Document ID:SPC-360
Revision ID:0
Effective Date:03/25/02

Specification

OU 7-10 Glovebox Excavator Method Project Design Input for Fissile Material Monitoring System (FMMS)

Prepared for:
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho

Idaho National Engineering
and Environmental Laboratory

Form 412.14
07/24/2001
Rev. 03

Document Type: SPC -360 Document Identifier: Rev-0

OU 7-10 Glovebox Excavator Method Project

Title: Design Input for Fissile Material Monitoring System (FMMS) Project No. (if applicable): 021052

Author: D. W. Akers Phone: 526-6118

Document Owner: S. A. Davies Phone: 526-4789

REVIEW CONCURRENCE AND APPROVAL SIGNATURES
Denote R for review concurrence, A for approval, as appropriate.

Type or printed name	R/A	Date	Organization Discipline	Responsibility
Signature				
D. W. Akers		3/25/02	Physics	Performer
D W Akers				
R. J. Gehrke	R		Physics	Checker
R. J. Gehrke Per Telecon DMM		3/25/02		
Dale Cresap	R		I&C Engineer	Reviewer
Dale Cresap		3-25-02		
W. Rick Horne	R		Radiological Engineering	Reviewer
W Rick Horne		3-25-02		
Steve Moody	R		Mechanical Engineer	Reviewer
Steve Moody		3/25/02		
Paul Sentieri	R		Criticality Safety	Reviewer
Paul Sentieri by telecon		3/25/02		
Leo Herbert	R	3-25-02	Quality Engineering	Reviewer
Leo Herbert				
Kelly Wooley	R	3/25/02	Industrial Safety	Reviewer
Kelly Wooley				
~~Mark Borland~~	~~R~~		~~Process Engineering~~	~~Reviewer~~ DMM 3/25/02
DO NOT REVIEW DMM 3/25/02				

James Barker	R		Operations	Reviewer
		3-25-02		
Dennis Conley	R		Operations	Reviewer
Dennis Conley		3/25/02		
Tom Hipp	A		I&C Engineering Lead	Approval
Tom Hipp		3/25/02		
Steve Davies	A		Project Engineer	Requestor
Steve Davies by KLS		3/25/02		

Specification Environmental Restoration	**OU 7-10 GLOVEBOX EXCAVATOR METHOD DESIGN INPUT FOR FISSILE MATERIAL MONITORING SYSTEM**	Identifier: SPC-360 Revision: 0 Page: **1** of 20
Document Control Center: (208) 526-0362	Document Owner: Pit 9	Effective Date: 03/25/02
	USE TYPE 3	Change Number:

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

1.1 System Identification

The objective of this project is to provide an integrated Fissile Material Monitoring System (FMMS) for the three OU 7-10 Glovebox Excavator Method Project gloveboxes used for processing waste. The objective of this document is to list and finalize the programmatic system and operational requirements to which the system will be designed. The purpose of the FMMS is to ensure that the drums do not exceed the operational control limit of 200g of fissile material per drum. It is not intended to count all material going into the waste drums. Some types of material are by definition well characterized and are not expected to have excessive fissile content. Material, such as unidentified combustible material and filter media, will be counted in a specimen well and the resulting measurement of fissile material will be assessed to determine if a drum filled with this material could exceed the 200 g limit.

This project will provide a highly automated, assay system that will be used to quantify the fissile material content of specimens being transferred through the three gloveboxes that make up the waste handling system and the fourth system for other samples. The FMMS is composed of a shielded chamber in each glovebox, load cells in each glovebox, an electrically-cooled, collimated germanium detector, a data acquisition system, and a operator controlled panel PC. The panel PC functions as the processing system to alert operators through the touch screens concerning the following:

- the quantity and type of specified radionuclide(s) present
- if the waste meets the defined criticality guidelines for fissile content such that the material can be disposed of immediately.
- immediate notification of the presence of high levels of radioactive or fissile material.

The system will also include a FMM Host computer that will serve as a backup storage medium for acquired spectra.

1.2 Limitations

System is designed for use at the OU 7-10 Glovebox Excavator Method Project site and is integrated with the glovebox system and facility operational requirements.

1.3 Ownership

This EDF is owned and is the responsibility of the OU 7-10 Glovebox Excavator Method Project, Pit 9 Operations, SYSTEM engineer.

