROMETRY ADDENDUM TO THE SITEWIDE CERCLA QUALITY ASSURANCE PROJECT PLAN

Prepared by

Fluor Daniel Fernald

for the

United States Department of Energy
Fernald Area Office

15 May 1998

1466

FD-1000
15 May 1998

Fernald Environmental Management Project

IN-SITU GAMMA SPECTROMETRY ADDENDUM TO THE SITEWIDE CERCLA QUALITY ASSURANCE PROJECT PLAN

Prepared by

Fluor Daniel Fernald

for the

United States Department of Energy
Fernald Area Office

15 May 1998

Appendix H

SCQ APPENDIX H

APPENDIX H

IN-SITU GAMMA SPECTROMETRY QA/QC PROGRAM

TABLE OF CONTENTS

H.1 Introduction 1

H.2 QA and QC Programs 2

H.3 Crosswalk Between the Real Time Instrumentation Measurement Program QA Plan and the SCQ 3

H.4 Elements of In-situ Gamma Spectrometry QC Measurements Procedure 3

APPENDIX H

IN-SITU GAMMA SPECTROMETRY QA/QC PROGRAM

H.1 INTRODUCTION

Two systems, the HPGe (high purity germanium detector) and the RTRAK (Radiation Tracking System), perform in-situ gamma spectrometry measurements to provide data on the concentrations of primary radiological contaminants of concern in surface (or exposed) soil at the FEMP.

The RTRAK system is a gamma-ray measurement system mounted on a tractor. The measurement system consists of a 4x4x16 (inches) NaI detector and associated electronics that provide high-speed pulse height analysis. This system allows the collection of a gamma energy spectrum, which can be analyzed to identify and quantify radioactive isotopes that may be present within the detector's viewing area. Gross gamma activity data may also be obtained, depending upon data usage requirements. The tractor is equipped with a global positioning system (GPS), operating in a real-time differential mode to provide location coordinates. Each energy spectrum is tagged with the location coordinates provided by the GPS. All energy and location data are stored on magnetic media by an on-board computer system. This information is used to accurately locate and subsequently map radiological data within the measurement area. A future version of the RTRAK, called RSS for Radiation Scanning System, will consist of a 4x4x16 (inches) NaI detector mounted on a three-wheeled, pushed vehicle to be used in areas that are inaccessible to the tractor-mounted system. This system will also contain the same type of GPS and electronics systems as the tractor version.

The HPGe system is also a gamma spectrometry system which is functionally identical to the RTRAK system. Gamma rays are detected by the HPGe crystal mounted on a tripod; but the detector output signals are processed by the same type of pulse amplification and pulse height analysis electronics employed in the RTRAK system. For each system, the output is a gamma ray spectrum which consists of a count of the number of gamma photons detected as a function of the photon energy. Peaks in these spectra occur at energies which are characteristic of the radionuclides present in the soil and other surroundings. The area under a given peak is directly proportional to the amount of that radionuclide present. Thus, both systems can identify which particular radionuclides are present in the soil as well as the amount of each that is present. One of the principal advantages of the HPGe system is its superior resolution. A high purity germanium detector will typically have a resolution (peak full width at half the maximum peak height) of 2 to 3 keV, whereas a NaI detector will have a resolution of 40 to 60 keV. In simple terms, the peaks in a NaI spectrum are much broader than those in a HPGe spectrum. This means that two or more characteristic gamma emissions which have energies that are less than about 60 keV apart will appear as one broad peak in a NaI spectrum, thereby making accurate quantification of each radionuclide very difficult. However, HPGe detectors can easily resolve gamma emissions which are only 2 or 3 keV apart. The superior resolution of the HPGe detector makes it possible to analyze more complex gamma ray spectra. This means that it is easier to identify situations in which there may be gamma rays of nearly identical energy interfering with one another. Further, one can also analyze materials with HPGe containing many different gamma emitters. Fortunately, the variety of radionuclides typically found in FEMP soils is small enough that accurate quantitative information may be obtained with both NaI and HPGe detectors.

The RTRAK and HPGe systems complement each other. The RTRAK is able to provide rapid, 100% coverage of an area. Its precision and detection limits are sufficient to determine the general patterns of contamination within a given area with respect to total uranium, thorium-232 and radium-226. Its data output is amenable to mapping and spatial averaging. The latter attribute makes RTRAK very useful for determining the average concentrations of soil contaminants. Finally, the RTRAK is ideal as a front-end survey tool to help focus and guide the use of HPGe. RTRAK measurements are made at ASL A data quality levels.

The high degree of resolution produced by the HPGe detectors permits the identification and quantification of specific isotopes. These characteristics enable the HPGe to provide high quality data that support the characterization and remediation of surface soils. With the detector lowered, the HPGe is able to focus on small areas and delineate hot spots that potentially exceed the waste acceptance criterion(WAC) or final remediation levels(FRLs). With the detector raised, the HPGe has a wide field of view that enables it to average data over a larger area, thereby maximizing data representativeness and minimizing heterogeneity effects associated with sampling discrete points. This characteristic permits the HPGe to be used in certification and pre-certification characterization activities.

H.2 QA AND QC PROGRAMS

The in-situ gamma spectrometry QA and QC programs at the FEMP are described in two formal documents. Plan number 20300-PL-002, entitled "Real Time Instrumentation Measurement Program Quality Assurance Plan," presents a comprehensive approach for the in-situ gamma spectrometry QA program. The QA plan delineates how quality will be maintained by implementing both the requirements of the Fluor Daniel Quality Assurance Program, RM-0012 (referred to hereafter as RM-0012), and the SCQ. The plan covers the elements needed for a program that produces environmental data which are accurate, precise, complete, representative, comparable, and legally defensible for the data's intended usage.

The QC procedure (ADM-16, entitled "In-Situ Gamma Spectrometry Quality Control Measurements") provides instruction for the collection and evaluation of specified QC measurements utilizing in-situ gamma spectrometry measurement equipment at the FEMP. Additionally, this procedure establishes a process for preparing and generating QC charts for in-situ gamma spectrometry, a chain of custody process for tracking computer data disk transfers, and a process for initiation of a nonconformance report when quality deficiencies are noted.

Both the QA plan and the QC procedure are stand-alone addenda to the SCQ. This allows both documents to be revised and reviewed independently of the remainder of the SCQ and vice versa. The intent is that when the in-situ gamma spectrometry program has matured such that revisions to the QA plan and QC procedure are infrequent, the necessity of having those two documents as stand-alone addenda will be obviated, and they will be merged into the SCQ proper.

H.3 CROSSWALK BETWEEN THE REAL TIME INSTRUMENTATION MEASUREMENT PROGRAM QA PLAN AND THE SCQ

Table 1 provides a correlation of specific program QA elements as they are found in the following documents: RM-0012, the Real Time Instrumentation Measurement Program QA Plan, and the SCQ. The elements of the Real Time Instrumentation Measurement Program (RTIMP) QA Plan are cross-walked to the corresponding elements of the other documents.

TABLE 1
CROSSWALK BETWEEN RTIMP QA PLAN, RM-0012 AND THE SCQ

ELEMENT	RTIMP QA Plan Section	RM-0012 Criterion	SCQ Section
Program	1.0	1	2.0, 12.4.6
Personnel Training/ Qualification	2.0	2	4.4.1
Quality Improvement	3.0	3	15
Documents and Records	4.0	4	4.4.2, 4.4.3, 7.3
Work Processes	5.0	5	9, 10, 11
Method Design	6.0	6	N/A
Procurement/Control of Materials and Services	7.0	7	3
Facilities/Equipment/ Calibration/Maintenance	8.0	8	8, 13
Management Assessment	9.0	9	16
Lab Assessments/Audits	10.0	10	12

H.4 ELEMENTS OF IN-SITU GAMMA SPECTROMETRY QC MEASUREMENTS PROCEDURE

This procedure applies to quality control activities conducted by FEMP personnel when carrying out in-situ gamma spectrometry measurements. QC activities covered by this procedure include:

1. RTRAK energy calibration
2. HPGe operational performance checks
   - HPGe pre-operational energy calibration
   - Field QC Station measurements
   - Field measurement interference check
   - HPGe post-operational energy check

3. Minimum detectable concentrations
4. Precision of duplicate HPGe measurements
5. HPGe performance criteria
6. HPGe detector counting efficiency determination
7. Control chart preparation and maintenance
8. Data review and approval
9. Initiating nonconformance reports

Attachment A in the QC procedure tabulates and summarizes all quality control parameters, their acceptance criteria, and the frequency with which they must be checked. This attachment is reproduced as Table 2.

TABLE 2
TABULATION OF QC CRITERIA AND REQUIREMENTS

RTRAK and RSS Detector QC Criteria and Requirements					
QC Element	**Nuclide**	**Gamma Energy**	**QC Criteria**	**Frequency**	**Control Chart**
Energy Calibration	Tl-208 Pb-212	2614.5 keV 238.6 keV	Channel 447 ± 2 Channel 40 ± 2	Days used prior to use	No
HPGe Detector QC Criteria and Requirements					
QC Element	**Nuclide**	**Gamma Energy**	**QC Criteria**	**Frequency**	**Control Chart**
Energy Calibration	Am-241 Cs-137 Co-60	59.5 keV 661.6 keV 1332.5 keV	Channel 158 ± 1 Channel 1763 ± 2 Channel 3553 ± 2	Days used prior to use	No
Detector Resolution	Co-60	1332.5	Measured mean value $\bar{x}$ $\pm 3\sigma$	Days used prior to use	Yes
Detector Counting Efficiency Check	Co-60	1332.5	Pre-determined check source value (decay corrected) $\bar{x}$ $\pm 3\sigma$	Days used prior to use	Yes

HPGe Field Measurements QC Criteria and Requirements				
QC Element	**Gamma Energy Nuclide or Basis**	**QC Acceptance Criteria**	**Frequency**	**Control Chart**
Field Measurement Interference	1460.8 keV	keV = 1460.8 FWHM = ± 3.0 keV or Channel = 3895.0 FWHM = ± 8 Channels	Each time measurement s are made	No

TABLE 2
(continued)

HPGe Field Measurements QC Criteria and Requirements				
QC Element	**Gamma Energy Nuclide or Basis**	**QC Acceptance Criteria**	**Frequency**	**Control Chart**
Field Control Station	Temperature Humidity Soil Moisture	No Criteria	Each day measurements are made	No
Minimum Detectable Concentration	Free Release Levels for Nuclides of Concern	for ASL D 95% UCL[1] < FRLs for ASL B 90% UCL[1] < FRLs	Quarterly	No
Measurement Accuracy (Total U, Th-232, Ra-226)	Compared to weighted average of physical samples	ASL D weighted average of physical sample ± 20% ASL B weighted average of physical sample ± 35%	Annually	No
Measurement Bias	Compared to weighted average of physical samples	Bias acceptable unless it produces errors resulting in accuracy being exceeded	Annually	No
Precision of Duplicates	At least one per 20 HPGe measurements	measured value >(5xMDC) then RPD $\leq \pm$20% measured value <(5xMDC) then RPD $\leq \pm$MDC	At least one per 20 HPGe measurements	No
Detector Counting Efficiency Determination	Determination of conversion (efficiency) factors	Initial conversion factor ± 10% for each gamma energy[2]	Annually	No

Notes: 1 The upper confidence level (UCL) for the MDC
2 Nuclide and Gamma Energies measured:

Cs-137	32.2
Eu-152	39.5
Am-241	59.5

000013

TABLE 2.
(continued)

Eu-152	121.8
Eu-152	244.7
Eu-152	344.3
Eu-152	411.1
Eu-152	444.0
Cs-137	661.6
Eu-152	778.9
Eu-152	964.0
Co-60	1173.7
Co-60	1332.5
Eu-152	1408.0

QA Plan

REAL TIME INSTRUMENTATION MEASUREMENT PROGRAM QUALITY ASSURANCE PLAN

20300-PL-002

FLUOR DANIEL FERNALD	REAL-TIME INSTRUMENTATION MEASUREMENT PROGRAM	PLAN NO: 20300-PL-002 EFFECTIVE DATE: 1-May-98 REV. NO: 1

PLAN APPROVAL

PLAN TITLE: Real Time Instrumentation Measurement Program Quality Assurance Plan

DOCUMENT NUMBER: 20300-PL-002

PREPARED BY: Tom Cox
SUBJECT EXPERT

APPROVAL: [signature] 4/30/98
Joan White
REAL TIME INSTRUMENTATION
MEASUREMENT PROGRAM MANAGER
DATE

APPROVAL: [signature] 4-30-98
Reinhard Friske
QUALITY ASSURANCE PROJECT LEAD
DATE

UNCONTROLLED

REVISION SUMMARY

Revision	Effective Date	Description of Revision
0	1/31/98	Initial. Plan requested by Joan White.
1	5/1/98	Incorporation of US EPA comments

TABLE OF CONTENTS

SECTION	TITLE	PAGE
Preface:	TITLE/APPROVAL PAGE	1
	REVISION SUMMARY	2
	TABLE OF CONTENTS	3
	LIST OF APPENDICES	3
	LIST OF ATTACHMENTS	4
	EXECUTIVE SUMMARY	5
1.0	CRITERION 1 - RTIMP PROGRAM	6
2.0	CRITERION 2 - RTIMP TRAINING AND QUALIFICATION	10
3.0	CRITERION 3 - QUALITY IMPROVEMENT	11
4.0	CRITERION 4 - DOCUMENTS AND RECORDS	16
5.0	CRITERION 5 - WORK PROCESSES	18
6.0	CRITERION 6 - METHOD DESIGN	22
7.0	CRITERION 7 - PROCUREMENT AND CONTROL OF MATERIALS, EQUIPMENT AND SERVICES	23
8.0	CRITERION 8 - EQUIPMENT CALIBRATION/MAINTENANCE	24
9.0	CRITERION 9 - MANAGEMENT ASSESSMENT	25
10.0	CRITERION 10 - ASSESSMENTS AND AUDITS	26

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX A -	DRIVERS/REFERENCES/INFORMATION SOURCES	27
APPENDIX B -	DEFINITIONS	30
APPENDIX C -	ACRONYMS	35
APPENDIX D -	CROSSWALK OF QA CRITERIA IN VARIOUS DRIVER DOCUMENTS	37
APPENDIX E -	RTIMP FUNCTIONAL ORGANIZATION CHART	38
APPENDIX F -	TABULATION OF QUALITY CONTROL CRITERIA AND REQUIREMENTS	39

LIST OF ATTACHMENTS

ATTACHMENTS	TITLE	PAGE
1	FIELD ELECTRONIC DATA TRANSFER FORM FS-F-5070	42
2	NONCONFORMANCE INFORMATION FORM FS-F-5080	44

EXECUTIVE SUMMARY

The Real Time Instrumentation Measurement Program Quality Assurance Plan (RTIMP QAP) presents a comprehensive approach for the in-situ gamma spectrometry quality assurance program. This plan identifies how Real Time Instrumentation Measurement Program (RTIMP) will maintain quality in its program by implementing the requirements of *Fluor Daniel Fernald Quality Assurance Program*, RM-0012 (referred to hereafter as RM-0012). The plan covers the elements needed for a RTIMP that produces environmental data which are accurate, precise, complete, representative, comparable, and legally defensible for the data's intended usage.

The plan involves traditional Quality Assurance (QA) elements to ensure "usable" results. These elements include the training and qualification of analysts, control of equipment and materials, use of standard methods development and validation of new methods, procurement, and control of materials and services. Other elements include standard operating procedures, nonconformances, document and records control, data management, assessments and audits. The elements of this plan are organized in a fashion that conforms to the criteria of RM-0012 as shown below.

MANAGEMENT	CRITERION	1 - PROGRAM
	CRITERION	2 - TRAINING AND QUALIFICATION
	CRITERION	3 - QUALITY IMPROVEMENT
	CRITERION	4 - DOCUMENTS AND RECORDS
PERFORMANCE	CRITERION	5 - WORK PROCESS
	CRITERION	6 - METHOD DESIGN
	CRITERION	7 - PROCUREMENT
	CRITERION	8 - EQUIPMENT CALIBRATION MAINTENANCE
ASSESSMENT	CRITERION	9 - MANAGEMENT ASSESSMENT
	CRITERION	10 - ASSESSMENTS AND AUDITS

The RTIMP mission includes responsibility for providing all on-site environmental in-situ gamma spectrometry data. More specifically, the RTIMP generates in-situ gamma soil analyses data to identify general patterns of contamination, to identify potential hot spots and/or waste acceptance criteria (WAC) exceedances, and to pre-certify areas for final remediation level (FRL) attainment. These analyses will enable Fluor Daniel Fernald (FDF) to meet operational and regulatory schedules and requirements during the remediation process.

To achieve data that meet required objectives, the following elements of a quality effort are being implemented:

- An internal Quality Control (QC) program that is managed by the Soils Characterization and Excavation Project (SCEP).
- Preparation and maintenance of control charts to demonstrate on-going system stability.
- An effective self-assessment program.
- An internal training program that meets the current needs of project personnel.
- A QA plan that takes into account the requirements of RM-0012, Department of Energy (DOE) and United States Environmental Protection Agency (USEPA) approved *Sitewide CERCLA Quality Assurance Project Plan* (SCQ), and the stated objectives.
- In conjunction with Remediation Data Management, an effective information and data management system.

In the sections that follow, the ten criteria of RM-0012 are invoked as required by Quality Level Four for the activity (refer to *Identifying Quality Assurance Program Requirements for Quality Levels,* QA-0003). The ten criteria established by RM-0012 and the application of appropriate resources based on the Quality Level ensure a fully functioning Quality Management System is in place to implement the QA requirements for the project. All 10 criteria of RM-0012 may be applied to RTIMP on a graded approach. The sections that follow shall recognize only the requirements of each criterion of RM-0012 that have been identified as applicable through the graded approach related in RM-0012.

Lastly, a quality control procedure implements major portions of the RTIMP. The QC procedure (ADM-16, entitled "In-Situ Gamma Spectrometry Quality Control Measurements") provides instruction for the collection and evaluation of specified QC measurements utilizing in-situ gamma spectrometry measurement equipment at the FEMP. Additionally, this procedure establishes a process for preparing and generating QC charts for in-situ gamma spectrometry, a chain of custody process for tracking computer data disk transfers, and a process for initiation of a nonconformance report when quality deficiencies are noted.

