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TA-55 Final Safety Analysis Report Comparison Document and DOE Safety Evaluation Report Requirements

Los Alamos
NATIONAL LABORATORY

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Table of Contents

Abstract **1**
Executive Summary **3**
TA-55 Final Safety Analysis Report Comparison Document and DOE Safety Evaluation Report Requirements **5**
SER Requirements 5
Zone 1 Exhaust Filters 5
Process Hazard Analysis Documents 6
System Design Description Preparation 7
Seismic Source Term 8
Flammable Gas Mountings 9
Plenum Cool-Down Sprays 9
Fire Hazard Analysis 10
Removal of H_2 Cylinders 10
Process Flow Diagrams 11
Glovebox Upgrades 11
Facility Cracking 11
Emergency Planning Consistent with FSAR Hazards 12
Degraded Storage Containers 13
EBA Selection 13
New Processes 19
Hazard Scenarios 22
Initial Screening 26
Intermediate Screening 30
Screening Standard Industrial Hazards 33
Accident Categories 36
Final Screening 40
References 59

List of Tables

Table 1-A. Hazard Scenarios for ROBOCAL 22
Table 1-B. Hazard Scenarios for Dimensional Gage Inspection 24
Table 2-A. Initial Screening Hazard Scenarios for ROBOCAL 27
Table 2-B. Initial Screening Hazard Scenarios for Dimensional Gage Inspection 29
Table 3-A. Intermediate Screening for ROBOCAL 30
Table 3-B. Intermediate Screening for Dimensional Gage Inspection 32
Table 4-A. Screening of Standard Industrial Hazards for ROBOCAL 33
Table 4-B. Screening of Standard Industrial Hazards for Dimensional Gage Inspection 35
Table 5-A. Sorting Accident Scenarios into Categories for ROBOCAL 36
Table 5-B. Sorting Accident Scenarios into Categories for Dimensional Gage Inspection 39
Table 6-A. Scenarios that Potentially Challenge Offsite Evaluation Guidelines for ROBOCAL 40
Table 6-B. Scenarios that Potentially Challenge Offsite Evaluation Guidelines for Dimensional Gage Inspection 42
Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR 43
Table 8-A. ROBOCAL Controls 57
Table 8-B. Dimensional Gage Inspection Controls 58

List of Acronyms and Abbreviations

Acronym or Abbreviation	Definition
^{238}Pu	plutonium-238
^{239}Pu	plutonium-239
ARIES	Automated Retirement and Integrated Extraction System
ASME	American Society of Mechanical Engineers
CAM	continuous air monitor
CAS	Criticality Alarm System
CSLA	criticality safety limit approval
EBA	evaluation basis accident
EBE	evaluation basis earthquake
EDE	effective dose equivalent
FHA	Fire Hazard Analysis
FSAR	Final Safety Analysis Report
FSTF	Full-Scale Test Facility
g	gram
GB	glovebox
HEPA	high-efficiency particulate air
HVAC	heating, ventilation, and air conditioning
IFIT	Isotopic Fuel Impact Test (Facility)
LANL	Los Alamos National Laboratory
LCO	limiting conditions of operation
LPF	leak path factor
MAR	material-at-risk
PrHA	Process Hazard Analysis
Pu	plutonium
RCT	radiological control technician
ROBOCAL	robot calorimeter
SDD	system design description
SER	Safety Evaluation Report
SNM	special nuclear material
SOP	safe operating procedure
SSC	systems, structures, and components
TRU	transuranic
TSR	Technical Safety Requirement
USQD	unreviewed safety question determination

TA-55 Final Safety Analysis Report Comparison Document and DOE Safety Evaluation Report Requirements

Abstract

This document provides an overview of changes to the currently approved TA-55 Final Safety Analysis Report (FSAR) that are included in the upgraded FSAR. The DOE Safety Evaluation Report (SER) requirements that are incorporated into the upgraded FSAR are briefly discussed to provide the starting point in the FSAR with respect to the SER requirements.

TA-55 Final Safety Analysis Report Comparison Document and DOE Safety Evaluation Report Requirements

Executive Summary

This document provides an overview of changes to the currently approved TA-55 Final Safety Analysis Report (FSAR) that are included in the upgraded FSAR. The DOE Safety Evaluation Report (SER) requirements that are incorporated into the upgraded FSAR are briefly discussed to provide the starting point in the FSAR with respect to the SER requirements.