1.4 Definitions/Glossary

Alarm System – Alarm bell and light, which is used to indicate whether the gamma detector is being exposed to radiation fields outside it's expected operating limit.

Cabling– Coaxial cable used to connect instrumentation and computers inside the Controlled Area with systems outside. Radiofrequency communications may be used where it offers an advantage over cabling.

Collimator – A physical shield that limits the field of view of the germanium detector.

Computer – For this application a standard laptop or desktop computer with Windows 98 or other compatible operating system will be used. This system will store spectral data and will provide spectral analysis including radionuclide identification and quantification.

Data Acquisition System – Computer software and hardware for obtaining, manipulating, analyzing gamma spectra and producing quantitative measurements.

Detector Assembly – The detector assembly is composed of a single detector and shield that can be integrally located in the Glovebox assembly.

Detector Enclosure – An enclosure used to prevent the measurement equipment from becoming contaminated and provide shielding from non-specimen emissions.

Gamma Spectrometer System – A gamma-ray spectrometer consisting of a Ge gamma-ray detector, power supply, pre-amplifier, amplifier , multichannel analyzer system, and software with computer interface for making measurements from the gamma isotopic detectors.

Gamma-Ray Detector – A high-purity germanium gamma-ray detector used to measure the gamma-ray emissions for identifying and quantifying the specific radionuclides present in acquired spectra.

Specimen Chamber - This is the chamber built into the bottom of the glovebox where waste will be placed to assay. The specimen chamber will have a built-in load cell to record the weight of waste and an inner liner that can be removed for decontamination. The specimen chamber will be shielded to prevent radioactive shine from the interior surface of the glovebox from reaching the detector (will be provided by engineering).

Minimum Detectable Activity - The Minimum Detectable Activity (MDA) is a spectrum-specific statistical parameter used to identify the detection capability of the instrument. The "MDA" is the amount of activity that would have to be present in a given spectrum to be detected with a confidence of 95%. In a proper analysis system, measured and "detected" activity values are routinely reported at levels below the calculated MDA. These activity levels are detected at confidences less than 95%.

Operator Control Panel – Console used by operators to control the starting of the data acquisition system and to inform them of information such as the concentration of fissile material and whether the debris exceeds defined fissile material limits.

FMM Host Computer –A computer station located in a uncontaminated area of the OU7-10 Glovebox Excavator Method Project site used as a backup and supplementary storage location for spectral data acquired from the individual panel PC's. This host computer will also serve as an immediate spare should one of the panel PC's fail.

1.5 Acronyms

μs	micro second
ALARA	As Low As Reasonably Achievable
amp	Ampere
c/s	counts/second
DOE	Department of Energy
ECF	Engineering Charge Form
EDF	Engineering Design File
FMM	Fissile Material Monitoring System
FWHM	full width at half maximum
KeV	Kilo-electron volt
LCO	Limiting Conditions of Operations
MDA	Minimum Detectable Activity
MeV	Million-electron volt
NIST	National Institute of Standards and Testing
PDSA	Preliminary Document Safety Analysis

SAR	Safety Analysis Report
SNM	Special Nuclear Material
SO Test	System Operations Test
TPR	Technical Procedure
TSR	Technical Safety Requirement
USB	Universal Serial Bus
USQ	Unreviewed Safety Question
V	Volt
WES	Weather Enclosure Structure

2. OVERVIEW

2.1 System Functions

The primary system functions are to:

1. Determine if fissile material, activation and fission products are present.

2. Determine whether the fissile material content exceeds a defined Minimum Detectable Activity (MDA) that is nominally 1 g of ^{239}Pu.

3. Determine the total quantity of fissile material present.

4. Provide suitable uncertainty data for the measurements to provide assurance that the measured and summed quantity of fissile would not exceed 200 g in a drum. Operations will determine the confidence interval needed to provide assurance that the measured and summed quantity of fissile material plus the upper limit of its to be determined confidence interval could not exceed 200 g in a drum.

5. Provide a load cell with a nominal range up to 100 lbs that will be located in the specimen chamber inside the glovebox. This load cell will be interfaced to the operator controlled panel PC.

6. Provide an operator control interface such that the operator can perform the following functions:

    - Energy calibrate and verify operability of the system at the beginning of each shift or as needed for verification with a radioactive source.

