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Title: Criticality Safety Evaluation for Small Sample Preparation and Non-Destructive Assay (NDA) Operations in Wing 7 Basement of the CMR Facility

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Criticality Safety Evaluation Team Review/Approval

This evaluation was generated with personnel familiar with the operations described herein to assure:

- **the accuracy and applicability of the process description,**
- **the completeness and accurate characterization of the upset conditions addressed,**
- **the applicability, usability, clarity, and validity of the controls.**

	Organization	**Date**	**Signature**
Operations Responsible Supervisor Approval Name: A. R. Schake	C-AAC	8/1/17	Ann Schake
CSO Review/Acknowledgement Name: P. T. Martinez	C-AAC	8/1/17	[signature]
Nuclear Criticality Safety Approval **This evaluation has been generated in accordance with the ANSI/ANS-8 standards per SD130**			
CSED Primary CSA Name: P. E. Kunkle	NCS	2017-08-01	[signature]
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NCS Management Review Name: A. R. Wysong	NCS	2017-08-01	[signature]

Operations Responsible Manager (ORM)Review/Approval

I approve this evaluation as the criticality safety basis for the operation and establish and approve the requirements for the process described herein.

Name: A. R. Schake	C-AAC	8/1/17	Ann Schake

1. Summary

Nuclear Criticality Safety (NCS) has reviewed the fissionable material small sample preparation and NDA operations in Wing 7 Basement of the CMR Facility.

This is a Level-1 evaluation conducted in accordance with NCS-AP-004 [Reference 1], formerly NCS-GUIDE-01, and the guidance set forth on use of the Standard Criticality Safety Requirements (SCSRs) [Reference 2].

As stated in Reference 2, the criticality safety evaluation consists of both the SCSR CSED and the SCSR Application CSED. The SCSR CSED is a Level-3 CSED [Reference 3]. This Level-1 CSED is the SCSR Application CSED. This SCSR Application (Level-1) evaluation does not derive controls, it simply applies controls derived from the SCSR CSED (Level-3) for the application of operations conducted here.

The controls derived in the SCSR CSED (Level-3) were evaluated via the process described in Section 6.6.5 of SD-130 (also reproduced in Section 4.3.5 of NCS-AP-004 [Reference 1]) and were determined to not meet the requirements for consideration of elevation into the safety basis documentation for CMR.

According to the guidance set forth on use of the SCSRs [Reference 2], the SCSR CSED (Level-3) is also applicable to the CMR Facility because the process and the normal and credible abnormal conditions in question are bounded by those that are described in the SCSR CSED.

The controls derived in the SCSR CSED include allowances for solid materials and solution operations. Based on the operations conducted at this location, there are less-than-accountable (LTA) amounts of ^{233}U.

Based on the evaluation documented herein, the normal and credible abnormal conditions that might arise during the execution of this process will remain subcritical with the following recommended controls.

1.1. Historical Reviews, Events, and Issues

As required by NCS-AP-004 [Reference 1], Section 4.2.2, applicable historical events and issues were reviewed to identify and address any outstanding matters:

1. Operational reviews, critiques or other events;
2. NNSA comments on existing evaluations; and
3. Screening Forms, and Release Reviews.

Operational Reviews and Events

The last operational review, CMR-7053-00, of this area was performed on 2017-04-04, with the observation that it could be used to create a level 1 CSED to implement the SCSR 520g limit. This document, NCS-CSED-17-072, is that CSED.

NNSA Comments on Previous CSEDs

For this location, there were no Level-3 style evaluations.

Screening Forms and Release Reviews

The previous technical basis is NCS-MEMO-09-026 [Reference 4] that was documented on 2009-06-10. This memo states that for the small quantity process and analysis activities which take place throughout the CMR facility in a number of rooms in Wings 3, 5, and 7, the room limits are typically equal to the workstation limits for these rooms, and there is little opportunity for interaction of the individual operations with other operations. It also notes that evaluations under which these operations are conducted are either absent due to the LSQ quantities involved or are covered by the following evaluation:

HSR-6-02-059 *Criticality Safety Evaluation for NMT-11Operations at CMR, TA-03, SM-29.*

There were no former Level-3 evaluations for the operations conducted at this location.