Six additional accidents were analyzed for the upgraded FSAR. The results are shown in Table 7. The accident analysis presents a bounding source term based on the facility fans being operable and the HEPA filters inoperable. It also presents mitigated source terms where the HEPA filters are operable, the fans are operable and inoperable, and the facility doors remaining closed. This ensures that the minimum and maximum dose is characterized for the evaluation basis accident releases. Source terms in the upgraded FSAR are similar to the currently approved FSAR. Table 7 includes a comparison.

The following additional changes were made in the upgraded FSAR.

- Leak path factors (LPF) were calculated using a facility model on Melcor®. These LPF are significantly lower than those calculated using Gasflow in the current FSAR.
- MACCS2® was used for calculating the rem/g doses that the MOI could be exposed to. More accurate input with respect to terrain, buoyant energy, etc., has led to lower rem/g doses in the upgraded FSAR. Appendix 3G of the upgraded FSAR explains the MACCS2 input that was used and the results.

The upgraded FSAR results demonstrate that the assumptions and basis for approval for the current FSAR are still valid and representative of the facility hazards and operations.

TA-55 Final Safety Analysis Report Comparison Document and DOE Safety Evaluation Report Requirements

This document provides an overview of the changes to the currently approved Final Safety Analysis Report (FSAR) that are included in the upgraded FSAR. The DOE Safety Evaluation Report (SER) requirements that are incorporated into the upgraded FSAR are briefly discussed to provide the starting point in the FSAR with respect to the SER requirements.

- Zone 1 Exhaust Filters
- Process Hazard Analysis Documents
- System Design Description Preparation
- Seismic Source Term
- Flammable Gas Mountings
- Plenum Cool-Down Sprays
- Fire Hazard Analysis
- Removal of H2 Cylinders
- Process Flow Diagrams
- Glovebox Upgrades
- Facility Cracking
- Emergency Planning Consistent with FSAR Hazards
- Degraded Storage Containers
- EBA Selection

SER Requirements

Zone 1 Exhaust Filters

As part of the SER requirements for the currently approved FSAR, Los Alamos National Laboratory (LANL) was required to upgrade the ventilation system Zone 1 HEPA exhaust filters to withstand 300 °F.

Continued on next page

Zone 1 Exhaust Filters, Continued

This requirement has been completed through DCP-99-101, *Plenum Cool Down Spray/Control Box Wiring Modifications*. Additionally, analyses for the FSAR upgrade (provided in Appendix 3-I) show that the 200 Area bleed-off filters (upstream of the exhaust filters) could be subjected to 104 °F temperatures during the evaluation basis 4.5-MW fire in Room 207. Because the bleed-off filters are only subjected to 104 °F temperatures, the exhaust filters are not affected by temperature.

Process Hazard Analysis Documents

As part of the SER requirements for the currently approved FSAR, LANL was required to institute a continuous process hazard analysis program.

This requirement was completed with process hazard analysis documents being prepared for all active processes in PF-4. These Process Hazard Analyses (PrHAs) were prepared according to NMT procedure NMT-AP-588, *Preparing Process Hazard Analyses*, and are consistent with DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, July 1994. Process subject matter experts were intimately involved in the *what-if* sessions and walkdowns, and they were required to review and approve each PrHA before it was deemed completed.

Process descriptions and accident scenario tables from the PrHAs were consolidated in the *Hazard Analysis Input Document*. This document provides the process descriptions for the authorization basis and provides the basis for identifying controls for the prevention and mitigation of hazards.

The accident scenario tables from the individual PrHAs contain the process controls, facility controls, and administrative controls that are required to reduce the risk associated with each scenario to an acceptable level. These controls provided the pool for selection of safety-class, safety-significant, and defense-in-depth controls.

Continued on next page

Process Hazard Analysis Documents, Continued

The PrHAs also provided an additional benefit when new processes that potentially required safety controls were identified before the process was ready for start up. An example of this was the combustible loading limit for the robot calorimeter (ROBOCAL) and the flammable gas limits placed on the Automated Retirement and Integrated Extraction System (ARIES).