- Perform a background measurement once each day or whenever a change is suspected. If the background is not at acceptable levels stop and find the source of the increased background.
- Enter the height to which the container in the chamber is filled. An accuracy percentage will determined in the FMMS Preliminary Hardware Design EDF.
- Start spectral acquisition.
- Determine if the specimen is large, odd shape or has a high density. If any of these cases is true the specimen will be rotated 180 °and 2 counts will be taken.
- Verify that the material in the container in the chamber does not exceed operational limits for the system (e.g., density or mass distribution).
- Before releasing the sample being counted, determine if the fissile material content could exceed 200 g if the specimen content was added to the drum. If so, do not add to the disposal drum.
- Be informed of the fissile material content of the debris based on the summed measurements and appropriate scaling factors
- Measure high levels of non-Fissile Material radioactivity and incorporate into the equation used to determine the MDA for this particular measurement.

7. Direct measurements will be performed for the following radionuclides and reported as either a quantitative value with uncertainties or as a MDA.

Table 1. FMMS Radionuclides.

Material Type Measured	Radionuclide
Transuranic/fissile	Pu-239
Transuranic	Am-241
Fissile	U-235
Fertile	U-238
Fission	Cs-137

Neutron activation	Co-60
Fissile	U-233
Fissile	Pu-241

Other radionuclides may also be detected and will be reported. Those radionuclides that are determined by scaling factors to quantify the transuranic content or other radionuclide content will be tagged as determined indirectly from scaling factors.

2.2 System Classification

The safety category of this system has been identified as consumer grade. The procurement will be performed as quality level 3. The integrated system will be qualified to quality level 3 through the System Operability test, which will assess the systems capability to detect, quantify, and identify the presence of fissile material to the limits prescribed.

2.3 Operational Overview

This system is composed of gamma-ray detectors with electrical coolers, collimators, cabling, data acquisition systems, computer, analysis software, and touch screen control panels at each of the gloveboxes. In addition, a load cell will be located at each measurement chamber location for calculating density. Further, a power conditioner must be present at each measurement location. The FMM Host computer will be located at a convenient location at the OU 7-10 Glove Box Excavator Method Project site.

3. REQUIREMENTS

3.1 System and Performance Requirements

3.1.1 System

3.1.1.1 The FMM shall consist of four main components: the detector assembly, data acquisition system/microprocessor, and the operators control assembly. Figure 1 shows the system block diagram.

3.1.1.2 The detector assembly shall contain a detector, associated electronics, and the detector collimator. This assembly will be positioned to view the “specimen chamber” where material will be placed for assay.