1.0 CRITERION 1 - RTIMP PROGRAM

1.1 Quality Assurance Management Program Drivers

1.1.1 Fluor Daniel Fernald Quality Assurance Policy

The policy of FDF is to provide products, processes, and services which meet the needs of the customer; and to perform required functions in a reliable and safe manner while improving the environment. FDF will continuously improve the quality of its products, processes, and services by doing the right thing in the right way, the first time, safely, and at least cost.

1.1.2 FDF Quality Assurance Program

RM-0012 describes the policies and practices which constitute the FDF quality assurance program for achieving or exceeding the required quality levels for activities associated with the Fernald Environmental Management Project (FEMP).

RM-0012 establishes the QA requirements for FDF and all other contractor and subcontractor organizations performing work at the FEMP. The QAP identifies and describes the essential elements of the QA activities that apply to the broad spectrum of work performed by FDF and its contractors and subcontractors for all activities associated with the FEMP.

1.1.3 Sitewide CERCLA Quality Assurance Project Plan

RTIMP teams conducting environmental sampling and analysis shall comply with quality assurance and quality control requirements specified in *Sitewide CERCLA Quality Assurance Project Plan* (SCQ), FD-1000, as approved by the DOE and the USEPA.

The SCQ is a working level document providing the standard QC protocols for laboratory analytical activities. The SCQ also describes the responsibilities of the various organizations involved in environmental remediation of the FEMP.

1.1.4 SCEP Quality Assurance Program

Soils Characterization and Excavation Project Project Execution Plan, 20300-PEP-0001 (SCEP PEP) identifies how SCEP will comply with the requirements of RM-0012 and which QA documents are applicable to the project.

Sitewide Excavation Plan, 2500-WP-0028 (SEP) outlines the responsibilities, processes, and actions to be taken by programs supporting the SEP to maintain the quality of the project and meet the requirements of RM-0012. Included in Appendix E of the SEP is information on processes for assuring quality for both the general program and for real time measurements. Appendix H of the SEP addresses expectation levels for real-time gamma instrumentation.

1.2 <u>Real Time Instrumentation Measurement Program Quality Assurance Plan</u>

The RTIMP QAP presents a comprehensive description of the quality assurance and quality control programs within the RTIMP. The plan covers the elements needed to assure that the RTIMP produces in-situ gamma spectrometry data that are accurate, precise, complete, representative and comparable for their intended usage. Therefore, data so generated will be scientifically valid and legally defensible.

1.3 Ethics Policy

Improper manipulation of information, falsification of data, or deviations from ethical scientific principles are prohibited in accordance with DOE Orders 2030.4B on Fraud, Waste and Abuse. FDF endorses these policies.

1.4 Real Time Instrumentation Measurement Program Organization

See the program organization in Appendix E.

1.5 Responsibilities

1.5.1 The Real Time Instrumentation Measurement Program Manager shall be responsible for:

- Ensuring the quality of product and program,
- Establishing training program requirements,
- Establishing a self assessment program,
- Initiating root cause analysis,
- Initiating action on and responding to non-conformance reports,
- Ensuring corrective actions are implemented,
- Establishing a quality control program,
- Establishing a preventive maintenance program, and
- Establishing an instrument calibration program.

1.5.2 The Procedure/Training Coordinator shall be responsible for:

- Implementing training program requirements,
- Coordinating training on all program procedures,
- Maintaining the training matrix,
- Performing training and procedure self assessments,
- Participating in root cause analysis investigation,
- Revising all program procedures, and
- Coordinating training to reflect procedure revision and corrective actions.

1.5.3 The Data Management Supervisor shall be responsible for:

- Ensuring the quality control program is implemented,
- Evaluating data and trending information,
- Identifying corrective action for nonconformance,
- Leading root cause analysis investigation,
- Performing data quality assessments,
- Reviewing of control charts,
- Reviewing of measurement results,
- Reviewing of training program,
- Verifying that maintenance is performed to program requirements, and
- Verifying that instruments are calibrated to program requirements.

1.5.4 The Field Supervisor shall be responsible for:

- Ensuring the quality of data and overall field program,
- Ensuring training program compliance,
- Ensuring work is performed in accordance with procedures,
- Ensuring only trained personnel perform the work,
- Ensuring procedure compliance,
- Implementing corrective actions,
- Implementing field quality control program,
- Implementing preventive maintenance program requirements,
- Implementing instrument calibration program,
- Performing self assessments for field data acquisition,
- Participating in root cause analysis investigations,
- Reviewing control charts, and
- Reviewing measurement results.

1.5.5 Technical Personnel shall be responsible for:

- Creating and verifying accuracy of control charts,
- Ensuring the quality of data/product,
- Maintaining procedure compliance,
- Participating in root cause analysis investigation,
- Performing field measurements in accordance with procedures,
- Performing field activities in accordance with corrective actions,
- Performing field self-assessments,
- Performing instrumentation calibrations in accordance with instrument calibration program requirements,
- Performing quality control measurements, and
- Performing maintenance in accordance with preventive maintenance program requirements.

1.5.6 Soil and Water Projects Quality Assurance/Quality Control (S&WP QA/QC) organization shall be responsible for:

- Evaluating and trending nonconformances,
- Initiating root cause analysis investigation,
- Performing independent quality assurance and quality control assessments,
- Reviewing of control charts,
- Reviewing of training program,
- Verifying that corrective actions are implemented,
- Verifying that maintenance is performed to program requirements,
- Verifying that instruments are calibrated to program requirements, and
- Verifying the quality control program is implemented.

1.6 Procedure ADM-16, *In-Situ Gamma Spectrometry Quality Control Measurements*

Procedure ADM-16 provides instruction for the collection and evaluation of specified QC measurements on in-situ gamma spectrometry equipment. The procedure also establishes processes for generating QC charts, tracking data disks and initiation of nonconformance reports. QC measurements exceeding acceptance criteria given in ADM-16 and nonconformances are corrected in accordance with the requirements specified in the Real Time Instrumentation Measurement Program Quality Assurance Plan.

2.0 CRITERION 2 -RTIMP Training and Qualification

2.1 Personnel Training and Qualification

Because the education, experience, and training of personnel directly affect the generation of scientifically valid, precise, accurate, defensible, and comparable data; the technical competence of personnel is a crucial component of data acquisition.

Position Descriptions, as specified by FDF Human Resources Department, define the levels of education and experience that are mandatory for each position in the Real Time Instrumentation Measurement Program. Candidates shall meet or exceed the listed requirements. Copies of personnel files are maintained by the Real Time Instrumentation Measurement Program Manager.

Training will consist of study and familiarization with relevant site documents, classroom presentations and briefings on current approved procedures, briefings on Material Safety Data Sheets (MSDS), on-the-job-training (OJT), and FDF supplied site related training. Vendor conducted classes may also be provided.

Specific training and qualification for gamma spectrometry and field operations shall be conducted by a qualified trainer and documented. The trainer shall be responsible for: 1) teaching the trainee how to perform the task required by the procedure; 2) ensuring that the trainee is capable of performing all of the required tasks safely and correctly; 3) ensuring the trainee is familiar with applicable RTIMP QA/QC requirements; 4) ensuring the trainee has an understanding of concepts and practices of in-situ gamma spectrometry and is capable of independently generating valid data; and 5) providing input on the qualification of the trainee.

2.2 Retraining

Procedure training for technical personnel shall be provided whenever there is a procedure change or revision. Retraining shall be provided for personnel performing measurements on a routine basis at least once every two years. If technical personnel do not perform measurements over a twelve month period of time, retraining is required prior to performing work. Retraining shall consist of reviewing applicable project procedure(s) and completing practical examination(s) on all measurement techniques.

2.3 Documentation

Training shall be documented in accordance with SCQ and site procedural requirements. Original documentation of training shall be maintained by Training Records. The Procedure/Training Coordinator will have copies of the documentation. Records shall be made available for all quality assessments and audits both internally and externally.

3.0 CRITERION 3 - QUALITY IMPROVEMENT

3.1 Method QC Requirements

The measurement quality control acceptance criteria shall follow criteria specified in plans and individual procedures controlling the operation of instruments. These documents shall meet the minimum control acceptance criterion for ASL A, ASL B, ASL D, and ASL E. Requirements for ASL B and ASL D are identified in Appendix F. These criterion were developed from results published in the following documents:

- *Comparability of In-Situ Gamma Spectrometry and Laboratory Data*, 20701-RP-0001, FEMP, July, 1997;
- *Comparability of In-Situ Gamma Spectrometry and Laboratory Measurements of Radon-226*, Addendum to 20701-RP-0001, October, 1997;
- *Comparability of Total Uranium Data as Measured by In-Situ Gamma Spectrometry and Four Laboratory Methods*, Addendum to 20701-RP-0001, September, 1997;
- *Effect of Environmental Variables Upon In-Situ Gamma Spectrometry Data*, Addendum to 20701-RP-0001, December, 1997;
- *RTRAK Applicability Study*, 20701-R.-002, FEMP, July, 1997; and
- *RTRAK Applicability Measurements in Locations of Elevated Radionuclide Concentrations*, Addendum to 20701-R.-002, FEMP, September, 1997.

3.2 Nonconformance Program

3.2.1 During the calibration and measurement process, the technician or other technical personnel shall check for suspect data and/or equipment malfunction. QC measurements shall be analyzed and the results assessed to identify outliers, trends, and shifts. Internal and external evaluations of performance such as numbers and types of nonconformances or failures, failure rates and changes or increases in maintenance requirements shall be conducted. Personnel identifying any nonconforming condition or equipment shall notify Field Supervisor or S&WP QA/QC organization to begin Nonconformance reporting process. Nonconformance will be identified and processed in accordance with *FDF Nonconformance Identification and Tracking System*, QA-0001.

3.2.2 A nonconformance is a deficiency in operation, documentation, procedures; a departure from a requirement that renders the quality of an item, datum, or activity unacceptable or indeterminate; or a condition in which characteristics of an item or service do not conform to prescribed limits as follows:

- Failure to fulfill the requirements of a project-specific plan (PSP) or approved procedural requirement,
- Failure of a procedure to yield the intended results,
- Failure to meet QC Criteria,
- Unavailability or inadequacy of a required document, and
- Unapproved variation from the PSP or approved procedure.

Note *Variances defined in section 3.4 are not deviations.*

3.2.3 Deviations which do NOT require a Nonconformance Report (NCR) but should be noted in the field log or field worksheet include (but are not limited to) the following:

- Log book or field worksheet entry errors which are correctable,
- Need for measurements to ensure 100% coverage of an area,
- Measurements re-done because of a location error on the original measurement,
- Re-calibrations and re-measurements required per individual procedures to meet quality control specifications, and
- Trends or shifts in control charts which do not exceed control limits.

3.2.4 Deficiencies which require initiation of Nonconformance Report include (but are not limited to) the following:

- Data quality conditions which result in deviations or modifications to operating procedures,
- Factors which detract from data defensibility, and
- Inability to meet method quality control specifications.

3.2.5 When nonconforming conditions or equipment are detected, data collection and processing by the involved equipment or system shall cease. Personnel detecting nonconforming condition or equipment must notify Field Supervisor or S&WP QA/QC organization and provide the following information:

- Nonconforming item,
- Measurements involved in the nonconformance,
- Date and time nonconformance discovered, and
- Location where nonconformance occurred.

3.2.6 *Nonconformance Information Form*, FS-F-5080 (see Attachment 2) may be completed and attached to NCR to identify the "Requirement" and "Nonconformance" for the NCR.

3.2.7 Corrective actions identified through root cause analysis, self assessment or by external audits are implemented by the Field Supervisor. Corrective action consists of permanently eliminating the problem or bringing the system back into control. Corrective action may include (but is not limited to) any of the following:

- Correction of calculations,
- Establishing or improving guidelines,
- Instrument cleaning,
- Method development,
- Obtaining new calibration and/or characterization standards,
- Part replacement,
- Procedure development,
- Re-calibration,
- Repairs, or
- Training.

3.2.8 Personnel assigned to implement corrective actions must document the completion of steps taken to correct the nonconformance.

3.2.9 Nonconformance correction shall be verified by performing quality control measurements and obtaining accurate results as applicable. Management review will be used to verify correction of nonconformances.

3.2.10 If an instrument or equipment cannot be brought back to specifications due to the extent of damage or economic limitations, the instrument or equipment shall be disposed of in accordance with standard practices.

3.2.11 When nonconforming conditions are detected, measurements and data collection must stop. When causes for the nonconformance have been determined and corrective action initiated; measurements may continue, if approved by Real Time Instrumentation Measurement Program Manger or designee. If not approved, measurements will not occur until corrective action is completed.

3.3 Root Cause Analysis

3.3.1 If S&WP QA/QC organization personnel determine that the NCR is a Concern, root cause analysis will be conducted to determine the cause of the nonconformance. The RTIMP management will complete a root cause investigation in accordance with procedure EM-0027.

3.3.2 In some cases, detection and root cause are simultaneous because the cause is obvious. In occurrences where the cause is obscure, extensive root cause investigation may be required. Identification of root cause may include (but is not limited to) investigation of the following:

- Algorithms,
- Geometry of the soil surface measured,
- Maintenance of equipment,
- Measurements (for potential re-measurements), and
- Weather conditions or other environmental factors.

3.3.3 Equipment or material identified as the cause of a nonconformance shall be tagged or otherwise identified to prevent use.

3.4 Variances

3.4.1 A variance is a pre-approved action performed in a manner different from that specified by the requirements of an approved procedure or project specific plan (PSP). The impact on the quality of work performed is evaluated, documented, and approved by the appropriate manager and the designated FEMP QA organization prior to implementation. Variances are not nonconformances. Variances should never have a negative impact on the quality of work.

3.4.2 Variances are a means of accomplishing timely changes in operating procedures or PSPs. The variance is a one-time change approved only for the specific activity described in the variance documentation and does not result in a revision to project-specific documents. If the same variance for a specific procedure becomes necessary on a frequent basis, this may indicate that the procedure requires revision. Multiple variances to a PSP may be acceptable, depending upon the circumstances and the nature of the variances.

3.5 Using Quality Control Measures

The use of quality control measures is guided by the characteristics and requirements of the measurement methodology as well as by program/regulatory needs. The choice of which quality control measures to use, how to use them, and how frequently are covered in individual procedures and in the QC procedure.

3.5.1 Radioactive calibration and check source QC measurements are made prior to detector operations. All sources must be verified before use. Certificate of Analysis will be checked to verify source identification, activity, and traceability to National Institute of Standards and Technology (NIST) standard. On-site source verification may be completed by Analytical Laboratory Services (ALS). QC sources shall be labeled and the label shall contain activity, identification number, traceability, and other pertinent information for individual sources.

The NIST and a variety of commercial companies supply radioactive sources at variable levels of activity and degrees of purity. Certificates of Analysis for these sources are maintained in the RTIMP project files. The procurement requirements for the evaluation of commercial suppliers are in Section 7 of this procedure.

3.5.2 RTIMP field QC measurements are made at designated times and field locations over a period of time. The performance of these measurements provides a means of assessing overall system precision, the effect of environmental variables, and the consistency of measured data.

3.5.3 Various QC indicators are plotted on control charts to assess long term data quality. The long term quality of parameters such as accuracy and precision of measurements are monitored. Quality control data shall be developed to cover operational needs, for oversight of ongoing programs, and for performance evaluations. The individual control charts shall be examined to identify outliers, trends, and shifts.

3.5.4 Quality Control reporting requirements include but are not limited to the daily (before each use) field worksheets completed by technical personnel. Occasional reports are generated to identify outlying results trends that are indicative of bias, shifts, or other quality problems and shall be reported to the Real Time Instrumentation Measurement Program Manager and Data Management Supervisor.

3.5.5 Control charts shall be prepared to support measurement results. The control charts will be used to trend internal control data and to evaluate control limits on a periodic basis and shall be reported to the Real Time Instrumentation Measurement Program Manager and Data Management Supervisor.

3.5.6 The Data Management Supervisor shall use statistical evaluation of quality control measurement results, as needed, to assess the quality of data.

3.5.7 Reports will document the performance level (quality measures) achieved as well as any standards. Reports will be specific enough and quantitative enough so that compliance or noncompliance with a standard or requirement can be objectively determined and quantitatively measured.

4.0 CRITERION 4 - DOCUMENTS AND RECORDS

4.1 Documents and Records

Identifying, retaining, storing, reproducing, retrieving, and disposing of FDF records shall be accomplished in accordance with the requirements of *Records Management*, MS-0002 and the SCQ. The SCQ describes the requirements and processes related to the control of documents and records generated by environmental sampling and analysis. These documents implement Criterion 4, "Documents and Records" of RM-0012. The principal documents and records created, controlled, or utilized by the project are:

- Backup electronic copies of computer files and measurement spectrum,
- Calibration curves,
- Counting reports,
- Electronic database records,
- Equipment certification information and manuals,
- Field Activity Logs,
- Field electronic data disks,
- Field worksheets,
- Instrument logs,
- Method development notes, worksheets, and data files,
- Nuclide peak reports,
- Procedures,
- Project Specific Plans,
- QC control charts, and
- Quality Assurance Plan.

4.2 Document Control

4.2.1 Documents that direct in-situ measurements (i.e., plans, PSPs, and procedures) are issued through and controlled by Engineering/Construction Document Control (ECDC).

4.2.2 Only approved, controlled and current revisions of in-situ measurement documents will be used. Superseded or canceled documents will be disposed of as directed by ECDC.

4.2.3 Field worksheets shall be reviewed for completeness, accuracy, and legibility on each day that measurements are made by the Field Supervisor or an individual designated by the Field Supervisor.

4.2.4 Instrument logs shall be maintained with the instrument until log is complete. Completed logs shall be transferred in accordance with SCQ requirements.

4.3 Record Control

4.3.1 Control over current project records shall be accomplished using filing system identified by record management function in the Soil Characterization and Excavation Project.

4.3.2 The Field Supervisor or designee shall ensure that the measurement raw data is stored and/or transferred in accordance with the procedure directing measurement system being utilized.

4.3.3 Hard copy files for the project are transferred to Sample and Data Management within the time frame specified in PSP or procedure directing measurement system being utilized.

4.4 Record Storage Requirements

4.4.1 All records shall be stored in lockable cabinets. If a sprinkler system is not available/present or is inoperable in the area of file cabinets, then fire-proof cabinets must be used to store records.

4.4.2 Hard copy records shall be legible, accurate, and complete; indexed to permit quick and accurate identification of items or activities to which they apply.