2. Recommended Controls

FMO ID	NMCA Location	Room Number
CMR-7051-00	N/A	7051, 7053, 7055, 7057, 7059, 7061, 7063, 7065

CRITICALITY SAFETY REQUIREMENTS	
Administrative Controls	
Material Limits	
Pu in Metal/Compounds/Dry-Residue/Solutions	≤ 520 grams
Other fissionable isotopes (not including ^{233}U) may be treated as Pu on a gram-for-gram basis	
Additional Restrictions	
• Fissionable solutions are collected in ≤ 2.2 liter containers	
• There is no volume limit on non-fissionable solutions	

2.1. Pu in Metal/Compounds/Dry-Residue/Solutions ≤ 520g

This control: 1) reduces the consequence of a mass upset, and 2) restricts the problem so as to make the analysis tractable. This control limits the amount of fissionable material to less than or equal to 520g. Personnel can ensure they are in compliance with this control by ensuring there is no more than 520g plutonium in metal/compounds/dry-residues/solutions.

Operations may treat hydrogenous residues such as IX resin as solutions.

2.2. Other fissionable isotopes (not including ^{233}U) may be treated as Pu on a gram-for-gram basis

This control allows other fissionable material to be treated as Pu on a gram-for-gram basis provided that they are in agreement with the following restrictions:

- For Americium (Am) where the weight percent (wt%) of ^{242}Am is ≤10% of the total Am, use a one-for-one equivalence with Plutonium.
- For Curium (Cm) where the combined wt% of ^{243}Cm and ^{245}Cm is ≤5% of the total Cm, use a one-for-one equivalence with Plutonium.
- ^{241}Pu may use the one-for-one gram equivalence if the isotopic concentration is less than the isotopic concentration of ^{240}Pu.

Personnel can ensure they are in compliance by ensuring there is no more than 520g of fissionable material and that the substituted material follows the above restrictions.

Furthermore, fissionable material may contain contamination level of other nuclides. <1g of these nuclides do not need to be counted toward the mass limit.

2.3. Fissionable solutions are collected in ≤ 2.2 liter containers
This control reduces the consequences of a mass upset condition. This control limits the volume of individual containers allowed in the fissionable material operation to less than or equal to 2.2 liters each. Personnel can ensure they are in compliance with this control by ensuring that only containers with volumes no larger than 2.2 liters are used.

2.4. There is no volume limit on non-fissionable solutions.
Housekeeping and maintenance non-fissionable cleaning solutions are not restricted.