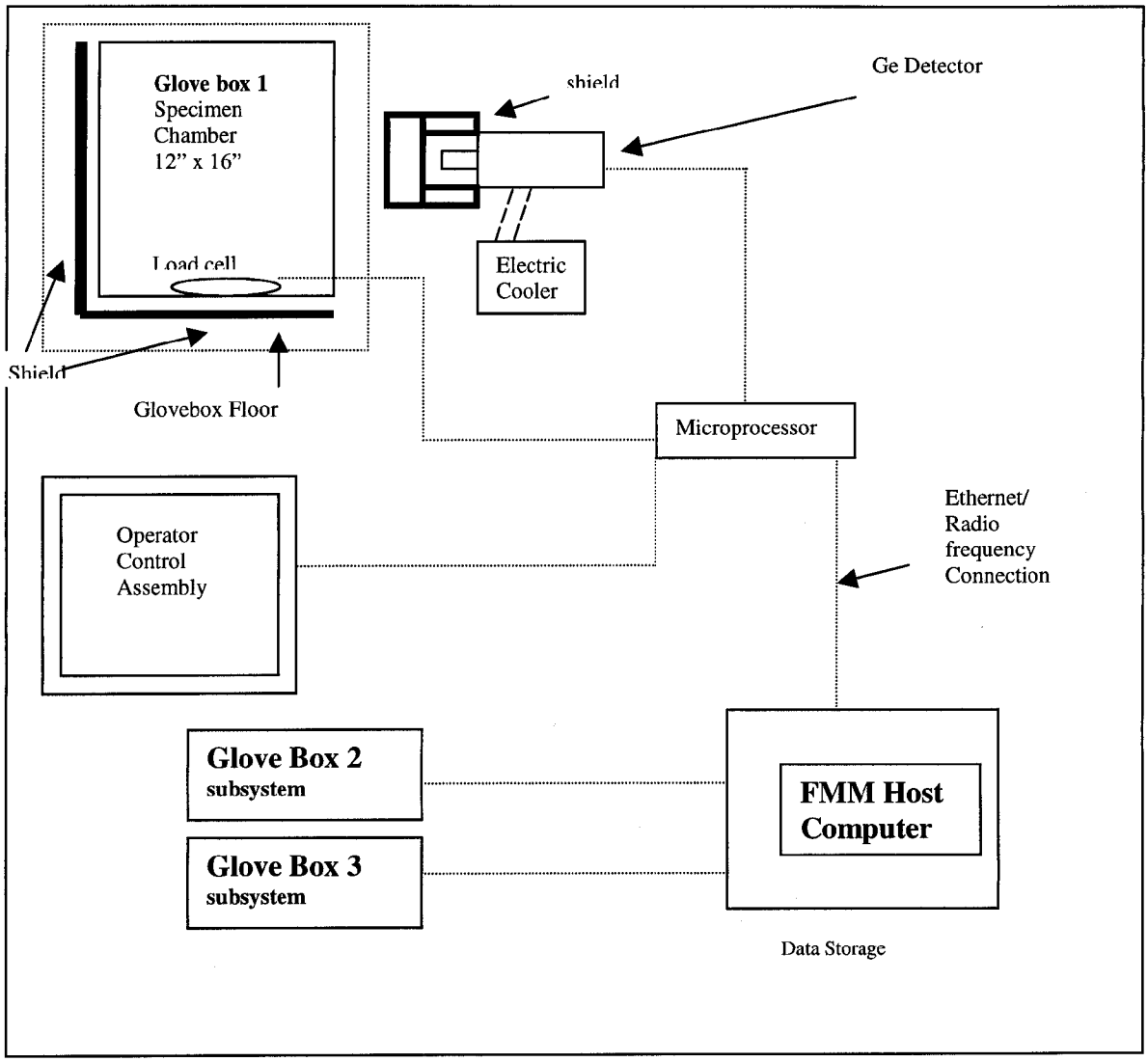

Figure 1. System block diagram.

3.1.1.3 An enclosure shall provide shielding for the detector assembly located in the glovebox. The radiation field surrounding the glovebox during normal glovebox operations should not exceed 5 mr/h.

3.1.1.4 The operator controlled panel PC assembly is a control console to be located at each assay station for operators to perform assays on specified waste or material types. This assembly will meet the requirements as defined in Section 2.1 item 6.

3.1.1.5 The FMM Host Computer will serve as the backup storage medium for spectra acquired on the operator controlled panel PC's and will be located in the WES at OU 7-10 Glovebox Excavator Method Project site.

3.1.1.6 The system is designed to perform the measurement of radioactive materials with a range of radioactive concentrations and densities. Density and activity ranges will be defined in the FMM Preliminary Software Design EDF.

3.1.1.7 The system must provide an estimate of radioactive material present and allow the quantity of fissile material present to be bounded with a to be determined confidence interval.

3.1.1.8 The ambient operating conditions are the humidity and temperature levels found at the Pit 9 site. It is expected that the facility ambient operating conditions are nominally 50-100^{o}F and 15%-85% humidity. The design life is 1year under the given conditions after installation at Pit 9.

3.1.1.9 The sequence of events for operation is as follows (Figure 2):

- At the beginning of the shift, the system is calibrated by a qualified *operator placing a 40 μCi ^{152}Eu source at a defined location in front of the detector or in the specimen chamber.

---

* This training qualification will be documented in TRAIN.

- The operator will start the calibration measurement process at the panel PC touch screen.
- The panel PC touch screen will inform the operator that the system is calibrated.
- The operator will perform a background measurement as indicated on the touch screen to ensure that there are not high levels of contamination in the chamber area. The computer will inform the operator of high background radiation levels.
- The operator will place waste in the identified container and will then place the container in the chamber.
- The operator will estimate the quantity of material in the container and touch the appropriate location on the panel PC touch screen.
- The system will perform the gamma spectrometry measurement and will provide the information listed in Section 2.1 item 4.
- The operator will then remove the waste sample (once it has been rotated 180° and recounted, if necessary). If it is within acceptable levels as indicated by the touch screen, the operator will dispose of the sample as part of regular waste. If high levels are recorded, the operator will follow appropriate administrative procedures and will inform management that a high level of fissile material or high levels of radioactive material have been detected
- At the end of the day's activities, the operator will repeat the calibration process if necessary to ensure that the system remained operable (i.e., calibrated) during the day.