4.4.3 Each diskette, tape, or other data medium shall be identified by a unique identifier. A hard-copy index of content shall be maintained in the project files.

4.5 Data and Record Storage

4.5.1 Quality control reports shall be filed and maintained as RTIMP permanent records.

4.5.2 Equipment information and calibration/characterization records shall be filed and maintained as RTIMP permanent records.

4.5.3 Raw data and electronic data files shall be maintained in project computer files for project review and usage.

4.5.4 Copies of worksheets shall be maintained in project files for project review and usage.

4.5.5 Records of verification of algorithms shall be maintained in the RTIMP permanent record.

4.6 Archiving

4.6.1 Data disk may be archived to project file storage to preserve data for later use if deemed necessary by Field Supervisor.

5.0 CRITERION 5 - WORK PROCESSES

5.1 Field Measurements

The tasks required to prepare for and make field measurements include the following:

- Conducting pre-measurement briefings to discuss the work scope, schedule and any hazards or safety precautions,
- Checking the condition of detectors, counting systems, cables and vehicles (if applicable),
- Filling detectors with liquid nitrogen if required,
- Exchanging or charging batteries in the multi-channel analyzer's, laptop computers and GPS units,
- Assembling the measurement systems,
- Selecting and accessing the appropriate software programs,
- Performing pre-measurement counting system calibrations,
- Performing QA/QC measurements,
- Finding field measurement location and obtaining measurements in accordance with the PSP,
- Performing post-measurement counting system calibration checks,
- Shutdown and storage of counting systems and equipment, and
- Document activities conducted.

5.2 Documentation

5.2.1 Documentation of all stages of in-situ measurements provides a record for accountability, traceability, and legal defensibility. Documents established and utilized (per DOE Order 1324.2A) may include any of the following:

- Calibration data,
- Counting reports,
- Electronic database records,
- Field Activity Logs,
- Field electronic data disks,
- Field worksheets,
- Method development notes, worksheets and data files,
- Radionuclide peak reports, and
- Procedures,
- Project Specific Plans,
- QC control charts, and
- Quality Assurance Plan.

NOTE *Erasures, scribble-outs, "white out" fluid, and other correction methods that eradicate or cover the original data shall not be used.*

5.2.2 RTIMP technical personnel shall legibly and accurately record data and information, including unusual circumstances, to ensure that results are traceable and to enable measurement conditions to be reviewed. Changes to any entry shall be accomplished by drawing a single line through the error (leaving original entry legible), entering the correct information above the original, and initialing and dating the change.

5.2.3 When a change is major, a brief statement explaining why the data are being altered shall be entered on the record being changed. Major changes must be approved by the next higher level of management.

5.2.4 Log pages shall be sequentially numbered. Log entries shall be recorded in chronological order per the requirements of the SCQ. Name of individual making entries on field logs and field worksheets shall be printed on page; followed by a signature and badge number.

5.2.5 Field worksheets shall be completed in accordance with the applicable procedure and reviewed by the Field Supervisor or designee. Review will be documented by placing signature and date on each page reviewed.

5.2.6 Following measurements in the field, the electronic data disks containing the measurement data will be transferred from technical personnel to the Field Supervisor or Data Management Supervisor. "Data disk" custody shall be documented on *Field Electronic Data Transfer Log*, FS-F-5070 (see Attachment 1). Custody will be maintained for disk until data on the disk has been reviewed, data copied to RTIMP temporary database on Network, data copied to permanent electronic database, and the data deleted from the disk.

Each transfer in custody shall be noted on *Field Electronic Data Transfer Log*, FS-F-5070 in accordance with the completion instructions. Accomplishment of data entry to RTIMP temporary database, data entry to SED, and data deletion from disk will be noted on *Field Electronic Data Transfer Log*, FS-F-5070 in accordance with the completion instructions.

5.3 Procedures

5.3.1 The RTIMP shall have written, authorized procedures detailing the operations and work performed. Procedures shall be developed, reviewed, approved, and controlled in accordance with the requirement of *FDF Site Procedure System*, MS-1001. These procedures encompass administrative, operational, and measurement aspects of the program. Procedures identify source documents published by agencies such as DOE, EPA, and the American Society for Testing and Materials (ASTM). Procedures are controlled documents and accessible to personnel in the work area. A file of all revisions of procedures is maintained. Procedures are reviewed periodically per FEMP site requirements. Revisions are made to address changes in data quality requirements, technology and equipment changes, and/or regulatory requirements.

5.3.2 Procedures that are prepared for the performance of in-situ measurements shall be an explicit written description that includes but is not limited to the following, as applicable:

- Accuracy, precision and other required QC parameters,
- A unique identification number for the procedure,
- Basis for the method or procedure;
- Data review process,
- Equations to calculate various parameters,
- Instructions for operation of equipment and completion of measurement,
- Instructions for storage of hard copy and magnetic media data,
- Specific instructions for the technical personnel performing the task,
- Safety precautions, and
- User instructions.

5.3.3 Procedures shall be prepared per the requirements of the SCEP and *Procedure Development and Training*, ADM-01. Procedures are formally reviewed by field personnel, technical experts, and the appropriate managers. After comment resolution, procedures are approved and issued as controlled documents for use.

5.3.4 Revisions to procedures and/or PSPs shall be approved and issued prior to implementation of changes in the field (e.g., retraining, briefing, work, etc.).

5.4 Data Reduction and Management

5.4.1 Equations, algorithms, and calculations used to reduce data must be documented in approved procedure(s). Any changes to equations, algorithms, or calculations must be submitted to the same review as originals; and procedure changes approved prior to use.

5.4.2 The flow of data for acquisition in the field to final archival is to be documented in operating procedure(s). Procedure(s) include personnel responsibilities and accountabilities.

5.5 Software

5.5.1 RTIMP utilizes software to collect and analyze measurement data. The titles and functions of the software used are:

- MAESTRO - a commercial multi-channel analysis software intended for the analysis of gamma spectra. The MAESTRO program permits the collection, display, manipulation and transfer of gamma spectra. Raw electronic data is stored in a format that can be read and graphically displayed by MAESTRO. MAESTRO is used for the collection, display and storage of both sodium iodide (NaI) and germanium (HPGe) detector generated output.

- MULTIACQ - a commercial software for use with the FEMP RTRAK and RSS counting systems. MULTIACQ software serves two functions. The first function is the starting and stopping of count acquisition for the multiple spectra that constitutes an RTRAK or RSS "run". The second function is to incorporate the signal from a global positioning system (GPS) into the spectra so that the exact location of every spectrum in a run can be determined.

- EGAS - a consultant supplied software. Sub-routines within EGAS are used to perform detector characterizations (efficiency calibration) and in conjunction with MAESTRO to produce peak reports containing quantified nuclide data.

5.5.2 A software verification process will be developed for all software used in the collection of data consistent with the requirements of Change In Operations (CIO) *Implementation of the Computer Software Management Plan and Software Validation and Verification for Sample and Data Management,* CIO No. EC97-0008. Verification and validation will be completed and documented for all software developed, modified, or maintained for the project to meet the requirements of the SCQ for a standard, structured software methodology for verification and validation.

5.5.3 A spreadsheet, such as Microsoft EXCEL, is used to record and graph quality control data to support QC functions.

5.5.4 The coordinated use of the software permits the following functions:

- Automated collection of multiple spectra during RTRAK and RSS runs,
- Detector energy and efficiency calibration,
- Quantification of measurement results,
- Quality Control,
- Reporting,
- Spectrum collection,
- Spectrum identification, and
- Transfer and storage of electronic spectra files.

5.6 Verification of algorithms.

5.6.1 The validity of algorithms and mathematical methods must be demonstrated using hand calculations or alternate software before any sample results are reported using the algorithm.

5.6.2 If the software or algorithm is changed or updated, it must be re-verified.

5.6.3 Verification of software or algorithm will be documented in accordance with *Implementation of the Computer Management Plan and Software Verification for Site Data Management,* CIO No. EC-970008.

6.0 CRITERION 6 - METHOD DESIGN

6.1 Method Verification

New or revised measurement methods shall be verified before technical personnel use the method to perform official measurements. (In addition, each technical person shall be trained in the performance of the method prior to using the method for measurements.)

6.1.1 Verification of new methods requires that sufficient measurements be performed to establish and document that the method meets all required performance parameters.

6.1.2 Verification of new methods requires the following QC elements to be addressed:

- Accuracy,
- Calibration
- Comparability with existing approved methods, if applicable,
- Detection limit, and
- Precision.

6.1.3 QC acceptance limits must be determined for inclusion of the method in the SCQ. If the proposed method has been promulgated by EPA, then those acceptance limits may be utilized.

6.1.4 Verification of non-routine, non-standard measurements, is feasible only to the extent of documenting that the methodology performed according to expectations.

6.1.5 Verification reports, results, and conclusions are reviewed by the Data Management Supervisor and are stored with the data files. If the data evaluation demonstrates that the method can perform the required measurements, and achieve required detection limits, a formal method shall be written and approved.

6.2 Unverified Methods

In unusual circumstances, projects or customers may request data from a method that has not been verified. The request may be granted if the following conditions are met:

- The Real Time Instrumentation Measurement Program Manager approves the request for data.
- ASL E Quality Control requirements are established in a DQO.
- The requester is notified, in writing, that the data is provisional because the method is not verified.
- The request, approval, and notification are recorded in the data record.
- The Data Management Supervisor and S&WP QA/QC organization must concur with the non-verified method.

6.3 Limit Designs

Limit Designs is defined as establishing limits on equipment or methods where no prior limits have been set. The Data Management Supervisor shall evaluate all available data on the equipment or methods. The data shall be evaluated and documented and made available for audits, surveillances, and assessments. The raw data, statistics, and calculations shall be documented in the design data package. When available vendor recommendations shall be considered.

7.0 CRITERION 7 - PROCUREMENT AND CONTROL OF MATERIALS, EQUIPMENT AND SERVICES

7.1 Required Materials, Equipment and Services

7.1.1 Materials, equipment and services specified by approved procedures shall be used to perform those tasks. All material shall be labeled, handled, and stored in accordance with procedures and materials safety data sheets (MSDS) if applicable. The use of purchased materials must be in accordance with the following conditions:

- Expiration dates of standards shall not be exceeded.
- Outdated and/or contaminated materials shall be disposed of in accordance with the applicable procedures.
- Prescribed practices shall be strictly adhered to in order to preserve material integrity.

7.2 Procurement

NOTE *Availability of services, complete service manuals (including information on preventative maintenance) and spare parts kits shall be important criteria when requesting services or selecting equipment.*

7.2.1 The Field Supervisor and Data Management Supervisor shall determine the need for materials, equipment or services, prepare a purchase request, and submit the request to the Real Time Instrumentation Program Manager and S&WP QA/QC organization for review, approval and forwarding to procurement.

7.3 Radioactive Sources

Source materials shall be purchased from the National Institute of Standards and Technology, the US Environmental Protection Agency (EPA), or other reliable documented source suppliers and must be NIST traceable.

7.4 Acceptance Criteria

7.4.1 Before an incoming shipment is accepted, S&WP QA/QC organization shall conduct a receipt inspection of items received; ensuring the material meets the specifications written on the purchase requisition. If specifications are not met, the Field Supervisor shall contact Procurement to resolve the discrepancy and an NCR will be issued.

7.4.2 When newly purchased equipment fails calibration or operating criteria, the failure shall be documented and the equipment returned to Procurement for return to the vendor for repair or replacement.

8.0 CRITERION 8 - EQUIPMENT CALIBRATION/MAINTENANCE

8.1 Facilities

The Real Time Measurement Program is operated from a project trailer and the RTRAK Building, both of which are located at the southwest corner of the site. Access to the facilities is through the site vehicle entry points with uniformed security attendance per DOE security requirements. Visitor access is controlled by the site access requirements.

8.2 Equipment and Instrumentation

8.2.1 Technical Personnel shall observe standard practices to maintain the integrity of equipment and instrumentation. Personnel using equipment and instrumentation shall be trained on the procedure applicable to the method being performed. Equipment and instrumentation shall only be used as specified in procedure.

8.2.2 Technical Personnel shall not use instrumentation requiring calibration and/or standardization to generate results unless the calibration/standardization is current. Technical Personnel shall prepare complete and accurate documentation to identify the instrument used to perform each measurement.

8.3 Calibration Frequency and Source Requirements

NOTE *Recording results permits monitoring of instrument or system status and provides a method for result traceability.*

8.3.1 The frequency at which instruments must be calibrated or standardized shall be stipulated in the appropriate operating procedures or *In-situ Gamma Spectrometry Quality Control Measurements*, ADM-16. Radioactive sources used in calibration shall conform to the following criteria:

- The accuracy of sources shall exceed the accuracy of the instrumentation sufficiently to ensure that the quality levels of measurement results are not compromised,
- The sources shall be traceable to NIST, and
- The date and time of calibration and the name of the operator shall be recorded on the field worksheet.

8.4 Preventative Maintenance (PM)

8.4.1 The PM requirements specified by the manufacturer shall be the starting point for the development of the PM program.

8.4.2 PM may need to be more or less frequent or intensive than specified by the manufacturer due to frequency of use, unusual environmental conditions in area of use, and/or documented experience with the equipment.

8.4.3 Because Technical Personnel and the Field Supervisor are responsible for the equipment and instruments in their area, they shall implement PM per an established schedule.

8.4.4 PM is to be performed on a frequency that satisfies warrantee stipulations to prevent loss or voiding of warranty.

8.4.5 Technical Personnel and the Field Supervisor shall provide support for the PM program by maintaining complete service manuals and stocking spare parts as applicable. The availability of personnel and resources on-site provides a means of ensuring optimum performance from equipment/instruments and minimizing downtime for equipment, instruments, and measurement systems.

8.4.6 Use of service manuals published by the equipment manufacturer and/or completion of a manufacturer provided training course is recommended to successfully implement the PM program when the system, equipment, or instrument is complex or unusual.

8.4.7 Service contracts may be procured to fulfill instrument repair and PM requirements for complex measurement equipment. Equipment PM and repair must be performed by a competent FDF technician, instrument repair technician, or by a competent instrument vendor's service representative.

8.4.8 Any person performing PM, including vendor and service agency representatives, shall record, in a field log, time and date, name, type of maintenance performed, deficiencies (if found), and action taken.

8.4.9 The PM program shall meet the requirements of the FEMP SCQ.

8.4.10 PM shall be performed in accordance with *In-situ Gamma Spectrometry Maintenance/Preventive Maintenance*, EQT-37.

9.0 CRITERION 9 - MANAGEMENT ASSESSMENT

9.1 Requirements

9.1.1 Management assessment of the RTIMP shall occur at least annually.

9.1.2 Management assessment shall be conducted in accordance with a plan. The Real Time Instrumentation Measurement Program Manager is responsible for developing and implementing the plan. The plan shall address those elements most essential to enabling the Field Supervisor and the Data Management Supervisor to evaluate the accuracy of measurement results, the quality and completeness of records and the degree to which the project meets customer needs.

9.1.3 Followup assessments shall include the evaluation of the effectiveness of management's actions in response to previous management assessments.

9.1.4 Team members of the RTIMP will conduct periodic self assessments of various aspects of RTIMP Operations. Concerns and recommendations will be reported to the Real Time Instrumentation Measurement Program Manager. Self-assessments will be documented in the form of a report to SCEP Management. The report will note areas for improvement and measures taken to address those areas.

10.0 CRITERION 10 - ASSESSMENTS AND AUDITS

10.1 S&WP QA/QC organization shall perform evaluations of RTIMP per approved FEMP procedures. The evaluations monitor the degree of compliance with the RTIMP QAP, the SCEP PEP, the SCQ and RM-0012. Evaluations shall be either program-wide for a particular quality assurance provision or on individual projects for overall compliance.

10.2 The RTIMP is subject to audits/surveillance of operations and data quality assurance/quality control programs by the EPA, DOE, and the S&WP QA/QC organization. The RTIMP Manager or designee shall be the point of contact for all auditing organizations.

10.3 <u>Assessment</u>

NOTE *At the FEMP the Quality Assurance function is an independent group that reports directly to the Office of the President.*

10.3.1 Independent Assessment - RTIMP management shall work with the S&WP QA/QC organization to assure that planned annual and periodic independent assessments will be conducted to measure analytical quality and process effectiveness and to promote improvement. Typically, field surveillances are conducted as described in PSPs for each sampling project. The organization(s) performing independent assessments shall have sufficient authority and freedom from the line organization to carry out its responsibilities and shall not be directly responsible for areas assessed. Persons conducting independent assessments shall be technically qualified and knowledgeable in the areas assessed.

10.3.2 RTIMP management shall track assessment/audit findings as applicable and assure their resolution in accordance with appropriate procedures, good practices, and best management practices. The affected management shall be responsible for corrective action in resolving findings.

10.4 <u>Quality Reports to SCEP Management</u>

10.4.1 The Data Management Supervisor shall provide reports of ongoing quality programs and special studies to the Real Time Instrumentation Measurement Program Manager.

10.4.2 S&WP QA/QC organization shall provide timely reports of audits and surveillances to the Real Time Instrumentation Measurement Program Manger.

Appendix A

Drivers

DOE 1324.2A	Document Control
DOE 2030.4B	Reporting Fraud, Waste, and Abuse to the Office of Inspector General
DOE 5700.6C	Quality Assurance
FD-1000	Site Wide CERCLA Quality Assurance Project Plan (SCQ)
PO-FMPC-1001	FEMP Conduct of Operation Policy
RM-0012	FDF Quality Assurance Program
10 CFR 830.120	Quality Assurance
20300-PEP-0001	Soils Characterization and Excavation Project Project Execution Plan
2500-WP-0028	Sitewide Excavation Plan

Appendix A (cont.)

References

ADM-16	*In-Situ Gamma Spectrometry Quality Control Measurements*
DOE-TIC-11026	Radioactive Data Tables by David C. Kocher
EQT-22	*High Purity Germanium Detector In-Situ Efficiency Calibration*
EQT-23	*Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*
EQT-33	*Real-Time Differential Global Positioning System - Operation*
EQT-34	*Operation of the Radiation Scanning System (RSS)*
EQT-36	*Field Instrument for Detection of Low Energy Radiation*
EQT-37	*In-situ Gamma Spectrometry Maintenance/Preventive Maintenance*
MS-1001	*FDF Site Procedure System*
RC-DOS-121	*Operation of the Liquid Nitrogen Transfer Dewar*
RC-DPT-035	*Inspection and Performance Testing of Portable Radiological Survey Instruments*
RP-0014	*Radiation Source Accountability and Control*

Appendix A (cont.)