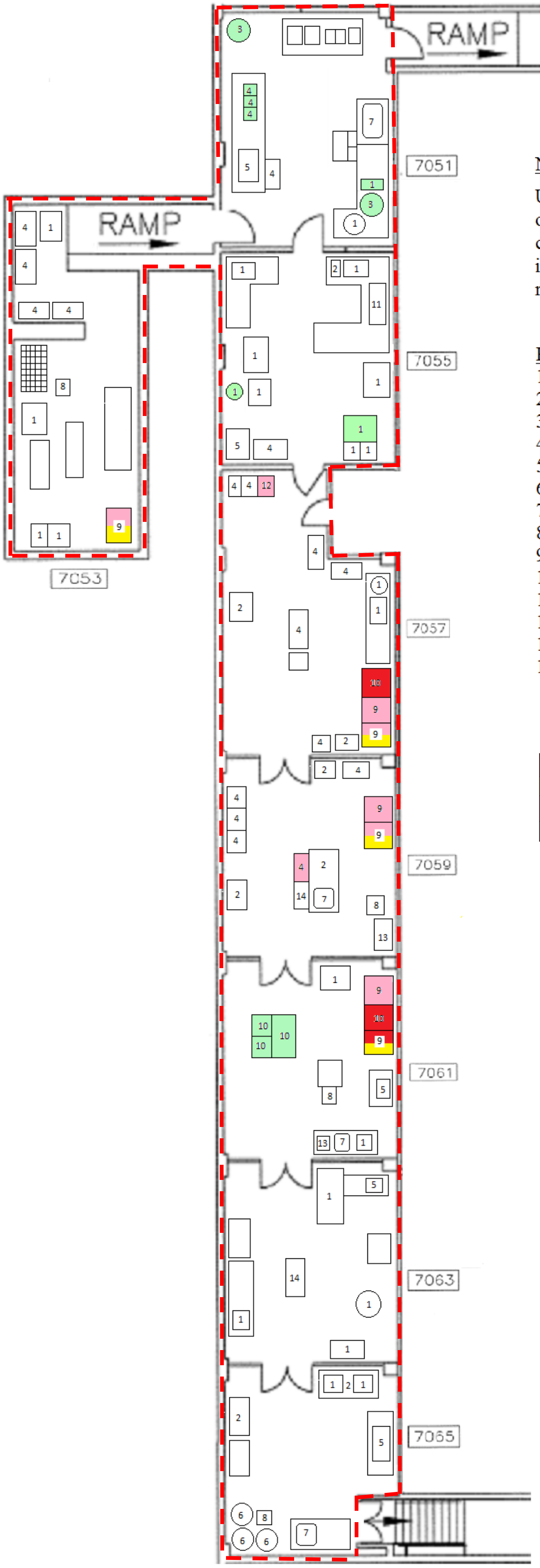
3. Process Description

3.1. Process-Specific Material Form Descriptions

This evaluation does not define its own process-specific material form. Plutonium compounds and plutonium residues are defined in CMR-AP-522 [Reference 6]. If there is ever a question as to how an item should be handled, please contact NCS for clarification.

3.2. General Location Description

For the purpose of this evaluation, the boundary of this Fissionable Material Operation (FMO) CMR-7051-00 is the set of eight interconnected rooms (7051, 7053, 7055, 7057, 7059, 7061, 7063, 7065) located in the basement of Wing 7 of the Chemistry and Metallurgy Research (CMR) Facility. This boundary also includes a small closet, labeled 7057A, located in room 7057. A detailed schematic of the instrumental breakdown of the FMO is shown in Figure 1. The items marked in this schematic are meant to be information only, and may change at a future date and time; this schematic is not meant to be a control.



Note:

Unmarked areas denote tools, computers, printers, or other instruments which do not contain, store, or come into contact with fissionable material. Such instruments will be analyzed with regard to their reflection and moderation capabilities.

Key:

1. Instrument containing fissionable material
2. Fissionable material samples
3. Dewar
4. Storage cabinet
5. Lead shielding surrounding fissionable material
6. Waste storage drum
7. Sink
8. Radioactive waste bin
9. Hood
10. Glovebox
11. Fixed contamination area
12. Safe
13. Corrosives
14. Flammable material

Accountable
Contains Beryllium
LTA
Out of Service

FMO boundary

Figure 1: Instrumental breakdown of FMO.

3.3. Material Handling/Staging

Fissionable material may be introduced/removed from this location. Under normal operations, material is typically moved using containers, cans, etc. Generally, material is hand-carried between rooms within the FMO in sealed containers. Additionally, samples on the order of 1µg which are affixed to glass cover slips for testing may be hand-carried outside of sealed containers.

Typical handling operations include combining of materials, splitting of materials, weighing of materials, sampling, etc.

3.4. Process Information

The major constitution of the nuclides involved in this FMO consists of plutonium isotopes, specifically ^{239}Pu and ^{240}Pu, as well as several uranium isotopes, specifically ^{234}U, ^{235}U, and ^{238}U. Less-than-accountable amounts of ^{233}U may be processed in this FMO. Other minor isotopes such as ^{241}Am, ^{243}Am, and ^{237}Np are also processed and/or stored in this FMO.

Fissionable material is found in several forms within this FMO. For example, fissionable material test solutions are created by mixing the fissionable material sample with a scintillation cocktail and are used in scintillation counters. Fissionable material solutions are also placed in hoods and gloveboxes for staging purposes.

Fissionable material dry-residues are generally made by placing a small drop of a fissionable material test solution on a glass cover slip; the drop is then dried down to fix the material onto the glass surface. This sample is placed inside a detection instrument to be tested.

Other larger fissionable material samples are placed within lead shielding, hoods, and gloveboxes to be stored.

Two major processes occur within this FMO: small quantity chemical separations / chemical preparation followed by nuclear counting, and non-destructive assay (NDA) operations.