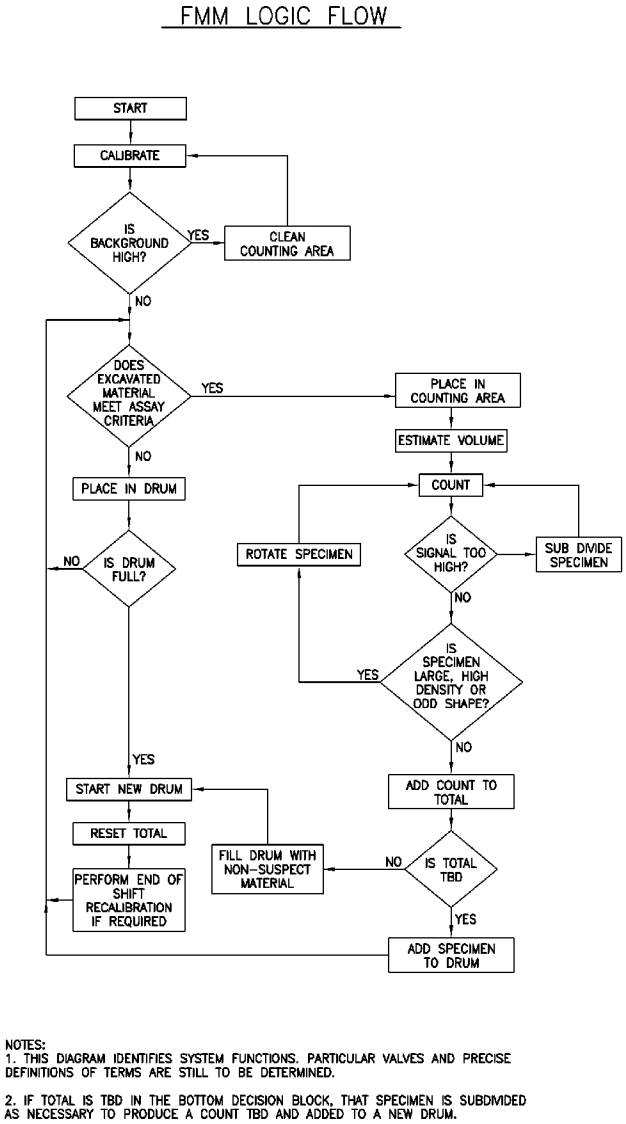

Figure 2. FMM logic flow diagram.

3.1.2 Subsystem and Major Components

The following components that will be procured include but are not limited to the following: (see Figure 1)

3.1.2.1 Germanium detectors with electrical cooling systems

3.1.2.2 Alarm system for over ranging of the gamma detectors

3.1.2.3 Gamma spectrometer data acquisition systems and power supplies

3.1.2.4 Complete gamma spectrometry analysis software package

3.1.2.5 Load cells for the specimen chamber

3.1.2.6 Appropriate cabling for the detector system

3.1.2.7 Power conditioners at each location to minimize electrical interference

3.1.2.8 Shielding and enclosure

3.1.2.9 Items to be fabricated include the collimators and cabling assemblies

3.1.3 Boundaries and Interfaces

3.1.3.1 The primary boundary is the radiation boundary of the OU 7-10 Glovebox Excavator Method Project site dig area.

3.1.3.2 The operator controlled panel PC touch screens and measurement assemblies will be located at each of the gloveboxes and at the other measurement locations to be defined by engineering and operations.

3.1.3.3 The FMM Host computer station will be located in an area of the OU 7-10 Glovebox Excavator Method Project site dig area as defined by engineering.

3.1.3.4 Cabling for the load cells will pass through bulkhead connections from the gloveboxes to the individual data acquisition system computers.

3.1.3.5 Radio frequency communications will be used between the FMM Host computer and the data acquisition system computers.

3.1.4 Codes, Standards, and Regulations

The system will be designed per the identified Codes, Standards and Regulations with the appropriate sections of the listed standards groups.