Information Sources

ANSI/ASA-ES-1991	Quality Assurance Program Requirements for Environmental Programs, September 1991. ASQC
ANSI/ASQC-E4	Quality Assurance Program Requirements for Environmental Programs
DOE Order 4700.1	Project Management System
DOE Order 5400.1	General Environmental Protection Program
QAMS-005/80	Interim Guidelines and Specification for Preparing Quality Assurance Project Plans
20701-RP-0001	Comparability of In-Situ Gamma Spectrometry and Laboratory Data.
20701-RP-0001 Addendum	Comparability of Total Uranium Data as Measured by In-Situ Gamma Spectrometry and Four Laboratory Methods
20701-RP-0001 Addendum	Comparability of In-Situ Gamma Spectrometry and Laboratory Measurements of Radon-226
20701-RP-002	RTRAK Applicability Study
20701-RP-002 Addendum	RTRAK Applicability Measurements in Locations of Elevated Radionuclide Concentrations
20701-RP-006	User Guidelines, Measurement Strategies and Operational Factors for Deployment of In-situ Gamma Spectrometry at the Fernald Site

Appendix B

Definitions

Accuracy - The closeness of a measured value to the accepted true value.

Algorithm - A rule or procedure for solving a mathematical problem that frequently involves repetition of operations.

Analytical Support Level (ASL) - Level of defined quality assurance/quality control parameters to assure data are satisfactory for their intended use.

Assessment - The act of reviewing, inspecting, testing, checking, conducting surveillance, auditing, or otherwise determining and documenting whether items, processes, or services meet specified requirements.

Audit - A planned and documented activity systematically performed to determine by investigation, examination, or evaluation of objective evidence the quality of operation of some function or activity. Audits may be of two basic types: (1) performance audits in which quantitative data are independently obtained for comparison with routinely obtained data in a measurement system, or (2) system audits of a qualitative nature that consists of an on-site review of the quality assurance system and physical facilities for sampling, calibration, and measurement.

Bias - The systematic error of a measurement relative to its accepted true value.

Calibration - The process of establishing a relationship between an instrument or measurement system response and the concentration of a standard or standards.

Calibration Standards - A series of known National Institute for Standards and Technology (NIST) traceable standards used for calibration of the instrument (i.e., preparation of the analytical curve).

Characterization - Process of measuring and defining detector response properties as a function of gamma-ray energy, gamma ray activity, and the angle at which gamma rays strike the detector.

Comparability - One of the five assessment criteria identified by the EPA to assure data quality; qualitatively expresses the confidence with which one data set can be compared to another. Analytical data generated by the same analytical procedures are comparable provided that relevant specified quality control elements such as detection limits, initial and continuing calibration performance, accuracy, precision and matrix interference acceptance criteria are met or exceeded. Data relevant for the same analytes that are generated by different analytical procedures are also comparable provided that QC performance criteria similar to those above are met or exceeded.

Appendix B (cont.)

Completeness - A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions. Completeness of a data package is a measure of the amount of valid data in the package compared to the amount that was expected to be obtained under normal conditions.

Concern - A determination of a programmatic breakdown or widespread problem supported by one or more findings.

Control Limits - The maximum allowed variability of a quality control parameter based on predetermined values. Any quality control value falling at or outside upper or lower control limits ($\pm 3\sigma$) represents an out-of-control data point, and must be investigated. Control limits may also be specified as a percentage of an established parameter, e.g. X ± 10%.

Controlled Document - Any document for which distribution and status are to be kept current by the issuer in order to ensure that authorized holders or users of the document have available the most up-to-date version for accomplishment of work action.

Corrective Action - Measures taken to rectify significant conditions adverse to quality and, where necessary, to preclude repetition.

Custodian - The person assigned to create and maintain control charts and to document quality control measurements for one or more methods they are certified to perform.

Data Quality - The totality of features and characteristics of data that bears on its ability to satisfy a given purpose. The characteristics of major importance are accuracy, precision, completeness, representativeness, comparability, traceability, and authenticity.

Data Quality Objectives (DQO) - Qualitative and quantitative statements that specify the quality of data required to support decision making.

Document - Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results. A document is not considered to be a Quality Assurance Record until it satisfies the definition of a Quality Assurance Record as defined in this section.

Environmental Gamma-ray Analysis (EGAS) - A contractor supplied software used to calculate gamma conversion factors and peak identification/quantification reports for in-situ gamma measurements.

Finding - An assessment conclusion that identifies for hardware items when the observed conditions represent a departure from requirements or specifications. Also, a procedural or program deviation which impacts the quality of work or the reliability of documentation.

Hardware/Software Verification/Validation - The process to demonstrate that computer equipment has the required capabilities and that programs correctly perform the expected functions.

Appendix B (cont.)

HPGe Detector - The solid state hyperpure germanium detectors used for in-situ collection of gamma spectra at specified field locations.

Industry Standard Software - Computer programs, without modification, that are widely used for commercial applications.

Integrity - An unimpaired condition that may relate to samples, reagents, or equipment.

Internal Audit - An audit of FDF organization's activities by representatives of another FDF organization to determine the status and assess the adequacy and effectiveness of the implementation of FDF procedures and compliance to requirements.

MAESTRO™ Software - A multi-channel analyzer (MCA) emulator program used to collect, display, manipulate and store gamma spectra.

Method - An orderly procedure or process.

MULTIACQ - A software program that controls repetitious timed acquisition of gamma spectra. MULTIACQ incorporates GPS data into the individual gamma spectrum permitting determination of the exact location of acquired spectrum on a real time basis.

Nonconformance - A departure from a specified requirement. Can be a condition in which a characteristic of an item does not conform to prescribed limits, a required document that is not available or is inadequate, a regulatory requirement that was violated, or a procedure that does not yield desired results.

Nonconforming Condition - A condition which does not conform to specified requirements for one or more characteristic.

Outlier - On a control chart, a plotted result that falls outside the upper or lower control limits, signifying an out-of-control situation for that particular analysis. For the purposes of this procedure, a value that falls outside the UCL or the LCL is considered an outlier. The control limits ($\pm$ 3s from the mean) represent a **99.7% level of confidence** that values falling between these limits are indicative of a system that is statistically in control.

Performance Check - An operational check to ensure that a component or system is performing as expected.

Precision - A measure of the mutual agreement among individual measurements of the same property, usually under prescribed similar conditions; that is, the repeatability of an analysis or measurement. Measurements that are repeatable within small limits are said to be precise. Precision is best expressed in terms of the standard deviation. Various measures of precision exist depending upon the "prescribed similar conditions". The precision of an analytical method is usually determined from the results of replicate samples.

Appendix B (cont.)

Preventive Maintenance (PM) - Maintenance performed for precautionary reasons to protect against malfunction or failure.

Procedure - A document that specifies or describes how an activity is to be performed; an operation, analysis, or action whose mechanics are thoroughly prescribed and documented and which is commonly accepted as the usual or normal method for performing certain routine or repetitive tasks.

Process - A series of actions that achieves an end or result.

Quality - Fitness for intended use, which includes conformance to requirements.

Quality Assurance (QA) - All those planned and systematic actions necessary to provide adequate confidence that an item will perform satisfactorily and safely in service. QA includes the system of activities whose purpose is to verify that quality control efforts are effective.

Quality Assurance Program (QAP) - The formal, approved, and controlled text that describes the FDF QA Program which ensures adherence to FDF policies for achieving required quality levels in the operation of the FEMP.

Quality Assurance Record - A completed document that furnishes evidence of the quality of items and/or activities affecting quality.

Quality Control (QC) - Requirements governing analytical methods in the laboratory to ensure that the data produced are within known probability limits of accuracy and precision.

Quality Control Parameter - An indicator of acceptable (in control) instrument performance, calibration, or stability. This parameter is usually a control sample, check standard or a calibration verification standard.

Representativeness - Expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, process condition, or an environmental condition. Data representativeness is a function of sampling strategy; therefore, the sampling scheme should be designed to maximize representativeness.

Radiation Scanning System (RSS) - Name given to the sodium iodide gamma counting system mounted on a jogging stroller.

Radiation Tracking (RTRAK) Vehicle - Name given to the sodium iodide gamma counting system mounted on a tractor.

Sodium Iodide (NaI) Detector - The sodium iodide scintillation detector used for in-situ gamma measurements in the RSS and the RTRAK at specified field locations.

Appendix B (cont.)

Significant Condition Adverse to Quality - A condition, if left uncorrected, which could significantly impact the quality of a measurement or program.

Sitewide CERCLA Quality Assurance Project Plan (SCQ), (FD-1000) - Document, as approved by DOE and EPA, provides overall SITEWIDE quality assurance planning for environmental sampling and analysis at the FEMP.

Standard - (noun) In context of equipment calibration, something set up and established by authority as a rule for the measurement of a parameter (e.g., concentration, length, temperature, mass). (adj) A regularly and widely used method (e.g., standard operating procedure), material (e.g., standard gauge), or calculation (e.g., standard deviation).

Statement of Work (SOW) - A document which defines the scope of work, performance conditions and may include the specific analytical methods to be used.

Surveillance - Equivalent to an EPA performance audit, a surveillance is a spot check of program implementation to determine conformance to specified requirements.

Validation - The process of evaluating a product at the end of the entire process to ensure compliance with requirements, or the measurement of effectiveness regarding corrective actions. Validation of a software algorithm involves the manual calculation of a result using the same mathematical procedure that is encoded in the software, and obtaining a result that is statistically the same as the result obtained from the software.

Verification - The process of confirming, substantiating, and assuring that analysis activities and ensuing results were properly generated and reported according to the requirements of relevant methods and/or SOPs.

Appendix C

Acronyms

ANSI	American National Standards Institute
ASL	Analytical Support Level
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department Of Energy
DQO	Data Quality Objective
EM#3	DOE Environmental Monitoring - Environmental S&A (Sampling and Analysis) Guidance No. 3
ES&H	Environmental Safety and Health
FACTS	Fernald Analytical Computerized Tracking System
FDF	Fluor Daniel Fernald
FEMP	Fernald Environmental Management Project
GPS	Global Positioning System
IDL	Instrument Detection Limit
MSDS	Material Safety Data Sheet
NIST	National Institute of Standards and Technology
OEPA	Ohio Environmental Protection Agency
OJT	On the Job Training
OSHA	Occupational Safety and Health Act (or Administration)
PM	Preventive Maintenance
QA	Quality Assurance

Appendix C (cont.)

QAP	Quality Assurance Program
QC	Quality Control
RM-0012	FDF Quality Assurance Program
SCQ	Sitewide CERCLA Quality Assurance Project Plan (FD-1000)
SOP	Standard Operating Procedure
USEPA	Environmental Protection Agency

Appendix D

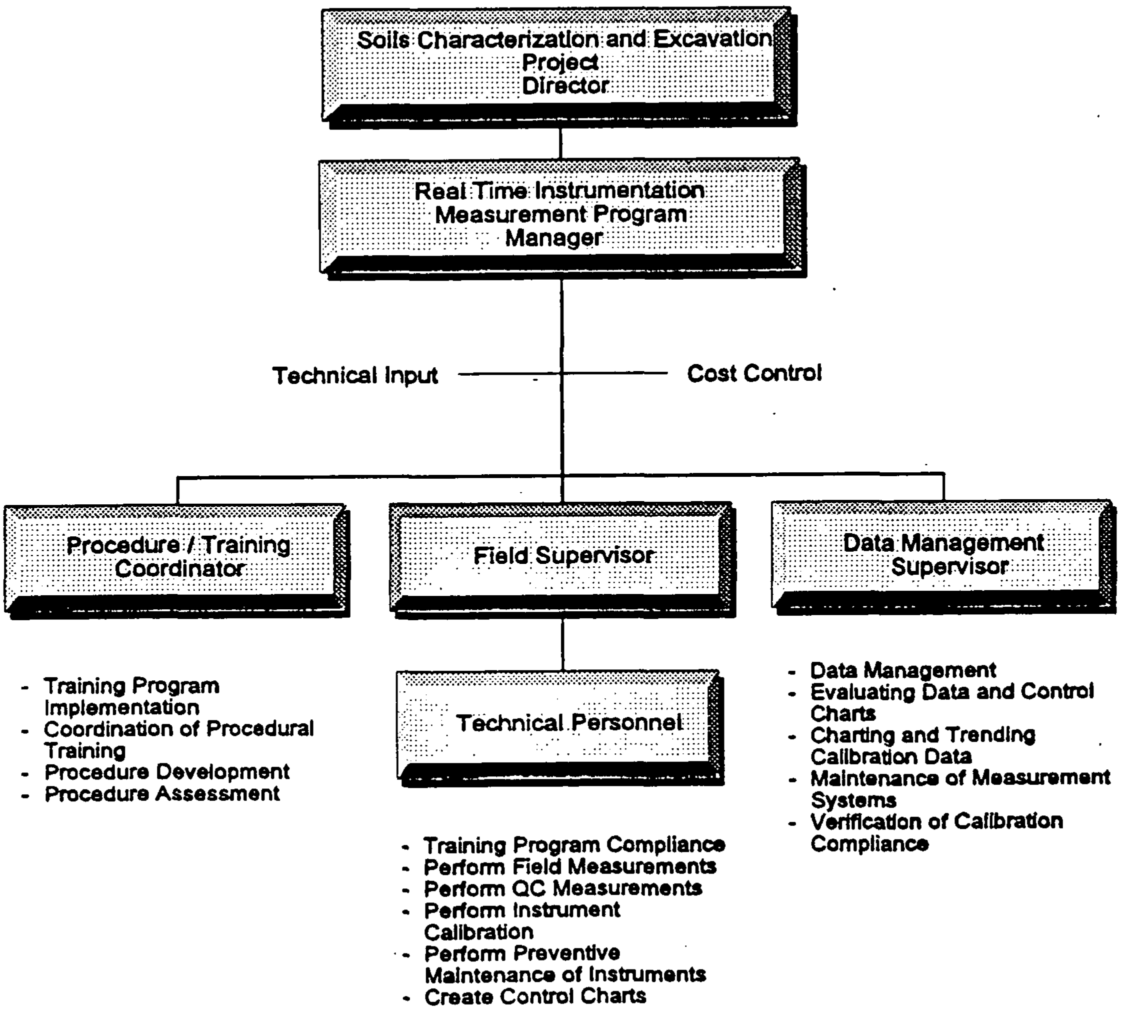
Crosswalk of QA Criteria in various driver documents

The following table provides a correlation of specific program QA elements as they are found in the following documents: The FDF QAP (RM-0012), the RTIMP QAP, DOE EM Environmental S&A Guidance #3, and the FDF SCQ. The elements of the RTIMP QAP are keyed to the corresponding elements of the other documents.

ELEMENT	RTIMP QAP section	RM-0012 criterion	DOE/EM # 3	FDF SCQ section
Program	1.0	1	A, A3	2.0,12.4.6
Personnel Training & Qualification	2.0	2	A4, A5	4.4.1
Quality Improvement	3.0	3	A12	15
Documents and Records	4.0	4	A13, A15	4.4.2,4.4.3 7.3
Work Processes	5.0	5	A10, A11 A14	9,10,11
Method Design	6.0	6	N/A	N/A
Procurement/ Control of Materials and Services	7.0	7	A7	3
Facilities/ Equipment/ Calibration/ Maintenance	8.0	8	A8, A9	8,13
Management Assessment	9.0	9	A17	16
Lab Assessments/ Audits	10.0	10	A16	12

Appendix E

RTIMP Functional Organization Chart



Appendix F

Tabulation of Quality Control Criteria and Requirements

R-TRAK and RSS Detector QC Criteria and Requirements

QC Element	Nuclide	Gamma Energy	QC Criteria	Frequency	Control Chart
Energy Calibration[1]	Tl-208 Pb-212	2614.5 keV 238.6 keV	Channel 447 ± 2 Channel 40 ± 2	Days used, prior to use	No

Note 1: **A post-operational energy check is performed at the conclusion of daily measurements to ensure that the system energy calibration and the detector resolution have been maintained in accordance with the QC Acceptance criteria given in this table. Post-operational energy checks are performed in accordance with instructions given in procedure ADM-16.**

HPGe Detector QC Criteria and Requirements

QC Element	Nuclide	Gamma Energy	QC Criteria	Frequency	Control Chart
Energy Calibration[2]	Am-241 Cs-137 Co-60	59.5 keV 661.6 keV 1332.5 keV	Channel 158 ± 1 Channel 1763 ± 2 Channel 3553 ± 3	Days used, prior to use	No
Detector Resolution	Co-60	1332.5	Measured mean value $\bar{x}$ ± 3 sigma	Days used, prior to use	Yes
Detector Counting Efficiency Check	Co-60	1332.5	pre-determined check source value (decay corrected) $\bar{x}$ ± 3 sigma	Days used, prior to use	Yes

Note 2: **A post-operational energy check is performed at the conclusion of daily measurements to ensure that the system energy calibration and the detector resolution have been maintained in accordance with the QC Acceptance criteria given in this table. Post-operational energy checks are performed in accordance with instructions given in procedure ADM-16.**

Appendix F (cont.)

Tabulation of Quality Control Criteria and Requirements

HPGe Field Measurements QC Criteria and Requirements

QC Element	Gamma Energy Nuclide or Basis	QC Acceptance Criteria	Frequency	Control Chart
Field Measurement Interference	1460.8 keV	FWHM 1460.8 ± 3.0 keV or Channel 3895 ± 8	Each time measurements are made	No
Field Control Station	 Total U Th-232 Ra-226 K-40	ASL-D measured value ±3 sigma measured value ±3 sigma measured value ±3 sigma measured value ±3 sigma	On each day measurements are made	Yes
Field Control Station	Temperature Humidity Soil Moisture	No Criteria	On each day measurements are made	No
Minimum Detectable Concentration	Free Release Levels for Nuclides of Concern	For ASL D 95% UCL[3] < FRLs For ASL-B 90% UCL[3] <FRLs	Quarterly	No

Note 3. The upper confidence level (UCL) for the MDC.

Appendix F (cont.)

Tabulation of Quality Control Criteria and Requirements

HPGe Field Measurements QC Criteria and Requirements (cont.)