In analytical chemistry, sample preparation is an imperative step in analysis techniques as some instruments may not be responsive to the material in its original form. Small quantity chemical separations / chemical preparation is performed in open-front hoods or designated areas within the FMO to prepare the material in question for nuclear counting. Packaging of material for NDA analysis may happen within the FMO or other FMOs.

NDA is a set of analysis techniques used to evaluate and characterize the properties of a material without damaging it. Radioactive and nuclear material can be characterized by the radiation it produces. NDA is used to detect and analyze such signatures in order to obtain information about the material in question.

Accomplishing these tasks requires much testing equipment. As a result, there are many instruments used within the boundary of this FMO which interact with fissionable materials. Photographs have been included of some significant instruments to provide a better understanding of the FMO. Although this list includes many instruments, it is not meant to be all encompassing.

3.4.1 Ortec Alpha Spectrometer

This instrument provides an alpha-particle spectrum of a sample of fissionable material. A small drop of the fissionable material test solution is placed on a glass cover slip, which is then dried down to fix the material onto the glass surface. This sample is placed inside the alpha spectrometer, at which point the alpha particles emitted by the sample hit the semiconductor detector surface and generate an electronic signal, and a multi-channel analyzer collects these signals for display in a spectrum. The average mass of fissionable material on these plates is about 1 to 10µg, with a maximum mass of 20µg.

Figure 2: Ortec Alpha Spectrometer and semiconductor detector.

3.4.2 Ortec Clamshell HPGe

The Clamshell HPGe is a High-Purity Germanium detector, which uses a germanium crystal to measure the energy of incident photons. Its chamber consists of an inner layer of copper, followed by 4 inches of lead shielding, and an outer layer of steel. A sample of fissionable material is placed inside the shield and tested for gamma rays up to a few MeV. At the low end, sample mass may be about 5mg, but sample mass can range up to 25g.

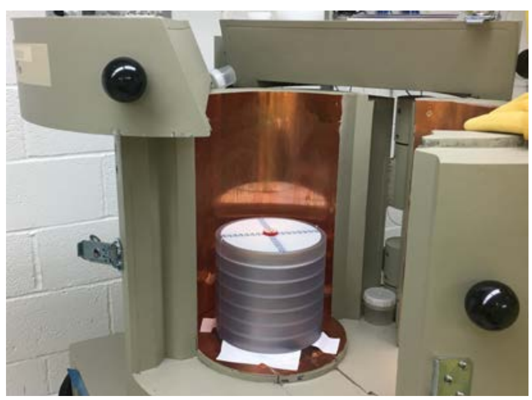


Figure 3: Ortec Clamshell HPGe.

3.4.3 Ortec Steelbox HPGe

The Steelbox HPGe is a High-purity Germanium detector, which uses a germanium crystal to measure the energy of incident photons. Its chamber is shielded by steel and lead. A sample of fissionable material is placed inside the chamber and gamma rays up to a few MeV are measured. Sample masses are in the same range as the Ortec Clamshell HPGe (5mg to 25g).

Figure 4: Ortec Steelbox HPGe.

3.4.4 Packard Cobra II Gamma Counter

This instrument measures gamma activity of a sample of fissionable material. The sample solution is placed in a tube which is lowered into a sodium-iodide (NaI(Tl)) well detector; the energy from each NaI(Tl) scintillation event is released as UV and visible photons, which are detected by the gamma counter photo-multiplier tube (PMT). The average mass of this sample is about 200 µg, with a maximum mass of 400µg.

3.4.5 Protean Alpha and Protean Alpha II

These instruments are alpha counting systems. A small drop of the fissionable material test solution is placed on a glass cover slip, which is then dried down to fix the material onto the glass surface. This sample is placed inside the gas proportional counter chamber and is purged with P-10 gas (10% methane in argon). Alpha particles ionize the P-10 gas and allow a small current to flow. The measurement of that current flow allows the individual alpha particles (but not their energy) to be detected and counted. The average mass of this sample is about 1 to 10µg, with a maximum mass of 20µg.

Figure 5: Protean Alpha II.

3.4.6 Sodium-Iodide (NaI(T1)) Gamma Detector

This instrument is used to measure gamma activity of a sample of fissionable material. A small drop of the fissionable material test solution is placed on a glass cover slip, which is then dried down to fix the material onto the glass surface, which is then placed inside the instrument for counting. The high-energy photon energy from each decay event is released as UV and visible photons, through interaction with the sodium-iodide crystal and are counted by photo- multiplier tubes (PMTs) within the instrument. The average mass of this sample is about 1μg.