NEC	National Electric Code, NFPA 70
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
UL	Underwriters Laboratories, Inc.
CFR	29 CFR 1910 OSHA Occupational Safety and Health Standards
N42.14-1999	Calibration and Use of Ge Detectors

Additional procedures and specifications include:

- MCP-2811, Design Control
- MCP-540, Documenting the Safety Category of Structures, Systems, and Components
- MCP-550, Software Management
- DOE-ID Architect and Engineering Standard
- TFR-155, OU 7-10 Glovebox Excavator Method System Design Criteria, Instrumentation and Controls
- SPC-355, FMM Performance Specification

3.1.5 Operability

The gamma spectrometry measurement systems must be operable and calibrated prior to making measurements of waste in the gloveboxes or other materials. The system must notify operators of the system operability.

3.2 Special Requirements

3.2.1 The special requirements associated with this system are contamination control for the detectors, electronic systems.

3.2.2 In addition, the systems must not be exposed to high levels of radio frequency noise and appropriate power conditioning must be present to prevent changes in the system operability. Note: Radios used by operations personnel must not create any potential interference.

3.2.3 The detector system itself must and will not be contaminated by radioactive material.

3.2.4 The FMM designer shall indicate with instructions any limiting conditions of operation such as welding or other potentially impacting operations.

3.2.5 Radiation and Other Hazards

Source accountability and storage must be addressed when sources are stored at the gloveboxes for use with the system. Accountability of these sources must be maintained by operations. The sources, 40 uCi of ^{152}Eu are not highly radioactive (25mrem/hr at 1 foot) and can be handled without significant radiation exposure.

3.2.6 ALARA

See MCP-91. The use of this system in the glovebox should minimize personnel exposure that might occur if individuals were contacting the material. There is no radioactive material associated with fabrication of the system.

3.2.7 Nuclear Criticality Safety

Nuclear criticality safety relating to the fissile material monitor (FMM) is discussed in the Preliminary Documented Safety Analysis (PDSA) and will be further developed in the Final Documented Safety Analysis (FDSA). Currently the FMM is not defined as safety significant and is not expected to be as the FDSA is completed. However, the FDSA may have TSR/LCO level surveillance requirements relating to the operability, reliance, and calibration of the FMM to ensure the drum fissile loading LCO is met.

3.2.8 Industrial Hazards

The only potential hazard exposure to individuals is the cooling agent in the electrical cooling systems for the detectors if it were to leak or escape. This is highly unlikely; however, an MSDS will be obtained for the cooling agent.

3.2.9 Operating Environment and Natural Phenomena

System to be used in the normal ambient operating environment found at OU 7-10 Glovebox Excavator Method Project site in the WES. Items that must be addressed include:

3.2.9.1 Equipment cabling must be run from the touch screens, the load cell and the detector assemblies to the control computer without physically being damaged. (Radio frequency communication may be required.)

3.2.9.2 The potential for high levels of background due to drum waste or contamination of the specimen chamber is addressed during the calibration process or if there are indications that the chamber may have been contaminated.

3.2.9.3 Radiation hardening is not required for this system based on the radiation fields expected at OU 7-10 Glovebox Excavator Method Project site

3.2.9.4 The detector assembly must be sized to fit and operate under all expected conditions surrounding the gloveboxes.

3.2.9.5 The FMM shall maintain structural integrity in accordance with PC-1 classification.

3.2.10 Human Interface Requirements

Operations will perform all system operations through the control assembly per the information requirements in Section 2.1

3.2.10.1 The FMM will permit the glovebox operators to readily read and control the FMM from a control panel conveniently located at the glovebox.

3.2.11 Specific Commitments

There is a specific requirement from the OU 7-10 project to provide assurance that the fissile material content of drums does not exceed 200 g.

3.2.12 Continued Support and Evaluations

Physics staff will perform regular system evaluations and data evaluations of background and waste data to assess potential system and fissile material concentration issues.

3.3 Engineering Design Requirements

3.3.1 Civil and Structural

The individual assay system with shielding has a conceptual design weight of approximately 150 pounds. R&D will work with Engineering to ensure that the FMM is structurally compatible with the gloveboxes once the final configuration of the assay system is known.

3.3.2 Mechanical and Materials

The detection system must be electrically isolated from the gloveboxes and must not be subjected to significant vibration and radio frequency noise from motors. It is anticipated that each detector will be placed on an electrically isolated platform at the end of the glovebox with appropriate electrical isolation and shock mounting if significant vibration is expected.

<u>Gamma Detectors</u>

- Electrical cooling system used with the detector

3.3.3 Chemical and Process

None

3.3.4 Electrical Power

Equipment shall be powered by Standard 120 VAC, 20 amp, GFI protected receptacles with at least two outlets. Also power conditioners will be required for each system due to the potential for power variations at a field site such as Pit 9.