QC Element	Gamma Energy Nuclide or Basis	QC Acceptance Criteria	Frequency	Control Chart
Measurement Accuracy (Total U, Th-232, Ra-226)	Compared to weighted average of physical samples	ASL D - weighted average of physical sample ±35% ASL-B - weighted average of physical sample ±35%	Annually	No
Measurement Bias	Compared to weighted average of physical samples	Bias acceptable unless it produces errors resulting in accuracy being exceeded	Annually	No
Precision of Duplicates	At least one per every 20 HPGe measurements.	measured value >(5 x MDC) then RPD ≤ ±20% measured value <(5 x MDC) then RPD ≤ ±MDC	At least one per every 20 HPGe measurements.	No
Detector Counting Efficiency Determination	Determination of conversion (efficiency) factors.	initial conversion factor ±10% for each gamma energy[4]	Annually	No

Note 4. Nuclide and Gamma energies measured:

Cs-137	32.2
Eu-152	39.5
Am-241	59.5
Eu-152	121.8
Eu-152	244.7
Eu-152	344.3
Eu-152	411.1
Eu-152	444.0
Eu-152	661.6
Cs-137	778.9
Eu-152	964.0
Eu-152	1173.7
Co-60	1332.5
Co-60	1408.0

Attachment 1

EXAMPLE *Field Electronic Data Disk Transfer Log,* FS-F-5070

FIELD ELECTRONIC DATA DISK TRANSFER LOG

Data Measurement Team:

Date Collected	Detector Number	Beginning File Number	Ending File Number	Copied to LAN		Disk Data Deleted	
				Initial	Date	Initial	Date

Comments:

Relinquished by Signature	Badge	Date	Time	Received by Signature	Badge	Date	Time

NOTE This log is a record of transfer of electronic files listed on log. Signatories are not responsible for content of files.

EXAMPLE *Field Electronic Data Disk Transfer Log,* FS-F-5070
(Completion Instructions)

1. **DATA MEASUREMENT TEAM:** Print names of team members conducting surveys.
2. **DATE COLLECTED:** Write date (m/dd/yy) that data on each disk was collected.
3. **DETECTOR NUMBER:** Number of detector used to collect data on each disk.
4. **BEGINNING FILE NUMBER:** Number of first static point or mobile location spectral file on each disk.
5. **ENDING FILE NUMBER:** Number of last static point or mobile location spectral file on each disk.
6. **COMMENTS:** Identify any breaks in data, missing files, files from differing projects, disk problems, or any other problems with disk listed.
7. **RELINQUISHED BY:** Signature of individual, currently in control of disk(s), who is turning control of disk over to responsible user of disk(s). Record signatory badge number and the date and time disk is turned over.
8. **RECEIVED BY:** Signature of individual, who is receiving control of disk(s). Record signatory badge number and the date and time disk(s) is received.
9. **COPIED TO LAN:** Initial and date each data disk entry when data is transferred from disk to LAN. Entry in this column denotes transfer is complete to LAN and disk data is no longer required to be retained.
10. **DISK DATA DELETED:** Initial and date each data disk entry when data is deleted from disk; so disk can be reused.

Attachment 2 Page 1 of 2

EXAMPLE *Nonconformance Information Form*, FS-F-5080

Nonconformance Information Form

Real Time Instrumentation Measurement Program

NCR Number & Rev:	Nonconformance Title:
1. Filed by:	2. Date:
3. Measurement(s) Affected - Spectrum File Number(s):	
REQUIREMENT AND NONCONFORMANCE (Check appropriate item(s))	
4. ☐ System failed energy calibration. Comments:	
5. ☐ Detector exceeded resolution criteria. Comments:	
6. ☐ Detector exceeded net peak area criteria. Comments:	
7. Detector did not meet MDC criteria for ASL B: Comments:	
8. Detector did not meet performance criteria for ☐ Accuracy for ASL B. Comments: ☐ Bias.	
9. Detector did not meet precision of duplicate criteria for: ☐ >5 x MDC. Comments: ☐ <5 x MDC.	
10.☐ Detector failed annual characterization.	
11.☐ Other	
12. Corrective Action Taken:	

Attachment 2

EXAMPLE *Nonconformance Information Form*, FS-F-5080
(Completion Instructions)

1. NCR NUMBER, REV, and NONCONFORMANCE TITLE: Nonconformance Report (NCR) number, Revision number, and title of Nonconformance to be completed by QA representative.
2. FILED BY: Name of individual initiating NCR.
3. DATE: Enter date (mm/dd/yy) that initiator of NCR identifies Nonconformance.
4. MEASUREMENT(S) AFFECTED: Enter file number(s) of spectra affected by Nonconformance.
5. REQUIREMENT AND NONCONFORMANCE: (Boxes 4-10)
   [a] Check appropriate box(es) identifying requirement(s) not met or criteria exceeded.
   [b] Provide detector number, date and time Nonconformance occurred, and conditions leading to Nonconformance noted in comments section after checked box.
6. OTHER: Identify other condition or process that is nonconforming and provide comment information as specified above.
7. CORRECTIVE ACTION TAKEN: List corrective action taken to resolve condition (i.e., repair of detector, replacement of cables, remeasurement of field locations, etc.).

QC Procedure

IN-SITU GAMMA SPECTROMETRY QUALITY CONTROL MEASUREMENTS

ADM-16

FERNALD Environmental Management Project	ENVIRONMENTAL MONITORING PROJECT PROCEDURE	FLUOR DANIEL FERNALD
EFFECTIVE DATE: 3/18/98	REV. NO: 0	PAGE 1 OF 43

PROCEDURE TITLE

In-Situ Gamma Spectrometry Quality Control Measurements

PROCEDURE NUMBER

ADM-16

PROCEDURE APPROVAL

INFORMATION ONLY

PREPARED BY: Tom Cox
SUBJECT EXPERT

APPROVAL: Joan White — 3/9/98
Joan White
REAL TIME INSTRUMENTATION MEASUREMENT PROGRAM MANAGER
DATE

APPROVAL: Mark J. Cherry — 3-11-98
Mark J. Cherry
ENVIRONMENTAL MONITORING PROJECT
DATE

APPROVAL: Harold E. Swiger — 3/9/98
Harold E. Swiger
QUALITY ASSURANCE
DATE

APPROVAL: Kevin R. Tschaenn — 3-11-98
Kevin R. Tschaenn
SAFETY AND HEALTH
DATE

REVISION SUMMARY

Revision	Effective Date	Description of Revision
0	18-March-98	Procedure requested by Joan White for Soils Characterization and Excavation Project.

TABLE OF CONTENTS

SECTION	TITLE	PAGE
Preface:	PROCEDURE TITLE/APPROVAL PAGE	1
	REVISION SUMMARY	2
	TABLE OF CONTENTS	3
	LIST OF ATTACHMENTS	4
	LIST OF TABLES	4
1.0	PURPOSE	5
2.0	SCOPE	5
3.0	DEFINITIONS	5
4.0	RESPONSIBLE PERSONNEL	7
5.0	PREREQUISITES	7
	5.1 Background	7
	5.2 Performance Documents	8
	5.3 Required Equipment	8
6.0	PROCEDURE	8
	6.1 Training	8
	6.2 Counting System Assembly and Operation	9
	6.3 RSS Energy Calibration	9
	6.4 R-TRAK Energy Calibration	11
	6.5 HPGe Operational Performance Checks	12
	6.5.1 HPGe Pre-Operation Energy Calibration	12
	6.5.2 Field Control Station Measurements	14
	6.5.3 Field Measurement Interference Check	15
	6.5.4 HPGe Post-Operational Energy Check	16
	6.6 Minimum Detectable Concentration	17
	6.7 Precision of Duplicate HPGe Measurements	18
	6.8 HPGe Performance Criteria	19
	6.9 HPGe Detector Counting Efficiency Determination	21
	6.10 Control Chart Preparation and Maintenance	22
	6.11 Data Review and Approval	25
	6.12 Initiating Nonconformance Report	26
7.0	RECORDS	27
8.0	DRIVERS	27
9.0	REFERENCES	27

LIST OF ATTACHMENTS

ATTACHMENT	TITLE	PAGE
A	Tabulation of Quality Control Criteria and Requirements	29
B	EXAMPLE HPGe Detector Counting Efficiency (Conversion Factor) Calculation	32
C	EXAMPLE Quality Control Chart	38
D	EXAMPLE *Field Electronic Data Disk Transfer Log,* FS-F-5070	40
E	EXAMPLE *Nonconformance Information Form,* FS-F-5080	42

LIST OF TABLES

TABLE	TITLE	PAGE
Table 1	RSS and R-TRAK Energy Calibration Criteria	[illegible]
Table 2	RSS and R-TRAK Spectral Review Energy Calibration Criteria	1[illegible]
Table 3	Germanium Energy Calibration Criteria	12
Table 4	Photopeak Resolution and Net Peak Area Tolerance Limits	13
Table 5	Field Control Station Measurement Evaluation Criteria	15
Table 6	HPGe Field Measurement Interference	16
Table 7	Minimum Detectable Concentration	18
Table 8	HPGe Duplicate Measurement Precision	19
Table 9	Analytical Laboratory Data Comparability	20
Table 10	Accuracy and Precision	20
Table 11	HPGe Detector Counting Efficiency Determination	21

1.0 PURPOSE

This procedure provides instruction for the collection and evaluation of specified quality control (QC) measurements on in-situ gamma spectrometry measurement equipment at the Fernald Environmental Management Project (FEMP). Additionally this procedure establishes a process for preparing and generating QC charts for in-situ gamma spectrometry, a process for tracking data disk transfer, and a process for initiation of a Nonconformance report.

2.0 SCOPE

The procedure applies to the QC measurement activities conducted by Real Time Instrumentation Measurement Program personnel when using in-situ gamma detectors for radiation measurements in support of FEMP environmental and remediation projects. Activities controlled by this procedure include:

- daily pre- and post-operational checks,
- interference checks conducted with each spectrum,
- radon corrections,
- detector characterization,
- control charting,
- data comparisons,
- data transfers, and
- identifying and initiating Nonconformances.

3.0 DEFINITIONS

Accuracy - The closeness of a measurement to its accepted true value.

Analytical Support Level (ASL) - The defined quality assurance/quality control (QA/QC) parameter to assure data are satisfactory for their intended use. For In-situ gamma spectrometry measurements, the analytical support level must satisfy data quality objectives (DQOs).

ASL B - Screening data with definitive confirmation. This is data generated by rapid, less precise methods of analysis. The data provide identification and quantification, although the results may be relatively imprecise.

ASL D - Definitive data. These data are defined as data generated using rigorous analytical methods. For data to be definitive, either analytical or total measurement errors must be determined.

Bias - The systematic error of a measurement relative to its accepted true value.

Control chart limits - The maximum allowed variability of a QC parameter based on pre-determined values. Any QC value falling at or outside upper or lower warning limits (± 2 sigma) represents an out-of-limits data point, and must be investigated. Any QC value falling at or outside upper or lower control limits (± 3 sigma) represents an out-of-control data point, requiring action.

Custodian - Project person assigned to create and maintain control charts and to document QC measurements for one or more methods they are certified to perform.

Detector characterization - The in-situ term for performing an efficiency calibration on an HPGe detector. At Fernald, in-situ detector characterization uses a geometric integration model to determine detector efficiency at gamma energies ranging between 32 and 1408 keV.

Detector resolution - The ability in a detection device to distinguish or resolve measurement data. In a gamma spectrometer, detector energy resolution or simply detector resolution is expressed as the full width in energy units, keV at half the maximum height counts or full width at half maximum (FWHM) of a spectrum energy peak.

Environmental Gamma-ray Analysis Software (EGAS) -EGAS is a contractor supplied software used routinely to calculate gamma conversion factors and peak identification/quantification reports for in-situ gamma measurements.

Field control station - The field analog of a laboratory control standard that has been adopted to address the influence of environmental factors such as soil moisture, atmospheric temperature and humidity on in-situ gamma spectrometry measurements.

High Purity Germanium Detectors (HPGe) - The solid state hyperpure germanium detectors used for in-situ collection of gamma spectra at specified field locations.

Minimum Detectable Concentration (MDC) - The statistically determined quantity of a radionuclide that can be measured at a preselected confidence level under specified conditions.

Outlier - On a control chart, a plotted result that falls outside the upper or lower control limits, signifying an out-of-control result for that particular analysis. For the purposes of this procedure, a value that falls outside the upper control limit (UCL) or the lower control limit (LCL) is considered an outlier.

Performance check - An operational check to ensure that a component or system is performing as expected.

QC parameter - An indicator of acceptable (in control) instrument or measurement performance, or stability.

Radiation Scanning System (RSS) - Name given to the sodium iodide gamma counting system mounted on a mobile platform.

Radiation Tracking (R-TRAK) Vehicle - Name given to the sodium iodide gamma counting system mounted on a tractor.

4.0 RESPONSIBLE PERSONNEL

Team Coach
Data Management Supervisor
Field Supervisor
Custodian
Technician/Analyst

5.0 PREREQUISITES

5.1 Background

Two types of gamma sensitive detectors are used by Real Time Instrumentation Measurement Program at the FEMP. On a comparative basis, sodium iodide detectors have high FWHM (usually 50-60 keV) and poor resolution; whereas germanium detectors have low FWHM (usually 2-3 keV) and good resolution. As a matter of convention, the resolution for all gamma detectors is evaluated at the 1332.5 keV peak of Co-60.

QC measurements are performed to ensure that instruments are operating as expected and that measurements are within acceptable limits. Each detector must undergo and pass the required quality control checks before being used on any given day to perform field measurements. If a given detector fails a particular QC check, that check must be repeated and successfully passed before the instrument may be used for real time measurements. When a detector is used for field measurements, the measurements must meet acceptance criteria or they will be rejected or adjustments for interference made.

Selected QC measurements are plotted on control charts in order to track instrument performance over time. Control chart generation, maintenance and review are part of an overall active QC program. Control charts are used to identify unusual trends that indicate problems before out of control situations occur. The preparation and use of control charts is critical for assuring the maintenance of compliant data of high quality.

A tabulation of quality control criteria and requirements is presented in Attachment A.

5.2 Performance Documents

Forms: *Field Electronic Data Transfer Log,* FS-F-5070
Gamma Spectrometry Field Worksheet, FS-F-4781
Nonconformance Information Form, FS-F-5080

Procedures: *Characterization of Gamma Sensitive Detectors,* EQT-22
Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors, EQT-23
Operation of Radiation Tracking Vehicle Sodium Iodide Detection System, EQT-30
Radiation Scanning System (RSS), EQT-34
Troxler 3440 Series Surface Moisture/Density Gauge - Calibration, Operation, and Maintenance, EQT-32

QC Charts
Training documentation

5.3 Required Equipment

Computer disk (formatted)
National Institute of Standards and Technology (NIST) traceable sources (HPGe detector):
- Americium-241(Am-241)
- Cesium-137 (Cs-137)
- Cobalt-60 (Co-60)
- Europium-152 (Eu-152) for detector characterizations

RSS, R-TRAK or HPGe detector and counting system, as appropriate
Thorium source for R-TRAK/RSS

6.0 PROCEDURE

6.1 Training

Team Coach

[1] Ensure personnel are trained to this procedure, or if in training, are closely supervised by personnel trained to this procedure.

[2] Ensure personnel training documentation is forwarded to FEMP Training Department files.

[3] Maintain copy of training documentation in project files.

6.2 Counting System Assembly and Operation

Technician/Analyst

[1] **IF** using RSS, **THEN** assemble **AND** perform software and amplifier checks for RSS in accordance with procedure *Operation of the Radiation Scanning System (RSS)*, EQT-34 **AND** proceed to Section 6.3.

[2] **IF** using R-TRAK, **THEN** assemble **AND** perform software and amplifier checks for R-TRAK in accordance with procedure *Operation of Radiation Tracking Vehicle Sodium Iodide Detection System,* EQT-30 **AND** proceed to Section 6.4.

[3] **IF** conducting daily HPGe operational performance checks, **THEN** assemble HPGe and ADCAM analyzer **AND** conduct system amplifier check in accordance with procedure *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors,* EQT-23 **AND** proceed to Section 6.5.

[4] **IF** determining or evaluating minimum detectable concentration for HPGe, **THEN** proceed to Section 6.6.

[5] **IF** evaluating precision of duplicate HPGe measurements, **THEN** proceed to Section 6.7.

[6] **IF** determining percent relative deviation between laboratory analytical and HPGe measurements (HPGe performance criteria), **THEN** proceed to Section 6.8.

[7] **IF** determining HPGe counting efficiency, **THEN** proceed to Section 6.9.

[8] **IF** preparing control charts, **THEN** proceed to Section 6.10.

[9] **IF** reviewing and transferring data, **THEN** proceed to Section 6.11.

[10] **IF** initiating a Nonconformance Report, **THEN** proceed to Section 6.12.

6.3 RSS Energy Calibration

Technician/Analyst

NOTE *Energy calibration is required daily on each detector prior to measurement collection. Energy calibration ensures that gamma photons with given energy levels are consistently detected in the same channels in a multi-channel analyzer.*

[1] Complete energy calibration for RSS in accordance with *Radiation Scanning System,* EQT-34.

[2] Check spectrum peak for Thallium (Tl-208) and for Lead (Pb-212) against criteria established in Table 1.

TABLE 1 - RSS and R-TRAK Energy Calibration Criteria

Source	Nuclide Measured	Channel Number	Energy
Thorium	Tl-208	447 ± 2	2614.5 keV
Thorium	Pb-212	40 ± 2	238.6 keV

NOTE *Each time pre-operations check is performed, Technician/Analyst shall ensure instrument is adjusted within established parameters.*

[3] **IF** detector can **NOT** be adjusted during pre-operational energy calibration to meet energy calibration criteria, **THEN** notify Field Supervisor.

Field Supervisor

[4] **IF** detector can **NOT** be adjusted during pre-operational energy calibration to meet energy calibration criteria, **THEN** ensure instrument is placed out of service and repaire **AND** initiate Nonconformance Report in accordance with Section 6.12.

Data Management Supervisor

[5] Review spectral data **AND** ensure spectrum peak is within energy calibration criteria established in Table 2.

TABLE 2 - RSS and R-TRAK Spectral Review Energy Calibration Criteria

Source	Nuclide Measured	Channel Number	Energy
Thorium	Tl-208	447 ± 10	2614.5 keV

[6] **IF** review of data reveals detector did **NOT** meet energy calibration criteria, **THEN** complete the following:

[a] Ensure instrument is placed out of service and repaired.