Figure 6: Sodium-Iodide Gamma Detector.

3.4.7 PerkinElmer Wizard2 Automatic Gamma Counter

This instrument measures gross gamma activity of a sample of fissionable material. The sample solution is placed in a tube which is lowered into a NaI(Tl) well; the energy from each scintillation event is released as photons, which are detected by the PMT. The average mass of this sample is about 200μg, with a maximum mass of 400μg, and the instrument can hold several hundred samples.

Figure 7: Wizard Automatic Gamma Counter.

3.4.8 Beckman Liquid Scintillation Detector

This liquid scintillation counter measures alpha/beta activity of a sample of fissionable material. The sample is mixed with a scintillation cocktail and placed inside the instrument; the energy from each decay event produces a pulse of UV and visible photons, which are counted by PMTs within the instrument. The average mass of this sample is about 1 to 10µg, with a maximum mass of 20µg.

3.4.9 Wallac Liquid Scintillation Counter

This liquid scintillation counter measures alpha/beta activity of a sample of fissionable material. The sample is mixed with a scintillation cocktail and placed inside the instrument; the energy from each decay event produces a pulse of UV and visible photons, which are counted by PMTs within the instrument. The average mass of this sample is about 1 to 10µg, with a maximum mass of 20µg. This instrument is currently out of service.

Figure 8: Wallac Liquid Scintillation Counter.

3.4.10 Gamma Well Test Tube Changer

The Gamma Well with test tube changer is a circular instrument that sits behind the gamma counters in room 7055. It was formerly used to count small volume solutions using a well geometry HPGe detector. It is currently out of service awaiting determination for re-use or disposition.

Figure 9: Gamma Well Test Tube Changer.

3.4.11 DYNAC II Centrifuge

This instrument spins solutions of fissionable material at high speeds to minimize the presence of small drops up the side of the gamma counting tubes.

Figure 10: DYNAC II Centrifuge.

3.4.12 Wrist Action Shaker

This instrument is used to mix, blend, or agitate aqueous and organic mixtures of fissionable material by shaking them to affect chemical separations.

Figure 11: Wrist Action Shaker.

3.4.13 Neutron Bubble Tubes

These tubes are used measure the flux and fluence of neutrons emitted by a neutron source such as PuBe. The testing platform is kept in the hallway between rooms 7051 and 7053 because it is made of concrete and has low ceilings, and such shielding eliminates a significant amount of background signal.

3.4.14 Fissionable Material Samples

In several locations within the FMO, samples of fissionable material may be shielded by lead or placed in drawers. These samples are generally drops of fissionable material test solution dried onto glass or metal plates, and are of average mass of about 1 to 10μg, with a maximum mass of 20μg.

3.4.15 Pyris Diamond DSC

This differential scanning calorimeter (DSC) measures the amount of energy absorbed or released by a sample as it is heated, cooled or held at constant temperature as a function of temperature. The average mass of a sample of fissionable material for this instrument is about 1μg.

3.4.16 Scanning Electron Microscope (SEM)

This instrument is a type of electron microscope (which uses a beam of accelerated electrons as a source of illumination) that produces images of a sample by scanning the surface with an electron beam. Particles of fissionable material are secured to the sample stub and inserted into the SEM vacuum chamber for observation. The average mass of this sample is about 1μg.

Figure 12: Scanning Electron Microscope (SEM).

3.4.17 Fissionable Material Scanner

This instrument scans a containerized sample of fissionable material using a 1D or 2D tungsten collimator and HPGe detector to provide a view of the distribution of activity within the container geometry.

3.4.18 Glovebox

There are 5 gloveboxes within the boundary of this FMO; 2 contain an accountable amount of fissionable material, and 3 are out of service. The 2 active gloveboxes are also used to store analytical residues. There is a separate procedure which details the average mass of fissionable material contained within each glovebox.