3.3.5 Instrumentation and Control

The system will be operated using standard off the shelf hardware and software that has been demonstrated to meet the specific analysis requirements of accurate quantitative analysis with the exceptions of the load cell and control functions from the control assembly. In addition data processing software will be tailored for this system as necessary.

The detection system must be electrically isolated from the gloveboxes.

The primary control channels are from the computer to the touch screens and the data acquisition and measurement systems under the gloveboxes. The control cables for the gamma spectrometer systems are for each system going to the various systems are the following:

- Data acquisition/ detector systems - USB or ethernet
- Load cell – typical 9 or less conductor cable
- Touch screens 9 conductor cable

Gamma Detectors

- Germanium detectors planar germanium – detector
- Transistor reset preamplifiers required for high rate operation
- Remote startup and control via Ethernet or USB connection
- Automatic high voltage shutdown

Gamma spectrometer system

- Digital pulse processing
- Associated amplifier, high voltage supply and preamplifier power
- Ethernet/USB control option
- Bias shutdown capability
- Process microprocessor

- Process spectral data with normal shaping times for semiconductor detectors with no significant degradation in resolution.

- Gamma spectrometry analysis software – GENIE 2K or ORTEC Gamma Vision.

3.3.6 Computer Hardware and Software

Gamma Spectrometry acquisition and analysis software – Includes standard laptop/desk top computer with Ethernet/USB access, Windows 98 and data acquisition software. All data will be backed up using the FMM Host Computer.

3.3.6.1 Data acquisition software- Analyze gamma spectra and produce quantitative measurements per calibration process to be defined in the Calibration Design EDF.

3.3.6.2 Complete gamma spectral analysis software that allows for calibration, efficiency and complete spectral analysis

3.3.6.3 A Configuration Management Plan (CMP) will be developed for the computer hardware software and documentation for the computer system in accordance with MCP-3630 "Computer System Change Control." This is the company implementation of the IEEE Standard on Configuration Management.

- Validation and verification of developed software as required per MCP-550 "Software Management" Appendix F. Primary validation will be through SO testing to demonstrate operability

3.3.7 Fire Protection

Nothing beyond existing facility protection.

3.4 Testing and Maintenance Requirements

3.4.1 Testability

3.4.1.1 Overall system calibrated with known NIST traceable sources. Individual components tested per the consumer

grade dedication requirements as listed in the purchase requisitions.

3.4.1.2 Physics will process the calibration results in a documented and approved EDF per a standard TPR developed for the SO testing and operations processes.

3.4.2 TSR-Required Surveillance

There are currently no TSR level surveillance requirements listed in the Preliminary Documented Safety Analysis (PDSA). The Final Documented Safety Analysis (FDSA) may have a surveillance requirement associated with the LCO relating to the operational drum fissile loading limits.

3.4.3 Non-TSR Inspections and Testing

Calibration report will be documented in an EDF. A TPR requirement for operations will be used to ensure that the detectors have current calibration and will be calibrated on a frequency in accordance with the calibration EDF.

3.4.4 Maintenance

Periodic system calibration using TPR requirements assures system operability. Current planning is to provide spares for all critical components. There are no specific maintenance items required.

3.5 Other Requirements

3.5.1 Security and SNM Protection

Access to the software and hardware must be limited as SNM decisions are being made based on the results of the analyses. Password protection will be used.

3.5.2 Special Installation Requirements

The equipment must be able to be installed at the OU 7-10 Glovebox Excavator Method Project gloveboxes. Due to the uniqueness and special features of the FMM, the system will be installed by INEEL crafts and technicians with instructions and guidance from R&D.

3.5.3 Reliability, Availability, and Preferred Failure Modes

This equipment must ensure that operability of the system is identified to operators and that failures due to high activity levels and potential electrical problems result in a defined failure mode. Likely failure modes are:

- Detector failure – Results in unacceptable calibration
- Power instability- Poor data and bad calibration
- High activity levels- Detected during measurement process (operators informed)
- Must meet the reliability as required in the FMM Performance Specification.

3.5.4 Quality Assurance

Consumer Grade and Quality level 3 requirements to all equipment for initial design. The entire system exclusive of the structural components will be qualified through the SO test

3.5.5 Miscellaneous

None