A compact disk (CD) with all PrHAs has been provided to DOE. The CD is dated December 2000.

Additional hazards that presented unreviewed safety questions (USQs) are listed with their resulting controls in Appendix D of the *Hazard Analysis Input Document*. Accident scenarios from the PrHA for each new process were included in the screening for evaluation basis accident (EBA) selection.

System Design Description Preparation

As part of the SER requirements for the currently approved FSAR, LANL was required to develop system design descriptions (SDDs) for all safety-class or safety-significant systems. The following SDDs have been prepared in support of meeting this requirement.

Document Number	Title
NMT8-SDD-0110	13.2 kV Power Distribution System
NMT8-SDD-1210	Confinement System
NMT8-SDD-1411	Criticality Alarm System
NMT8-SDD-4100	Electrical Distribution System
NMT8-SDD-5110	Paging System
NMT8-SDD-6110	Glovebox System
NMT8-SDD-3310	Fire Suppression Water Supply System
NMT8-SDD-3320	Fire Suppression Sprinkler System
NMT8-SDD-0121	Uninterruptible Power Supply System
NMT8-SDD-5211-01	Facility Control System Hardware
NMT8-SDD-5211-02	Facility Control System PLCs
NMT8-SDD-6200	Ventilation System
NMT8-SDD-**XXX**	Hydrogen Detection System

Seismic Source Term

As part of the SER requirements, LANL upgraded the seismic capacity of ^{238}Pu gloveboxes, hoods, and associated passthroughs to survive the 0.3 g evaluation basis earthquake (EBE).

All active ^{238}Pu gloveboxes and hoods that would not survive to the EBE have been structurally upgraded to withstand the EBE except for three gloveboxes in Room 204:

- GB-201—Introductory and Pass Through
- GB-272—Storage
- GB-273—Introductory and Pass Through

These three gloveboxes are rated to 0.27 g and are used for plutonium (Pu) in solid form or fully encapsulated resulting in 0 g material-at-risk (MAR) for seismic purposes.

The seismic event accident analysis was developed using the 24-month average inventory for each mass location. This data is classified. NMT Division management has requested that this event be developed using the nonclassified criticality safety limits for each mass location. The write up is currently being drafted and will be provided. The seismic source term calculated from the criticality safety limit approval forms (CSLAs) is presented here and compared to the seismic source term from the current FSAR. The positive effect of the glovebox seismic upgrades can be readily observed by the reduction in source term that is attributed to the gloveboxes.

The seismic upgrades have resulted in a decrease in the ^{238}Pu component of the unmitigated seismic source term from 0.19 g (using a 1.0 leak path factor [LPF]) in the current FSAR to 0.121 g (using a 1.0 LPF) in the upgraded FSAR.

It should be noted that the ^{238}Pu seismic source term is no longer due to any glovebox operations. It is the result of additional floor locations that were not present during the previous FSAR preparation. Specifically, these waste staging areas (Room 201B). Room 201B material is slated to be processed through the aqueous recovery of ^{238}Pu process.

Continued on next page

Seismic Source Term, Continued

The ^{239}Pu seismic source term has been lowered from 85.2 g (current FSAR source term using 1.0 LPF from glovebox operations) to 81.3 g (upgraded FSAR source term from glovebox operations and floor locations). This is a net reduction of 3.09 g.

Additional analysis of the seismic source term data shows that the seismic upgrades that were implemented on 61 ^{239}Pu gloveboxes resulted in a 4.08 g reduction in source term. Additional reductions in glovebox limits of 2.9 g were realized by lowering limits to reflect actual process needs in non-seismically qualified gloveboxes. Increases in the amount of 3.09 g were seen because of the addition of floor locations.

Taking the current source term and subtracting seismic upgrades and process reductions and then adding in floor locations results in the following calculation:

$$85.2\ g - 4.08\ g - 2.91\ g + 3.09\ g = 81.3\ g$$

Flammable Gas Mountings

As part of the SER requirements for the currently approved FSAR, LANL was required to verify the seismic capacity of all internal facility flammable gas mountings and piping.