3.4.19 Hood

There are 7 open-front hoods within the boundary of this FMO; 3 of them are LTA, 3 are LTA and contain beryllium, and 1 is accountable and contains beryllium. These hoods are generally used for sample preparation and chemical separation, and each hood contains fissionable material of an average mass of about 0.1g, with a maximum mass of 0.2g. These samples are used for various instruments, including but not limited to the Scanning Electron Microscope (SEM) in room 7053 and the counting instruments in room 7055 and 7063.

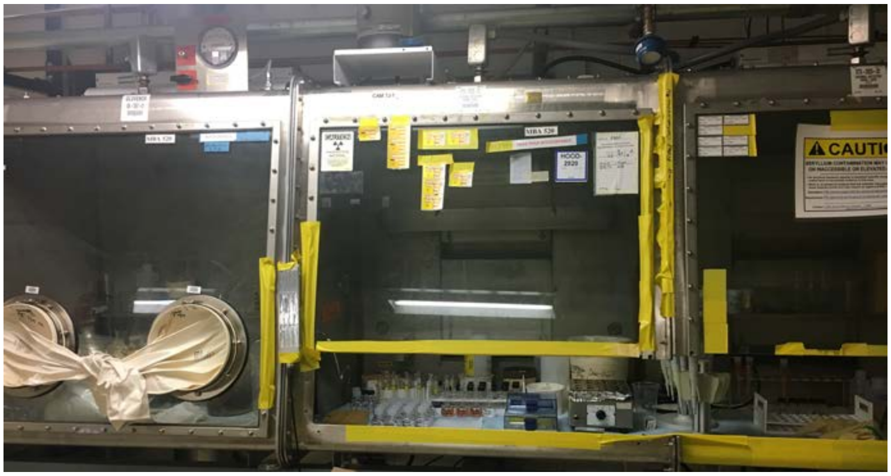


Figure 13: Glovebox and Hood Set-up.

3.4.20 Continuous Air Monitor (CAM)

This instrument protects against detrimental effects of alpha emission and radioactivity by monitoring the air in the proximity of the glovebox or hood in use and notifying the operator of unsafe levels of nuclear material outside of an enclosure. It also discriminates between radon, which occurs naturally, and actinide material, which can be harmful to personnel.

Figure 14: Continuous Air Monitor (CAM).

3.4.21 Balance

This instrument provides precise mass measurements of samples of fissionable material.

3.4.22 Safe
This safe contains several samples of fissionable material. The average mass of each sample is on the order of magnitude of about 1μg.

3.4.23 Storage cabinets
There are several storage cabinets within the boundary of the FMO. These contain a variety of items: general tools and laboratory supplies, files, flammable liquids, corrosives, and samples of fissionable material. For those that contain fissionable material samples, the average mass of such a sample is on the order of about 1μg.

3.4.24 Lead shielding
In several locations throughout the FMO, lead bricks are used for shielding purposes. In room 7051, a bisco box, lead, and doped polymer bricks are used to shield plutonium-beryllium (PuBe) material; the average mass of this material is about 10g within the shielding configuration, however this shielding configuration has previously been used to shield up to 25g of fissionable material in this area. In room 7055, lead is available to be used for shielding. In room 7061, lead is used to shield fissionable material of an average mass of about 5g. In room 7065, lead is used to shield fissionable material of an average mass of about 5g; however, the lead bricks have previously been used to shield up to 25g. All materials within these locations adhere to the double confinement layer packaging policy.

3.4.25 Additional Processes
In addition to the many instruments used for non-destructive assay purposes within the FMO boundary, there are several instruments that do not interact with fissionable material. These include but are not limited to compressed air canisters, computers, dewars, general tools and laboratory supplies, printers, sinks, and vacuum pumps.

This location is used for destructive and non-destructive analysis of fissionable materials within the Actinide Analytical Chemistry (AAC) Group. The intent for destructive and non-destructive analysis is to determine the elemental / isotopic composition of the fissionable materials in question. Fissionable materials are typically introduced into this location in sealed containers, and are hand-carried between rooms. The operations are limited to a 520g plutonium mass limit.

3.5. Maintenance, Housekeeping and Hold-up
The small sample preparation and analysis instruments and hoods require semi-regular maintenance and housekeeping. Various hand tools, tooling, and diagnostic equipment are allowed at this location to facilitate maintenance/housekeeping activities as required. As gloveboxes are used to store mainly less-than-accountable (LTA) fissionable material and waste, they require the same such maintenance but less often.