[b] Identify all spectral data requiring re-survey (if applicable).

[c] Initiate Nonconformance Report in accordance with Section 6.12.

6.4 R-TRAK Energy Calibration

Technician/Analyst

NOTE *Energy calibration is required daily on each detector prior to measurement collection. Energy calibration ensures that gamma photons with given energy levels are consistently detected in the same channels in a multi-channel analyzer.*

[1] Complete energy calibration for R-TRAK in accordance with *Operation of Radiation Tracking Vehicle Sodium Iodide Detection System,* EQT-30.

[2] Check spectrum peak for Thallium (Tl-208) and for Lead (Pb-212) against criteria established in Table 1.

NOTE *Each time pre-operations check is performed, Technician/Analyst shall ensure instrument is adjusted within established parameters.*

[3] **IF** detector can **NOT** be adjusted during pre-operational energy calibration to meet energy calibration criteria, **THEN** notify Field Supervisor.

Field Supervisor

[4] **IF** detector can **NOT** be adjusted during pre-operational energy calibration to meet energy calibration criteria, **THEN** ensure instrument is placed out of service and checked **AND** initiate Nonconformance Report in accordance with Section 6.12.

Data Management Supervisor

[5] Review spectral data **AND** ensure spectrum peak is within energy calibration criteria established in Table 2.

[6] **IF** review of data reveals detector did **NOT** meet energy calibration criteria, **THEN** complete the following:

[a] Ensure instrument is placed out of service and repaired.

[b] Identify all spectral data requiring re-survey (if applicable).

[c] Initiate Nonconformance Report in accordance with Section 6.12.

6.5 HPGe Operational Performance Checks

6.5.1 HPGe Pre-Operation Energy Calibration

Technician/Analyst

NOTE 1 *Energy calibration is required daily on each detector prior to measurement collection. Energy calibration ensures that gamma photons with given energy levels are consistently detected in the same channels in a multi-channel analyzer.*

NOTE 2 *Each time pre-operations check is performed, Technician/Analyst shall ensure instrument is adjusted within established parameters.*

[1] Perform 'Source Check Spectrum Acquisition' with Am/Cs/Co sources in accordance with *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*, EQT-23.

[2] Check peak of Am/Cs/Co spectrum against tolerance limits listed in Table 3 to ensure amplifier gain is set correctly.

TABLE 3 - Germanium Energy Calibration Criteria

Isotope	Channel	Energy
Americium-241	channel 158 ±1	59.5 keV
Cesium-137	channel 1763 ±2	661.6 keV
Cobalt-60	channel 3553 ±3	1332.5 keV

[3] **IF** adjustments are made to amplifier and resulting spectrum results are **NOT** within tolerance limits, **THEN** readjust amplifier settings **AND** recheck peak of Am/Cs/Co spectrum against tolerance limits listed in Table 3.

[4] **IF** recheck of spectrum results are **NOT** within acceptance limits, **THEN** notify Field supervisor.

Field Supervisor

[5] **IF** checks of spectrum results are **NOT** within acceptance limits, **THEN** ensure instrument is placed out of service and repaired **AND** initiate a Nonconformance Report in accordance with Section 6.12.

Technician/Analyst

[6] Perform energy calibration on each multi-channel analyzer (MCA) in accordance with *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*, EQT-23.

[7] Notify Custodian that energy calibration is complete and ready for control charting.

Custodian

[8] Plot photopeak resolution and net peak area measurements for each detector on individual control chart.

[9] Ensure photopeak resolution and net peak areas agree within specified tolerances listed in Table 4.

TABLE 4 - Photopeak Resolution and Net Peak Area Tolerance Limits

Nuclide	Energy, keV	Resolution	Net Peak Area, counts or cps
Co-60	1332.5	Measured mean of resolution ($\bar{x}$ ± 3 sigma)	pre-determined check source mean ($\bar{x}$ ± 3 sigma)

[10] **IF** results are within ± 2 sigma, **THEN** notify Field Supervisor that detector is ready for field measurements.

Field Supervisor

[11] **IF** results are within ± 2 sigma, **THEN** perform the following:

[a] **IF** detector is to be used for collection of field control station measurements, **THEN** notify Technician/Analyst to collect measurement in accordance with Section 6.5.2.

[b] **IF** detector is to be used for normal field measurements, **THEN** notify Technician/Analyst to collect measurement in accordance with Section 6.5.3.

Custodian

[12] **IF** result is outside ± 3 sigma, **THEN** notify Field Supervisor for further evaluation.

[13] **IF** result is outside ± 2 sigma **BUT** within ±3 sigma, **THEN** perform the following:

[a] Perform two additional measurements.

[b] Enter **AND** label two measurements on control chart.

[c] Check data to determine whether results indicate statistical variation or trend.

[d] **IF** both measurements are within ± 2 sigma, **THEN** notify Field Supervisor that detector is ready for field measurements.

[e] **IF** either measurement is outside ±2 sigma, **THEN** perform two more measurements.

[14] **IF** either of two measurements are still outside ±2 sigma, **THEN** notify Field Supervisor for further evaluations.

[15] **IF** photopeak resolution and net peak area do NOT agree within set parameter tolerance limits, THEN instrument must pass two source recounts to be placed in service.

Data Management Supervisor

[16] Review spectral data **AND** ensure photopeak resolution and net peak areas are within tolerance limits established in Table 3.

[17] **IF** review of data reveals detector did **NOT** meet tolerance limits, **THEN** ensure instrument is placed out of service and repaired.

6.5.2 Field Control Station Measurements

Technician/Analyst

NOTE *Field Control Stations are low background field measurement locations on FEMP site which have uranium concentrations at or near free release level for uranium. Measurements are made on each day field measurements are collected.*

[1] Perform 'Equipment Setup and Measurement' of detector in accordance with *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*, EQT-23 at Field Control Station.

[2] Ensure temperature and humidity have been received from Control and recorded.

[3] Ensure soil moisture reading is collected in accordance with *Troxler 3440 Series Surface Moisture/Density Gauge - Calibration, Operation, and Maintenance*, EQT-32.

Custodian

NOTE *Measurement data from spectrum for Total Uranium, Thorium-232 (Th-232), Radium-226 (Ra-226), and Potassium-40 (K-40) shall be entered onto control chart.*

[4] Plot photopeak resolution and net peak area measurements on control chart after spectrum acquisition is complete.

[5] Review measurement results for analytes identified in Table 5 **AND** evaluate if each falls within statistical criteria specified.

TABLE 5 - Field Control Station Measurement Evaluation Criteria

Radionuclide	Evaluation Criteria
Total Uranium	measured value ±3 sigma
Th-232	measured value ±3 sigma
Ra-226	measured value ±3 sigma
K-40	measured value ±3 sigma

[6] **IF** all analyte results are within ±3 sigma for morning field control station measurement, **THEN** notify Technician/Analyst to collect field measurements in accordance with Section 6.5.3.

[7] **IF** all analyte results are within ±3 sigma for afternoon field control station measurement, **THEN** notify Technician/Analyst to conduct post-operational energy check in accordance with Section 6.5.4.

[8] **IF** any analyte falls outside of measured value ±3 sigma, **THEN** notify Field Supervisor for further evaluations.

Field Supervisor

[9] **IF** any analyte falls outside of measured value ±3 sigma, **THEN** identify **AND** resolve data difference.

Data Management Supervisor

[10] Review spectral data **AND** evaluate whether photopeak resolution and net peak areas for each analyte listed in Table 5 falls within statistical criteria specified.

[11] **IF** any analyte falls outside of measured value ±3 sigma, **THEN** identify **AND** resolve data difference.

6.5.3 Field Measurement Interference Check

Technician/Analyst

NOTE *Interference check must be conducted for each spectrum acquired during course of day.*

[1] Perform 'Equipment Setup and Measurement' of detector in accordance with *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*, EQT-23.

NOTE *Exceedence of resolution acceptance criteria is indication of spectral interference (i.e., Thorium-232 decay chain).*

[2] Ensure resolution meets acceptance criteria established in Table 6 for HPGe detector **PRIOR** to saving spectral data.

TABLE 6 - HPGe Field Measurement Interference

Nuclide	Acceptance Criteria	
	Channel Number = 3895.0	Energy (keV) = 1460.8
K-40	FWHM ≤ 8.0	FWHM ≤ 3.0

[3] **IF** FWHM is ≥ 8.0 channels (or 3.0 keV), **THEN** contact Field Supervisor for guidance **PRIOR** to proceeding.

Field Supervisor

[4] Determine if additional field measurements will be necessary to compensate for interference.

[5] **IF** measurements for day are complete and detector is to be used for collection of field control station measurement, **THEN** notify Technician/Analyst to collect measurement in accordance with Section 6.5.2.

[6] **IF** measurements for day are complete and detector is **NOT** to be used for collection of field control station measurement, **THEN** notify Technician/Analyst to collect post-operational energy check measurement in accordance with Section 6.5.4.

6.5.4 HPGe Post-Operational Energy Check

Technician/Analyst

NOTE *Energy calibration is required daily for each detector after completion of measurement collection. This check is performed to ensure that system has maintained energy calibration and that system resolution is acceptable. No adjustments are performed during post-operation energy calibration.*

[1] Conduct 'Post-Operation Check' in accordance with *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*, EQT-23.

Custodian

[2] Check peak location of Am/Cs/Co spectrum against tolerance limits listed in Table 3.

[3] **IF** photopeak resolution and net peak area for Co-60 does **NOT** agree within tolerance limits established in Table 4, **THEN** notify Field Supervisor.

Field Supervisor

[4] **IF** detector photopeak resolution and net peak area for Co-60 does **NOT** agree within tolerance limits established in Table 4, **THEN** complete the following:

[a] Identify all spectral data since last energy calibration requiring re-survey.

[b] Initiate Nonconformance Report in accordance with Section 6.12.

Data Management Supervisor

[5] Review spectral data **AND** ensure photopeak resolution and net peak area for Co-60 are within tolerance limits established in Table 4.

[6] **IF** review of data reveals detector did **NOT** meet tolerance limits for Co-60, **THEN** complete the following:

[a] Identify all spectral data requiring re-survey (if applicable).

[b] Initiate Nonconformance Report in accordance with Section 6.12.

6.6 Minimum Detectable Concentration

Field Supervisor

[1] Select location for collection of MDC measurements; which has been determined to have activity at or near background levels for primary constituents of concern radionuclides.

Technician/Analyst

NOTE *MDC will be updated quarterly using seven separate measurements collected in afternoon.*

[2] Position detector at field location selected by Field Supervisor.

[3] Perform 'Equipment Setup and Measurement' of detector in accordance with *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*, EQT-23 at field location.

Data Management Supervisor

[4] Calculate MDC using the following formula:

$$MDC\ (pCi/g) = K(2.71 + 4.65\ s_b)$$

where:

K = conversion (efficiency) factor for each spectrum region of interest.
s_b = standard deviation of background counts. For MDC measurements, s_b is square root of counting background for region of interest. Value for background is obtained by subtracting net counts from gross counts for region of interest.

[5] Compile list of MDC for each detector for primary radionuclide constituents of concern.

[6] Identify **AND** document the Analytical Support Level (ASL) at which each detector may be used to operate referencing Table 7.

TABLE 7 - Minimum Detectable Concentration

QC Element	Frequency	Acceptance Criteria	
Minimum Detectable Concentration	Quarterly	ASL D ASL B	95% UCL* <FRLs 90% UCL <FRLs

*Upper confidence limit (UCL)

6.7 Precision of Duplicate HPGe Measurements

Technician/Analyst

NOTE *At least one duplicate HPGe measurement shall be performed with every 20 HPGe measurements.*

[1] Collect two consecutive measurements at same location and for same amount of time in accordance with *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*, EQT-23.

Data Management Supervisor

[2] Determine whether precision of duplicates for constituents of concern is within acceptable limits by using acceptance criteria found in Table 8 to compare two HPGe readings.

TABLE 8 - HPGe Duplicate Measurement Precision

QC Element	Frequency	Acceptance Criteria
Precision of Duplicates	At least one per every 20 HPGe measurements.	If measured value >(5 x MDC), then Relative Percent Difference ≤ ±20% If measured value <(5 x MDC), then measurement difference ≤ ±MDC

[3] **IF** precision does **NOT** agree within tolerance limits, **THEN** complete the following:

[a] Identify all spectral data that will require re-survey.

[b] Initiate Nonconformance Report in accordance with Section 6.12.

[c] Identify and resolve cause for acceptance criteria failure.

6.8 HPGe Performance Criteria

Field Supervisor

NOTE *HPGe performance criteria and percent relative deviation between laboratory analytical and HPGe measurements shall be determined annually for each detector.*

[1] Identify locations to be measured to conduct comparability data collection.

Technician/Analyst

[2] Acquire two spectra at location identified by Field Supervisor, save data, **AND** document collection in accordance with *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*, EQT-23 for the following nuclides:

- Total Uranium (ppm),
- Th-232 (pCi/g),
- Ra-226 (pCi/g) both morning and evening measurements, and
- K-40.

Field Supervisor

[3] Ensure physical samples are collected from depth of zero to six inches at location measured and submitted to analytical laboratory for nuclides listed in Step [2].

Data Management Supervisor

[4] Determine relative percent deviation of means using the following formula:

$$\textit{Relative Percent Deviation} = \left[\frac{\bar{x}_1 - \bar{x}_2}{\bar{x}}\right] \times 100$$

Where:

$\bar{x}_1$ - mean of laboratory data weighted* to simulate HPGe measurements at given detector height,

$\bar{x}_2$ - mean of duplicates for HPGe measurements at given detector height, and

$\bar{x}$ - average of two means.

* 20701-RP-0001, Comparability of In-Situ Gamma Spectrometry and Laboratory Data, July 14, 1997. Weighting factor are given in Tables 2-2, 2-3, and 2-4. Computational methods are given in Section 3.2.2.

[5] Determine which acceptance criteria is appropriate for percent relative deviation of means using limits established in Table 9.

TABLE 9 - Analytical Laboratory Data Comparability

QC Element	Frequency	Classification	Evaluation Criteria
Relative Percent Deviation	Annually	Very Similar Acceptably Similar Dissimilar	<20% acceptable >20% & <35% acceptable >35% unacceptable

[6] Determine whether each HPGe meets acceptance criteria identified in Table 10 for accuracy and precision.

TABLE 10 - Accuracy and Precision

QC Element	Frequency	Acceptance Criteria
Accuracy	Annually	ASL D - weighted average of physical samples ±20% ASL B - weighted average of physical samples ±35%
Bias	Annually	Bias is acceptable unless it leads to errors that result in accuracy criteria being exceeded.

[7] Identify **AND** document on appropriate *Characterization Data Sheet,* FS-F-4780 ASL at which each detector may be used to operate referencing Table 10.

[8] **IF** detector does **NOT** meet criteria specified in Table 10 for either ASL, **THEN** identify **AND** resolve cause for criteria failure.

6.9 HPGe Detector Counting Efficiency Determination

Technician/Analyst

NOTE *Following initial measurements to determine detector counting efficiency, detectors are efficiency calibrated annually or after detector repairs effecting physical characteristics of detector element.*

[1] Collect source measurements for each detector in accordance with *Characterization of Gamma Sensitive Detectors,* EQT-22.

[2] Calculate efficiency for each detector in accordance with EGAS (See Attachment B for example of detector counting efficiency calculation).

Data Management Supervisor

[3] Review spectral data.

[4] **IF** annual remeasurement for detector counting determination was acquired, **THEN** ensure detector efficiency for each energy peak is within conversion factor tolerance limits listed in Table 11.

TABLE 11 - HPGe Detector Counting Efficiency Determination

QC Element	Frequency	Acceptance Criteria
Conversion Factor	Annually	Initial conversion factor ±10% for each gamma energy.

[5] **IF** conversion factor is **NOT** within tolerance limits, **THEN** complete the following:

[a] Ensure instrument is placed out of service and repaired.

[b] Initiate Nonconformance Report in accordance with Section 6.12.

6.10 Control Chart Preparation and Maintenance

Custodian

NOTE 1 *Measurement of daily/before use check standard precludes necessity of performing full instrument calibration prior to each use, assures equipment is maintained in characteristic state of control and is proof of integrity of measurements being conducted. Control charting is done in EXCEL®. Process for creating and managing control charts listed in this procedure reflect method used in this program.*

NOTE 2 *Photopeaks from each nuclide measured during pre-operation energy calibration may be control charted, but only Co-60 peak parameters must be control charted (see Attachment A for parameters to control chart). Initial control charts are prepared by obtaining at least 20 separate spectrum (counts) of Co-60.*

[1] Collect peak channel, resolution, and net peak area data (Section 6.5.1, Step [8]) from last 20 pre-operation energy calibrations conducted for detector.

[2] IF 20 or more separate counts of source have **NOT** already been acquired as part of normal calibration or field counting, **THEN** acquire sufficient spectrum to total 20 total counts of check source in accordance with Section 6.5.1 to create initial control chart.

[3] Ensure count time is long enough to assure the counting uncertainty for each photopeak control charted is less than 5%.

NOTE *It is important to duplicate movement and placement of source during operational check counting by removing source from and then placing it back into repeatable counting geometry.*

[4] IF multiple spectra of Co-60 will be counted for initial control chart, **THEN** remove source from **AND** replace into repeatable geometry.

[5] Record the following information for each separate spectrum count:

- detector serial number,
- analyst's name and badge number,
- date and time of spectrum acquisition,
- check source identification number(s),
- resolution (FWHM) of peak(s) used on control chart,
- net peak area (counts) of each peak in each of spectrum, and
- counting time.

Custodian

[6] Determine counts rate [counts per second (cps)] for peak(s) in each spectrum using the following formula:

$$x_i = \frac{\text{Net peak area (counts)}}{\text{Counting time (seconds/minutes)}}$$

NOTE *Net count rate is multiplied by conversion (efficiency) factor to produce disintegration rate.*

[7] Determine mean net peak area of $\bar{x}$ using the following formula:

$$\bar{x} = \sum \frac{x_i}{n}$$

where:
x_i = individual count rates
n = number of individual measurements
$\bar{x}$ = mean net count rate

[8] Determine standard deviation (s) of $\bar{x}$ by performing the following:

$$s = \sqrt{\frac{\sum (\bar{x} - x_i)}{n - 1}}$$

where:
s = standard deviation
x_i = individual count rates
n = number of individual measurements
$\bar{x}$ = mean net count rate

[9] Multiply standard deviation (s) by 2 or 3, respectively to determine warning (±2 sigma) and control (±3 sigma) limit values for control chart.