This requirement was completed in accordance with the memorandum to DOE numbered NMT8:97-066. New mountings and piping are reviewed through the unreviewed safety question determination (USQD) process to ensure this requirement is met for new installations.

Plenum Cool-Down Sprays

As part of the SER requirements for the currently approved FSAR, LANL was required to correct the discrepant as-found condition.

Continued on next page

Plenum Cool-Down Sprays, Continued

According to NMT1-10:99-200, *TSR Transition Review Final Report* (Kent Sasser et al.), corrective actions have been completed according to DCP-97-021, *Plenum Cool Down Spray/Control Box Wiring Modifications*. The ability to activate the second plenum spray or to shut off either spray from the Facility Control System has been completed. Discussions with the responsible facility engineer confirmed that the facility instrumentation engineer and HVAC engineer completed connection and testing of the 140 °F activation sensor.

The analysis in Appendix 3-I of the FSAR shows that the recirculation subsystem HEPA filters could be exposed to 314 °F if a 4.5-MW fire consumed a room. This temperature is achieved only if the safety significant sprinklers do not activate. A fire in Room 207 would result in the MOI receiving a dose of 5.6 rem from the unmitigated release. This is below the 25-rem offsite guideline, making additional safety-class controls unnecessary. The safety-class exhaust filters do not see a significant temperature increase under this fire scenario. Further controls on combustible items in Room 207 are being considered (Room 207 is singled out because there is sufficient fixed combustibles present to achieve a 4.5-MW fire).

Fire Hazard Analysis

As part of the SER requirements for the currently approved FSAR, LANL was required to update the Fire Hazard Analysis (FHA).

This was completed according to the SER. The FHA was also updated in support of the upgraded FSAR effort and has been submitted to DOE with the 90% completed upgraded FSAR.

Removal of H_2 Cylinders

As part of the SER requirements for the currently approved FSAR, LANL was required to remove all hydrogen cylinders outside PF-4 to eliminate leakage inside the facility following an EBE. This was completed according to NMT1-10:99-200, *TSR Transition Review Final Report*.

Process Flow Diagrams

As part of the SER for the currently approved FSAR, it was recommended that LANL develop process flow diagrams for significant hazard processes. These drawings have been submitted to DOE with the 90% completed upgraded FSAR.

Glovebox Upgrades

As part of the SER for the currently approved FSAR, it was recommended that LANL upgrade an additional 50 gloveboxes based on cost benefit considerations.

Since the SER was issued, gloveboxes have been upgraded on a case-by-case basis. Any glovebox that is moved to another location is upgraded if needed. Any new glovebox is originally designed to survive the EBE. Any time a process in a glovebox is changed, it is reviewed to determine if the seismic source term was increased because of the new process. If the source term is increased, the glovebox is upgraded.

These practices have resulted in 61 ^{239}Pu gloveboxes being upgraded in addition to the ^{238}Pu gloveboxes already upgraded. The seismic source term did decrease because of these upgrades as explained above.

Facility Cracking

As part of the SER for the currently approved FSAR, it was recommended that LANL determine the cause and stability of facility cracking.

The building cracking was evaluated by the facility structural engineer. The conclusion was that the cracking is superficial and poses no threat the facility confinement.

Continued on next page

Facility Cracking, Continued

Cracking was first observed in the PF-4 structure shortly after construction. A survey of the cracks was performed in 1980, and their locations were plotted on elevation drawings of the walls. The cracks are small, less than 1/16-in. in width, and occur at roughly a 4-ft to 6-ft spacing around the exterior of the building. They appear to be caused by temperature and shrinkage effects from when the concrete was originally placed. This conclusion is supported by two studies. First, an additional survey of the cracking was completed in 1996 and the locations were plotted over the original 1980 survey. The pattern and location of the cracks matched well with the original survey. Second, a monitoring program was initiated and tracked with DCP-98-089, *Install Crack Monitors Per SER.* Selected cracks were monitored over the course of a year, and only slight movement was observed with changes in temperature.

Methods of repair and sealing were evaluated. Because of their small size and low relative movement, the cracks were sealed using an elastomeric sealant. An elastomeric paint was applied as a final coating. The finish has an expected life of approximately 10 years. The sealing has been performing as expected to date.