Over time, fissionable material build-up may occur within hoods, gloveboxes, and lead shielded areas; good housekeeping practices reduce the amount of build-up in these locations.

3.6. Waste Management
Residues are generated in small amounts, in the form of analytical consumables, worker PPE, and cleaning materials.

3.7. Fire-fighting

Sprinkler systems are present at this location.

4. Normal and Credible Abnormal Process Conditions

In conjunction with input from operations personnel and process specialists, a “What If” method was used in order to identify the changes in process conditions. The identified changes in process conditions that may have impact on the criticality safety of the operation are categorized as either a normal condition or a credible abnormal condition.

This evaluation satisfies both the Process Analysis requirement of ANSI/ANS-8.1 [Reference 8] as required by SD-130 and the Double-Contingency principle of ANSI/ANS-8.1 as recommended by SD-130. The influence of parameter changes on the subcriticality of the operation, as required by ANSI/ANS-8.1 is understood, as this CSED analyzed the normal and credible abnormal conditions that impacts one or multiple parameters. The CSED team identified and categorized changes in process conditions that impact parameters important for the criticality safety of the operations as being independent from one another, or those which could affect multiple parameters due to a single credible abnormal condition. For example, flooding is a change in process condition that affects multiple parameters, such as moderation, reflection, and absorption. Also, an operator could accidentally introduce several fissionable material samples into the Ortec Clamshell HPGe while it is at capacity, perhaps affecting only one parameter: mass. These two changes in process conditions are unlikely, and independent from one another.

The sub-sections will discuss the normal and credible abnormal conditions for operations conducted in CMR Wing 7 basement, to determine if analysis provided in the SCSR CSED is applicable and bounding for the operations conducted in this location.

4.1. Normal Conditions

Under normal conditions, this location is administratively restricted to 520g of fissionable materials in compounds and dry-residue. Plutonium is the bounding fissionable material for the range of normal (as well as credible abnormal) conditions.

The analysis performed in Reference 3 provides a discussion about what is required to have 520g Pu(0) reach critical and that the conditions required to occur are not credible in a realistic processing environment. Besides limited amounts of cleaning fluid, moderation sources that may be present in this dry operation are bound by water and therefore, the analysis in Reference 3 bounds the operations conducted at this location.

This operation will not use any cryogenic materials such as liquid nitrogen or liquid helium, which may have a potential to lower the critical mass beyond the standard laboratory operating environment, to cool fissionable materials. Liquid nitrogen is sometimes used to cool germanium crystals for gamma detectors.

Based on discussions above, the normal conditions for the small sample preparation and NDA operations conducted at this location are bound by the analysis in Reference 3 and will remain subcritical.

4.2. Credible Abnormal Conditions

The analysis in Reference 3 considers several credible abnormal conditions: loss of mass control, loss of interaction control, loss of volume control, and loss of control of multiple parameters. Comparison of those abnormal conditions with those in the small sample preparation and NDA operations in the Wing 7 Basement of the CMR Facility is summarized below.

- The loss of mass control analysis performed in Reference 2 analyzes the most reactive, credible mass upset conditions for 520g operations for the entire facility. Based on the 520 g administrative limit, the most reactive credible loss of mass control scenario is expected to be 1,040g from double batching of similar types of materials. Other nuclides such as americium, are expected, however in lower content compared to the total plutonium mass, and so these nuclides are judged to be bound by plutonium. Based on the analyzed mass upset discussed above, the analysis performed in the SCSR CSED is bounding for all credible mass upset conditions that might occur at this location, and demonstrates that it will remain subcritical.

- No credit was taken for moderation. The analysis performed in the SCSR CSED analyzes full water reflection. In addition, the SCSR CSED considers the moderating effects of graphite as well as beryllium, and judged that the amounts necessary to create a critical configuration is not credible within a typical operations including operations in this FMO.

- The loss of reflection control analysis performed in Reference 3 analyzes all credible reflection upset conditions for the 520 g operations under the scope of the SCSR CSED, and bounds operations at this location. Reference 3 considers full water reflection in the analysis. Based on the analyzed reflection upset discussed above, the analysis performed in the SCSR CSED is bounding for all credible reflection upset conditions that might occur at this location, and demonstrates that it will remain subcritical.