NOTE *Example Quality Control Chart can be found Attachment C.*

[10] Prepare control chart by completing the following on graph:

[a] Place consecutive calendar dates on x-axis.

[b] Define ranges on y-axis using the following values:

- $\bar{x}$ as central or average value for check source count,
- ± 2 sigma as upper and lower warning limits, and
- ± 3 sigma as upper and lower control limits.

[11] Determine radioactive decay correction using the following equation:

$$A = A_0 e^{-\lambda t}$$

where:	A	=	The source activity at the time of measurement.
	A_0	=	The source activity at the time the source was prepared.
	λ	=	The radioactive decay constant.
	t	=	The time elapsed between A_0 and A.

[12] Correct check sources for radioactive decay to account for reduction in source activity between starting and ending dates on control chart.

[13] Plot control chart data (i.e., resolution, net peak area) on appropriate graph corresponding with calendar date of collection on a weekly basis.

NOTE *Statistically, certain number of counts on system are expected to fall outside control chart limits if system is behaving as expected.*

[14] **IF** result exceeds control chart limit (warning or control), **THEN** record result on control chart **AND** take corrective action listed in appropriate Section of this procedure corresponding to QC element being measured.

[15] Report any trends or charting problems to the Data Management Supervisor.

Data Management Supervisor

[16] Review the control charts quarterly.

[17] **IF** all control charts have been resolved of problems, **THEN** instruct Custodian that previous quarter's control charts can be printed and filed.

Custodian

[18] Print out **AND** file control charts as instructed by the Data Management Supervisor.

[19] Construct new control charts as instructed beginning in Step [1].

6.11 Data Review and Approval

Technician/Analyst

[1] Record date, detector number, and run numbers on label(s) of data disk with electronic files for pre-operation check, post-operation check, and field measurements.

[2]. List following information for data disk in Step [1] on *Field Electronic Data Disk Transfer Log,* FS-F-5070 (see Attachment D):

- detector number,
- printed name of team members,
- date data was collected, and
- beginning and ending file numbers.

[3] Forward completed *Gamma Spectrometry Field Worksheet(s),* FS-F-4781 to Field Supervisor for review.

NOTE *Every time data disk changes custody it must be documented on* Field Electronic Data Disk Transfer Log, *FS-F-5070. This log is record of electronic file transfer only; signatories are not responsible for file content.*

[4] Transfer electronic files for pre-operation check, post-operation check, and field measurements by placing signature, badge number, date, and time of transfer in "Disk Relinquished by" box of *Field Electronic Data Disk Transfer Log,* FS-F-5070.

Field Supervisor

[5] Receive electronic spectral data by placing signature, badge number, date, and time of receipt in "Disk received by" box of *Field Electronic Data Disk Transfer Log,* FS-F-5070.

[6] Review *Gamma Spectrometry Field Worksheet,* FS-F-4781 and spectral data **AND** ensure the following:

- all sequential file names are accounted for on *Gamma Spectrometry Field Worksheet,* FS-F-4781, and
- sequential file names **NOT** available or applicable to project are documented on *Gamma Spectrometry Field Worksheet,* FS-F-4781, or Data Entry Lead of Remediation Data Management is notified that particular file will **NOT** be available.

[7] **IF** file names are **NOT** accounted for on *Gamma spectrometry Field Worksheet,* FS-F-4781, **THEN** resolve status of files **NOT** accounted for on worksheet.

NOTE *Signature indicates Field Supervisor has reviewed and approved worksheet and corresponding spectral data.*

[8] Sign *Gamma Spectrometry Field Worksheet,* FS-F-4781.

[9] Transfer computer data files (electronic spectral/count data) to appropriate project data management section by copying to designated file on LAN in a timely manner (typically same day as available) **AND** note transfer on *Field Electronic Data Disk Transfer Log,* FS-F-5070 by initialing and dating applicable boxes.

[10] **IF** electronic files are deleted from data disk for disk reuse, **THEN** note deletion on *Field Electronic Data Disk Transfer Log,* FS-F-5070 by initialing and dating applicable boxes.

[11] Forward copies of associated *Gamma Spectrometry Field Worksheet,* FS-F-4781 to Data Entry Lead of Remediation Data Management in timely manner (typically same day as available).

[12] Transfer copy of following field documents to appropriate project data management section:

- *Field Activity Log,* FS-F-3682, and
- *Gamma Spectrometry Field Worksheet,* FS-F-4781.

[13] Forward corrections made to *Gamma Spectrometry Field Worksheet,* FS-F-4781 or data files to appropriate data management files and to Data Entry Lead of Remediation Data Management in timely manner (typically same day as available).

6.12 Initiating Nonconformance Report

Field Supervisor

NOTE *Incomplete measurement does* ***NOT*** *necessitate the initiation of a Nonconformance.*

[1] Acquire copy of *Nonconformance Information Form,* FS-F-5080 (See Attachment E) to identify nonconforming condition or equipment.

[2] Check box of requirement corresponding with nonconforming condition or equipment identified **AND** identify condition.

[3] List any measurements that would be affected by nonconforming condition.

[4] Give completed *Nonconformance Information Form,* FS-F-5080 to Quality Assurance representative to process with Nonconformance Report (NCR) in accordance with *FDF Nonconformance Identification and Tracking System,* QA-0001.

[5] Identify to Quality Assurance corrective action taken to correct nonconforming condition or equipment.

7.0 RECORDS

NOTE *Records generated by this procedure are project specific. Records shall be retained by Field Supervisor in fire-proof cabinets up to one year or until after completion of remediation area, whichever is longer. At completion of project needs, records will be transferred and stored in accordance with* disposition of Records: Transfer and Retrieval, *MS-0002.*

Forms: *Field Electronic Data Transfer Log,* FS-F-5070
Gamma Spectrometry Field Worksheet, FS-F-4781
Nonconformance Information Form, FS-F-5080
Computer Data Files (electronic spectral/count data)
QC Charts

8.0 DRIVERS

FEMP Quality Assurance Program Description, RM-0012

FEMP Sitewide CERCLA Quality Assurance Project Plan (SCQ), FD-1000

Real Time Instrumentation Measurement Program Quality Assurance Plan, 20300-PL-002

9.0 REFERENCES

ASTM Method D3856-88.

ASTM Practice D4210-89.

ASTM Method D5283-92.

Comparability of In-Situ Gamma Spectrometry and Laboratory Data, 20701-RP-0001.

Comparability of In-Situ Gamma Spectrometry and Laboratory Measurements of Radon-226, 20701-RP-0001 Addendum.

Comparability of Total Uranium Data as Measured by In-Situ Gamma Spectrometry and Four Laboratory Methods, 20701-RP-0001 Addendum.

Environmental Sampling and Analysis, L.H. Keith, Lewis Publishers: Chelsea, MI, 1991, Section II.

Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors, EQT-23.

Operation of Radiation Tracking Vehicle Sodium Iodide Detection System, EQT-30.

Operation of Radiation Scanning System (RSS), EQT-34.

Quality Assurance in Analytical Chemistry, Werner Funk, Vera Dammann and Gerhild Donnevert, VCH Publishers: New York, 1995 (Translated by Ann Gray).

Radiation Source Accountability and Control, RP-0014, Radiological Control Department

R-TRAK Applicability Measurements in Locations of Elevated Radionuclide Concentrations, 20701-RP-002 Addendum.

R-TRAK Applicability Study, 20701-RP-002.

Theory and Problems of Statistics, Murray R. Speigel, 2nd edition, Mcgraw Hill Inc.: New Yo. 1995.

Users Guidelines, Measurement Strategies, and Operational Factors for Deployment of In-Situ Gamma Spectrometry at the Fernald Site, 20701-RP-0006.

ATTACHMENT A

Tabulation of Quality Control Criteria and Requirements

R-TRAK and RSS Detector QC Criteria and Requirements

QC Element	Nuclide	Gamma Energy	QC Criteria	Frequency	Control Chart
Energy Calibration	Tl-208 Pb-212	2614.5 keV 238.6 keV	Channel 447 ± 2 Channel 40 ± 2	Days used, prior to use	No

HPGe Detector QC Criteria and Requirements

QC Element	Nuclide	Gamma Energy	QC Criteria	Frequency	Control Chart
Energy Calibration	Am-241 Cs-137 Co-60	59.5 keV 661.6 keV 1332.5 keV	Channel 158 ± 1 Channel 1763 ± 2 Channel 3553 ± 3	Days used, prior to use	No
Detector Resolution	Co-60	1332.5	Measured mean value $\bar{x} \pm 3$ sigma	Days used, prior to use	Yes
Detector Counting Efficiency Check	Co-60	1332.5	pre-determined check source value (decay corrected) $\bar{x} \pm 3$ sigma	Days used, prior to use	Yes

ATTACHMENT A

Tabulation of Quality Control Criteria and Requirements

HPGe Field Measurements QC Criteria and Requirements

QC Element	Gamma Energy Nuclide or Basis	QC Acceptance Criteria	Frequency	Control Chart
Field Measurement Interference	1460.8 keV	keV = 1460.8 FWHM ≤ 3.0 keV. or Channel = 3895.0 FWHM ≤ 8 Channels	Each time measurements are made	No
Field Control Station	Total U Th-232 Ra-226 K-40	ASL -D measured value ±3 sigma measured value ±3 sigma measured value ±3 sigma measured value ±3 sigma	On each day measurements are made	Yes
Field Control Station	Temperature Humidity Soil Moisture	No Criteria	Each day measurements are made	No
Minimum Detectable Concentration	Free Release Levels for Nuclides of Concern	For ASL-D 95% UCL[1] <FRLs For ASL-B 90% UCL[1] <FRLs	Quarterly	No

Note 1. The upper confidence level (UCL) for the MDC.

ATTACHMENT A

Tabulation of Quality Control Criteria and Requirements

HPGe Field Measurements QC Criteria and Requirements (cont.)

QC Element	Gamma Energy Nuclide or Basis	QC Acceptance Criteria	Frequency	Control Chart
Measurement Accuracy	Compared to weighted average of physical samples	ASL-D - weighted average of physical sample ±20% ASL-B - weighted average of physical sample ±35%	Annually	No
Measurement Bias	Compared to weighted average of physical samples	Bias acceptable unless it produces errors resulting in accuracy being exceeded	Annually	No
Precision of Duplicates	At least one per every 20 HPGe measurements.	measured value >(5 x MDC) then RPD ≤±20% measured value <(5 x MDC) then measurement difference ≤ ±MDC	At least one per every 20 HPGe measurements.	No
Detector Counting Efficiency Determinatio n	Determination of conversion (efficiency) factors.	initial conversion factor ±10% for each gamma energy[2]	Annually	No

Note 2. Nuclide and Gamma energies measured:

Cs-137	32.2
Eu-152	39.5
Am-241	59.5
Eu-152	121.8
Eu-152	244.7
Eu-152	344.3
Eu-152	411.1
Eu-152	444.0
Eu-152	661.6
Cs-137	778.9
Eu-152	964.0
Eu-152	1173.7
Co-60	1332.5
Co-60	1408.0

ATTACHMENT B

EXAMPLE HPGe Detector Counting Efficiency (Conversion Factor) Calculation

On October 27, 1997 an annual efficiency calibration was performed on HPGe detector number 30687 in accordance with operating procedure EQT-22. Spectra acquired from this calibration were used in conjunction with EGAS software to determine gamma conversion factors for detector.

In this exercise, equations used in EGAS are used to perform hand calculations to demonstrate how measurement data are used and how conversion factors are determined. Due to complexity of calculation, conversion factors will only be determined for two gamma energy lines, 59.5 keV peak of Am-241 and 661.6 keV peak of Cs-137. In actual calibration, conversion factors are determined using EGAS at 14 different gamma energies to produce detector conversion factors graph. However, conversion factor at each of these 14 points is calculated in same manner.

Step 1 - Determine Detector Effective Area

This term geometrically relates source strength to relative count rate of detector. Equation as follows:

$$A_0 = \frac{4\pi r^2 \ N/T}{S_0} \times e^{r/\lambda_a}$$

Where: A_0 = detector effective area as determined by measurement made at 0 degrees normal to detector fa[c]e in units of cm^2 cps/γ/s

- r = source to detector distance (cm)
- N = signal or net counts
- T = count time (seconds)
- S_0 = source strength, γ/s or dps. Disintegration rate is equal to decay corrected dps x gamma yield for energy measured.
- **NOTE** *Hand calculation uses branching ratio of 0.359 for Am-241 at 59.5 keV which may be slightly different from EGAS. Branching ratio used for Cs-137 at 661.6 keV is 0.8462 which is same as value used by EGAS.*
- λ_a = mean free path in air for gamma energy (cm)

Am-241 at 59.5 keV

Values for terms in equation are obtained from two 0° measurements of Am-241 source made on 10/27/97 , EGAS reference information and radioactive decay corrections of measurement sources and gamma branching ratios. Data are found in Table 1.

Table 1

N (counts)	T (seconds)	r (cm)	S_0 (dps)	λ_a (cm)
22571 ± 160	60	100	1.370×10^6	4369.46
22454 ± 157	60	100	1.370×10^6	4369.46

NOTE *Value for λ_a for Am-241 at 59.5 keV was supplied by Ron Reiman for use with EGAS.*

ATTACHMENT B

EXAMPLE HPGe Detector Counting Efficiency (Conversion Factor) Calculation

S_0 at 59.5 keV was determined using radioactive decay equation as follows:

$$A = A_0 e^{-\lambda t}$$

Where: A = source activity at time of measurement
A_0 = original source activity at time of preparation
= 103.4 μCi for Am-241
= 105.7 μCi for Cs-137
λ = radioactive decay factor = ln 2/half life
For Am-241, λ = 0.693/432.2 years = 1.604 x 10^{-3}/year
For Cs-137, λ = 0.693/30.17 years = 2.297 x 10^{-2}/yr
t = time elapsed between source preparation and measurement
= For Am-241 prepared on 4/15/96 = 560 days or 1.534 years
= For Cs-137 prepared on 3/15/96 = 591 days or 1.6192 years

Am-241 Decay Correction

$$A\ (Activity) = 103.4\ \mu Ci\ e^{-1.604^{-3}/yr\ x\ 1.534\ yr} = 103.15\ \mu Ci$$

Converting μCi to dps

$$A\ (\text{Activity}) = 103.15\ \mu\text{Ci} \times 3.7 \times 10^4\ \text{dps}/\mu\text{Ci} = 3.816 \times 10^6$$

$$S_0 = 3.816 \times 10^6\ \text{dps} \times 0.359\ (\text{branching factor}) = 1.370 \times 10^6\ \gamma/\text{sec.}$$

Effective area (A_0) for first count is:

$$A_0 = \frac{4\ x\ 3.1416\ x\ (100\ cm)^2\ x\ (22571\ counts/60\ seconds)}{1.370\ x\ 10^6\ dps}\ x\ e^{\frac{100\ cm}{4369.46\ cm}} = \underline{35.30}\ \frac{cm^2\ cps}{\gamma/sec}$$

Effective area (A_0) for second count is:

$$A_0 = \frac{4\ x\ 3.1416\ x\ (100\ cm)^2\ x\ (22454\ counts/60\ seconds)}{1.370\ x\ 10^6\ dps}\ x\ e^{\frac{100\ cm}{4369.46\ cm}} = \underline{35.12}\ \frac{cm^2\ cps}{\gamma/sec}$$

In comparison, A_0 values from EGAS at 59.5 keV are respectively 35.90 and 35.70 cm^2 cps/dps.

EXAMPLE HPGe Detector Counting Efficiency (Conversion Factor) Calculation

Cs-137 at 661.6 keV

Values for terms in equation are obtained from two 0° measurements of Cs-137 source made on 10/27/97 , EGAS reference information and radioactive decay corrections of measurement sources and gamma branching ratios. Data are found in Table 2.

Table 2

N (counts)	T (seconds)	r (cm)	S_0 (dps)	λ_a (cm)
20938	60	100	3.519×10^6	10044.09
20539	60	100	3.519×10^6	10044.09

NOTE *Value for λ_a were supplied by Ron Reiman for use with EGAS.*

S_0 at 661.6 keV was also determined using radioactive decay equation as previously explained.

Cs-137 Decay Correction

$$A\ (Activity) = 109.7\ \mu Ci\ e^{-2.297^{-2}/yr \times 1.6192\ yr} = 105.69\ \mu Ci$$

$$A\ (Activity) = 105.69\ \mu Ci \times 3.7 \times 10^4\ dps/\mu Ci = 3.911 \times 10^6\ dps$$

$$S_0 = 3.911 \times 10^6 \times 0.8462\ (branching\ factor) = 3.309 \times 10^6\ \gamma/sec$$

Effective area (A_0) for first count is:

$$A_0 = \frac{4 \times 3.1416 \times (100\ cm)^2 \times (20938\ counts/60\ seconds)}{3.309 \times 10^6\ \gamma/sec} \times e^{\frac{100\ cm}{10044.09\ cm}} = \underline{13.12}\ \frac{cm^2\ cps}{\gamma/sec}$$

Effective area (A_0) for second count is:

$$A_0 = \frac{4 \times 3.1416 \times (100\ cm)^2 \times (20539\ counts/60\ seconds)}{3.309 \times 10^6\ dps} \times e^{\frac{100\ cm}{10044.09\ cm}} = \underline{12.87}\ \frac{cm^2\ cps}{dps}$$

In comparison, A_0 values from EGAS are respectively 13.15 and 13.13 cm^2 cps/dps.

Step 2 - Determine Rθ

Am-241 at 59.5 keV

This term is ratio of detector response in counts at angle θ to response at θ = 0°.

$$R\theta = \frac{Counts\ at\ \angle\ \theta}{Counts\ at\ \theta = 0\ degrees}$$

ATTACHMENT B

EXAMPLE HPGe Detector Counting Efficiency (Conversion Factor) Calculation

For this determination, two count measurements at $\theta = 0°$ for 59.5 keV given in Table 1 are averaged. Average value is 22512.5 counts. Measurement for $\theta = 10°$ is 23540 counts. Value for Rθ is:

$$R\theta = \frac{23540\ counts}{22512.5\ counts} = 1.046$$

To determine counting efficiency at 59.5 keV, Rθ values for all angular measurements must be determined. Data are found in Table 3.