  A particular credible reflection upset condition for this FMO may occur in the Ortec Clamshell HPGe and the Ortec Steelbox HPGe. The chambers of these instruments contain steel shielding, which is sometimes more reflective than water. However, based on analysis in Reference 7, the potential reflection due to steel shielding is still bounded by that of full water reflection.

- The loss of interaction control analysis performed in Reference 3 analyzes all credible interaction upset conditions for a defined 520 g operation, including operations located in gloveboxes. There are no other FMOs in the Wing 7 Basement. Thus, the analysis performed in the SCSR CSED is bounding for all credible interaction upset conditions that might occur at this location, and demonstrates that it will remain subcritical.

- The loss of volume control analysis performed in Reference 3 analyzes all credible volume upset conditions for the 520 g operations under the scope of the SCSR CSED, and bounds operations at this location. The 2.2 liters volume restriction applies to fissionable material in solutions; however, as the solutions used in this FMO are on the order of 5g, a volume upset is essentially not credible. Additionally, the analysis in Reference 3 analyzes the plutonium metal-water mixture at optimal concentration, meaning that any increase or decrease in the system volume would result in a decrease in reactivity. The facility uses 2.2-liter containers for solutions. Even if an operator were to obtain a container of greater size than 2.2 liters, it would still be bound by the analysis in Reference 3 because the analysis evaluates a single container of plutonium metal-water mixture at various volumes much greater than 2.2 liters. Based on the analyzed volume upset discussed above, the analysis performed in the SCSR CSED is bounding for all credible volume upset conditions that might occur at this location, and demonstrates that it will remain subcritical.

- No credit is taken for material density/concentration. The analysis performed in SCSR CSED analyzed each material using the most reactive density. Solutions were analyzed at varying concentration such that the optimal concentration was analyzed for both normal and credible abnormal conditions.

- No credit is taken for enrichment/isotopic. The analysis performed in the SCSR CSED uses Pu(0) in 520 g plutonium solution, that is, no credit was taken for ^{240}Pu content.

- No credit is taken for neutron absorber. The analysis performed in the SCSR CSED does not rely on absorber in the processed materials. Furthermore, the presence of absorber material would increase the safety margin of the operations.

- No credit is taken for geometry. The analysis performed in the SCSR CSED analyzes 520 g Pu(0) at optimal geometry, such that no specific geometry is credited for subcriticality.

- The analysis performed in Reference 3 analyzes all credible concurrent loss of control of multiple parameters for the facility and showed them to be subcritical. The location of the small sample preparation and NDA operations does not introduce any scenario that is not analyzed and/or not bounded by the SCSR CSED.

Based on discussions above, the credible abnormal conditions for the small sample preparation and NDA operations conducted at this location are bound by the analysis in Reference 3 and will remain subcritical.

5. Analysis

Not applicable to this SCSR Application (Level-1) CSED.

6. Conclusion

The small sample preparation and NDA operations with the recommended criticality safety requirements in Section 2 of this document satisfy the Process Analysis Requirement of ANSI/ANS-8.1 [Reference 8] and will remain subcritical under both normal and credible abnormal conditions. Please contact NCS at your earliest convenience if you have any questions or concerns regarding this evaluation.

7. References

1. **NCS-AP-004**, *Criticality Safety Evaluations*, 2016-10-07.
2. **NCS-MEMO-17-007**, *Application of Standard Criticality Safety Requirement Evaluations*, 2017-02-13.
3. **NCS-CSED-17-009**, *Criticality Safety Evaluation of Standard Criticality Safety Requirements #1 – 520 g Operations in PF-4*, 2017-02-28.
4. **NCS-MEMO-09-026**, *Status of the Nuclear Criticality Safety Program at CMR.*
5. **ESH-6-99-026**, *Plutonium Equivalencies for Thorium (Th), Protactinium (Pa), Uranium (U), Neptunium (Np), Americium (Am), and Curium (Cm)*, 1999-03-31.
6. **CMR-AP-522**, *CMR Nuclear Criticality Safety*, 2016-02-12.
7. **NCS-TECH-16-008**, *Critical Mass Curves of Plutonium Spheres with Various Reflectors*.
8. **ANSI/ANS-8.1-2014**, *Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors.*