Table 3

Measurement Angle	Net Peak Counts	Rθ
10°	23540	1.046
20°	25366	1.127
30°	26935	1.196
40°	29191	1.297
50°	30366	1.349
60°	30803	1.368
70°	33556	1.491
80°	29246	1.299
90°	27922	1.240

<u>Cs-137 at 661.6 keV</u>

Average value for two A_0 counts for Cs-137 (from Table 2) is 20738.5 counts. Rθ values for Cs-137 at 661.6 keV are:

Table 4

Measurement Angle	Net Peak Counts	Rθ
10°	20963	1.011
20°	22073	1.064
30°	22288	1.075
40°	23120	1.115
50°	23840	1.150
60°	24461	1.179
70°	25268	1.218
80°	25434	1.226
90°	20539	0.990

ATTACHMENT B

EXAMPLE HPGe Detector Counting Efficiency (Conversion Factor) Calculation

Step 3 Integrate Information from Steps 1 and 2 into Geometric Efficiency Calculation

This calculation is done to determine counting efficiencies (conversion factors) at 59.5 keV and 661.6 keV Equation used for calculation and assumptions made while using equation are as follows:

$$\frac{S_v^z/\rho}{N_p} = \frac{1 - e^{-\alpha z}}{\alpha z} \beta \left[\frac{A_0 \rho_s}{2} \int_0^{\pi/2} \frac{R(\theta) \tan\theta \, e^{-(\mu/\rho)_a \rho_a h \sec\theta}}{\alpha + (\mu/\rho)_s \rho_s \sec\theta}\right]^{-1}$$

Where: S_v^z = activity per unit volume at some depth z beneath surface, (γ/s)/cm³.

N_p = net photopeak count rate (cps)

β = conversion factor to convert γ/s (dps) to pCi/g for specific isotope.
1 pCi = 3.7 x 10^{-2} dps.

A_0 = detector effective area at 0° in units of cm² cps/γ/s. A_0 values are:
Am-241 = 33.72 and 33.55. The average = 33.64
Cs-137 = 13.11 and 12.87. The average = 12.99

Rθ = ratio of detector's response at angle θ to that at θ = 0 degrees. Rθ values are giver Tables 3 and 4.

$(\mu/\rho)_a$ = air attenuation coefficient, cm²/g; term varies with nuclide energy.
Am-241 = 1.77 x 10^{-1} cm²/g at 59.5 keV.

Cs-137 = 7.70 x 10^{-2} cm²/g at 661.6 keV.

$(\mu/\rho)_s$ = soil attenuation coefficient, cm²/g; term varies with nuclide energy
Am-241 = 2.48 x 10^{-1} cm²/g at 59.5 keV
Cs-137 = 7.81 x 10^{-2} cm²/g at 661.6 keV

ρ_a = air density, g/cm3; value used is 0.001293 g/cm³.

ρ_s = soil density, g/cm³; value used is 1.5 g/cm³ .

α = reciprocal of relaxation length, cm^{-1}.
= 1 x 10^{-6}/cm for sub-surface deposits (used for this calculation) and 1 x 10^{6}/cm for surface deposits.

Note Relaxation length is thickness of material required to reduce concentration to 1/e of original concentration.

z = depth beneath surface (cm); value used is 3 cm.

h = detector height above measurement plane (cm); for 1 meter measurement, value is 100 cm.

Due to complexity of integration of 9 angular measurements for each gamma energy, determination was performed using three FORTRAN subroutines prepared by Ron White from the following reference:

"Numerical Recipes in Fortran, The Art of Scientific Computing", W. H. Press, S.A. Teukolsky, W.T. Vettering and B. P. Flannery, Second Edition, Cambridge University Press, 1992.

Subroutines used from this reference are as follows:

1. Page 131, SUBROUTINE trapzd(func, a, b,s,n).
2. Page 131 SUBROUTINE qtrap(func, a, b, s).
3. Page 103 SUBROUTINE polint(xa, ya, n, x, y, dy).

ATTACHMENT B

EXAMPLE HPGe Detector Counting Efficiency (Conversion Factor) Calculation

Results of numerical integrations compared to EGAS values are given in Table 5.

Table 5

Nuclide	Energy (keV)	Conversion Factor (pCi/g/cps) Calculated	Conversion Factor (pCi/g/cps) EGAS
Am-241	59.5	0.318	0.321
Cs-137	661.6	0.291	0.268

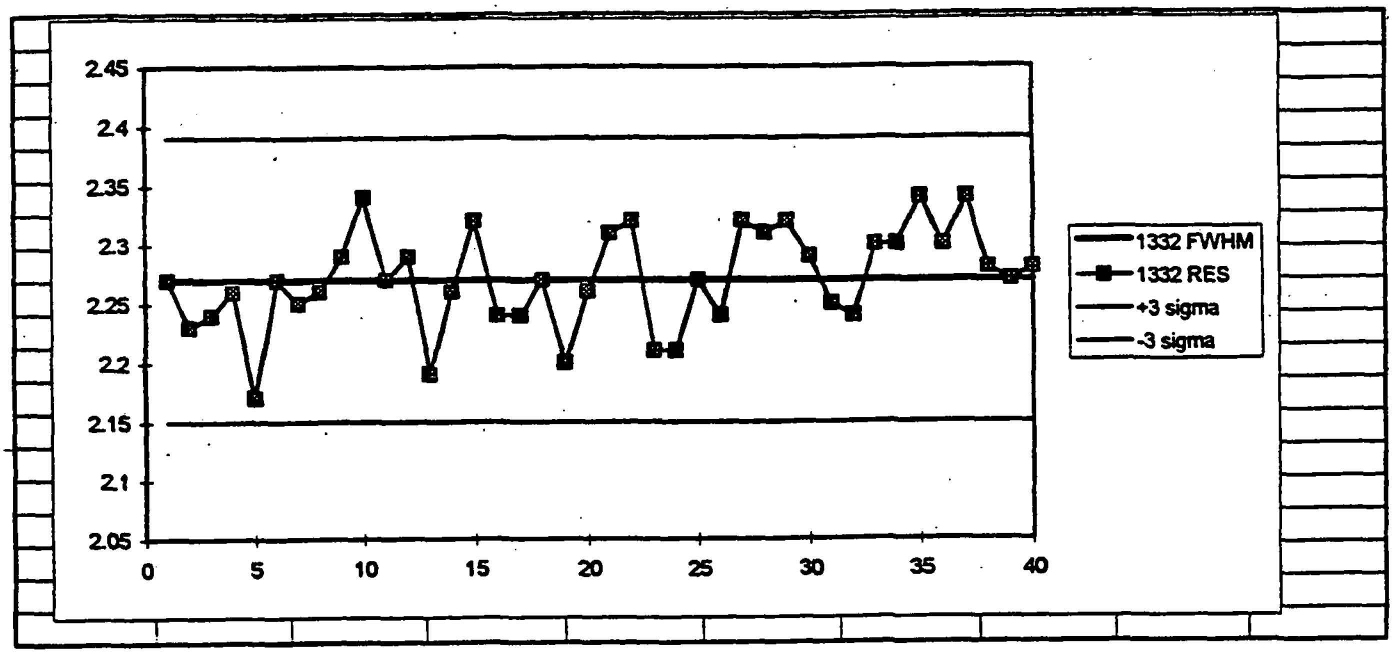
For Am-241, calculated value is ~ 1% lower than EGAS value.
For Cs-137, calculated value is ~ 8.6% higher than EGAS value.

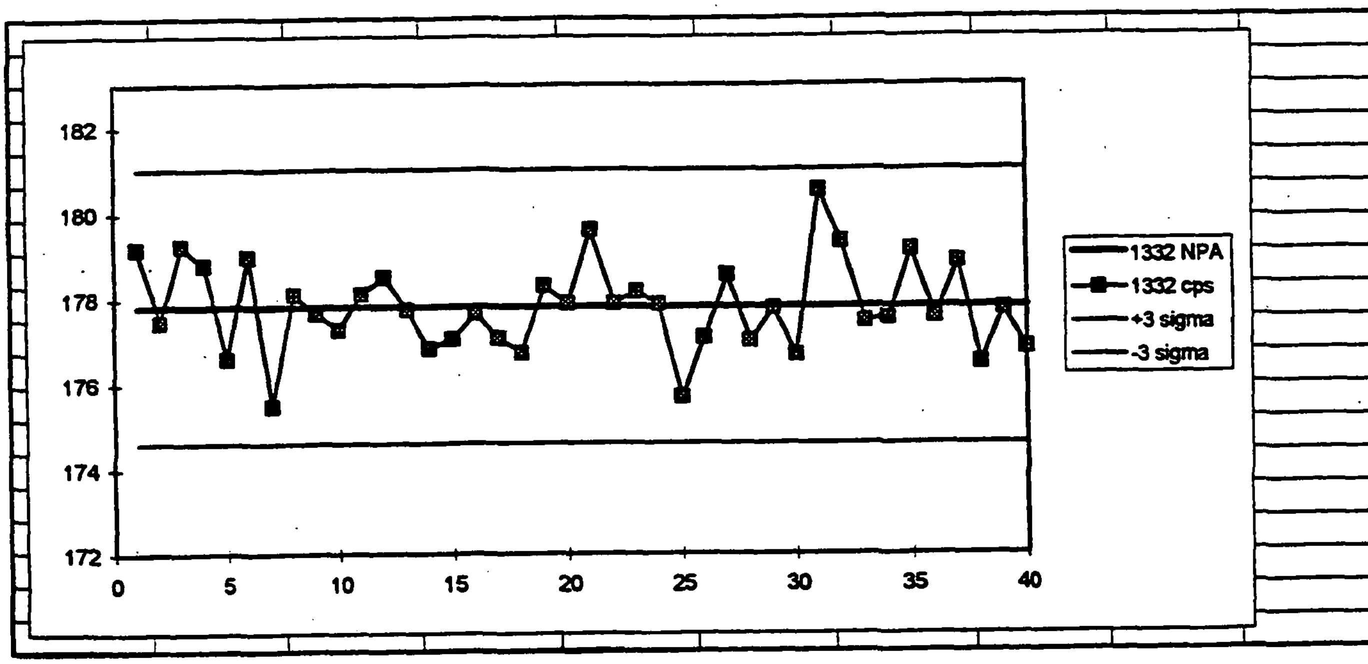
ATTACHMENT C
EXAMPLE Quality Control Chart

Page 1 of 2

30687 QA - Co-60 Check Source

1332 keV FWHM and 1332 keV NPA





ATTACHMENT C
EXAMPLE Quality Control Chart

30687 QA - Co-60 Check Source

#	Number	1332 FWHM	1332 RES	+3 sigma	-3 sigma	1332 NPA	1332 cps	+3 sigma	-3 sigma
1	1	2.27	2.27	2.39	2.15	177.81	179.1833333	181.02	174.6
2	2	2.27	2.23	2.39	2.15	177.81	177.4477778	181.02	174.6
3	3	2.27	2.24	2.39	2.15	177.81	179.25	181.02	174.6
4	4	2.27	2.28	2.39	2.15	177.81	178.7877778	181.02	174.6
5	5	2.27	2.17	2.39	2.15	177.81	176.6	181.02	174.6
6	6	2.27	2.27	2.39	2.15	177.81	178.9944444	181.02	174.6
7	7	2.27	2.25	2.39	2.15	177.81	175.4916667	181.02	174.6
8	8	2.27	2.26	2.39	2.15	177.81	178.0988889	181.02	174.6
9	9	2.27	2.29	2.39	2.15	177.81	177.6666667	181.02	174.6
10	10	2.27	2.34	2.39	2.15	177.81	177.2766667	181.02	174.6
11	11	2.27	2.27	2.39	2.15	177.81	178.1083333	181.02	174.6
12	12	2.27	2.29	2.39	2.15	177.81	178.5022222	181.02	174.6
13	13	2.27	2.19	2.39	2.15	177.81	177.7333333	181.02	174.6
14	14	2.27	2.26	2.39	2.15	177.81	176.8311111	181.02	174.6
15	15	2.27	2.32	2.39	2.15	177.81	177.05	181.02	174.6
16	16	2.27	2.24	2.39	2.15	177.81	177.6488889	181.02	174.6
17	17	2.27	2.24	2.39	2.15	177.81	177.0666667	181.02	174.6
18	18	2.27	2.27	2.39	2.15	177.81	176.7222222	181.02	174.6
19	19	2.27	2.2	2.39	2.15	177.81	178.3	181.02	174.6
20	20	2.27	2.26	2.39	2.15	177.81	177.8811111	181.02	174.6
21	21	2.27	2.31	2.39	2.15	177.81	179.6083333	181.02	174.6
22	22	2.27	2.32	2.39	2.15	177.81	177.88	181.02	174.6
23	23	2.27	2.21	2.39	2.15	177.81	178.1583333	181.02	174.6
24	24	2.27	2.21	2.39	2.15	177.81	177.8611111	181.02	174.6
25	25	2.27	2.27	2.39	2.15	177.81	175.675	181.02	174.6
26	26	2.27	2.24	2.39	2.15	177.81	177.0722222	181.02	174.6
27	27	2.27	2.32	2.39	2.15	177.81	178.5583333	181.02	174.6
28	28	2.27	2.31	2.39	2.15	177.81	176.9966667	181.02	174.6
29	29	2.27	2.32	2.39	2.15	177.81	177.775	181.02	174.6
30	30	2.27	2.29	2.39	2.15	177.81	176.6733333	181.02	174.6
31	31	2.27	2.25	2.39	2.15	177.81	180.525	181.02	174.6
32	32	2.27	2.24	2.39	2.15	177.81	179.32	181.02	174.6
33	33	2.27	2.3	2.39	2.15	177.81	177.45	181.02	174.6
34	34	2.27	2.3	2.39	2.15	177.81	177.5477778	181.02	174.6
35	35	2.27	2.34	2.39	2.15	177.81	179.1416667	181.02	174.6
36	36	2.27	2.3	2.39	2.15	177.81	177.5633333	181.02	174.6
37	37	2.27	2.34	2.39	2.15	177.81	178.85	181.02	174.6
38	38	2.27	2.28	2.39	2.15	177.81	176.4822222	181.02	174.6
39	39	2.27	2.27	2.39	2.15	177.81	177.7416667	181.02	174.6
40	40	2.27	2.28	2.39	2.15	177.81	176.82	181.02	174.6

ATTACHMENT D

Page 1 of 2

EXAMPLE *Field Electronic Data Disk Transfer Log,* FS-F-5070

FIELD ELECTRONIC DATA DISK TRANSFER LOG

Data Measurement Team:

Date Collected	Detector Number	Beginning File Number	Ending File Number	Copied to LAN		Disk Data Deleted	
				Initial	Date	Initial	Date

Comments:

Relinquished by	Signature	Badge	Date	Time	Received by	Signature	Badge	Date	Time

NOTE This log is a record of transfer of electronic files listed on log. Signatories are not responsible for content of files.

FS-F-5070 (REV0 3/6/98)

ATTACHMENT D Page 2 of 2

EXAMPLE *Field Electronic Data Disk Transfer Log,* FS-F-5070
(Completion Instructions)

1. **DATA MEASUREMENT TEAM:** Print names of team members conducting surveys.
2. **DATE COLLECTED:** Write date (m/dd/yy) that data on each disk was collected.
3. **DETECTOR NUMBER:** Number of detector used to collect data on each disk.
4. **BEGINNING FILE NUMBER:** Number of first static point or mobile location spectral file on each disk.
5. **ENDING FILE NUMBER:** Number of last static point or mobile location spectral file on each disk.
6. **COMMENTS:** Identify any breaks in data, missing files, files from differing projects, disk problems, or any other problems with disk listed.
7. **RELINQUISHED BY:** Signature of individual, currently in control of disk(s), who is turning control of disk over to responsible user of disk(s). Record signatory badge number and the date and time disk is turned over.
8. **RECEIVED BY:** Signature of individual, who is receiving control of disk(s). Record signatory badge number and the date and time disk(s) is received.
9. **COPIED TO LAN:** Initial and date each data disk entry when data is transferred from disk to LAN. Entry in this column denotes transfer is complete to LAN and disk data is no longer required to be retained.
10. **DISK DATA DELETED:** Initial and date each data disk entry when data is deleted from disk; so disk can be reused.

ATTACHMENT E

Page 1 of 2

EXAMPLE *Nonconformance Information Form*, FS-F-5080

Nonconformance Information Form

Real Time Instrumentation Measurement Program

NCR Number & Rev:	Nonconformance Title:
1. Filed by:	2. Date:
3. Measurement(s) Affected - Spectrum File Number(s):	
REQUIREMENT AND NONCONFORMANCE (Check appropriate item(s))	
4. □ System failed energy calibration. Comments:	
5. □ Detector exceeded resolution criteria. Comments:	
6. □ Detector exceeded net peak area criteria. Comments:	
7. Detector did not meet MDC criteria for ASL B: Comments:	
8. Detector did not meet performance criteria for □ Accuracy for ASL B. Comments: □ Bias.	
9. Detector did not meet precision of duplicate criteria for: □ >5 x MDC. Comments: □ <5 x MDC.	
10.□ Detector failed annual characterization.	
11.□ Other	
12. Corrective Action Taken:	

ATTACHMENT E

EXAMPLE *Nonconformance Information Form*, FS-F-5080
(Completion Instructions)

1. NCR NUMBER, REV, and NONCONFORMANCE TITLE: Nonconformance Report (NCR) number, Revision number, and title of Nonconformance to be completed by QA representative.
2. FILED BY: Name of individual initiating NCR.
3. DATE: Enter date (mm/dd/yy) that initiator of NCR identifies Nonconformance.
4. MEASUREMENT(S) AFFECTED: Enter file number(s) of spectra affected by Nonconformance.
5. REQUIREMENT AND NONCONFORMANCE: (Boxes 4-10)
   [a] Check appropriate box(es) identifying requirement(s) not met or criteria exceeded.
   [b] Provide detector number, date and time Nonconformance occurred, and conditions leading to Nonconformance noted in comments section after checked box.
6. OTHER: Identify other condition or process that is nonconforming and provide comment information as specified above.
7. CORRECTIVE ACTION TAKEN: List corrective action taken to resolve condition (i.e., repair of detector, replacement of cables, remeasurement of field locations, etc.).