Emergency Planning Consistent with FSAR Hazards

As part of the SER for the currently approved FSAR, it was recommended that LANL verify that the emergency planning requirements for PF-4 cover the spectrum of accident consequences covered in the FSAR.

The *TA-55 Emergency Plan*, TA55-PLAN-007, details how personnel respond to various accident scenarios. These include radiological releases, nonradiological releases, radiological and nonradiological releases, earthquakes, fires, and different levels in the facility from the basement through the mezzanine, etc.

Additionally, these procedures are currently being reviewed and revised in accordance with NMT Division management directions.

Degraded Storage Containers

As part of the SER for the currently approved FSAR, it was recommended that LANL implement a long-term solution to the packaging of nonhermetically sealed containers.

The Laboratory is continuing to repackage all suspect containers and has initiated using 3013 containers in the ARIES process. Through this effort, the number of degraded containers has been continually reduced. Exactly how much of a reduction has not been quantified. However, it is felt that the process of ensuring container integrity will be continuous. This is in order to minimize the risk of discovering an original container that has developed some degradation and to discover a degradation problem with a repackaged container before it has degraded to the point of release. All high hazard containers (showing visual degradation) have been repackaged.

EBA Selection

The consequences of each scenario in the hazard tables were used in the screening process that led to selection of EBAs. The results of the accident selection process show that while the current FSAR preparers did not have the benefit of the completed PrHAs, the accidents they identified survived the screening and were independently elevated to EBAs. The similar conclusions reached between the current FSAR and upgraded FSAR indicate that both preparers used a reasonable approach to accident selection.

Accident scenarios that survived the screening (see Section 2.3 of the *Hazard Analysis Input Document*) were placed in categories. At least one EBA was selected for each accident category.

To demonstrate the screening criteria and selection of EBAs, two processes (ROBOCAL and Dimensional Gage Inspection) were mapped from the *Hazard Analysis Input Document* through the selection of EBAs. Tables 1 to 6 demonstrate the screening process. Immediately following Tables 6-A and 6-B is an explanation of whether or not the mapped scenarios were selected as EBAs.

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A comparison of the current EBAs and those analyzed in the FSAR upgrade is provided in Table 7. This table is intended to identify the additional analysis that was performed and to present the major assumptions used in the accident analysis, the material-at-risk (MAR), LPF, etc. to quickly point out any differences. It is intended to be a quick comparison tool.

Leak Path Factors and rem/g Doses

Table 7 illustrates that even though the preparers of the current FSAR and the preparers of the upgraded FSAR used some different tools in the accident analysis, the source terms were actually very close. The main difference in the analysis is the application of the modeling software Melcor® to develop the LPF and MACCS2® to develop rem/gram factors for isotope releases. Each model is being independently evaluated by the LANL Office of Authorization Basis.

Although MACCS was used in the current FSAR, the input was somewhat different for the upgraded FSAR. Melcor was not used to calculate LPF for the current FSAR. Input to these models is presented in Appendices 3G (MACCS2) and 3I (Melcor) of the upgraded FSAR. The differences are due to having the benefit of an approved FSAR as a starting point and adding the knowledge and judgement gained since the FSAR was originally prepared.

The upgraded FSAR results demonstrate that the assumptions and basis for approval for the current FSAR are still valid and representative of the facility hazards and operations

A notable difference in the upgraded FSAR is the presentation of the accident analysis results using three different leak path factors. The LPF that are presented are unmitigated, which represents the absolute worse case release. This condition represents the ventilation fans running and the HEPA filters failing. This is a truly biased worst-case release because, for example, the electrical system is not expected to survive the earthquake. Therefore, this represents a worst-case LPF beyond what is necessary for the accident analysis.

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Leak Path Factors and Rem/g Doses (continued)

Usually, two mitigated LPF are presented. They represent the variations with the HEPA filters in place and the ventilation fans running and not running. Both of these variations were presented to provide additional information and to demonstrate the effect of the safety-class HEPA filters and the safety-significant ventilation system. The mitigated LPF were calculated with the facility doors shut. Therefore, it can be confidently said that the actual release from the facility caused by any of the EBAs that were evaluated would be between the mitigated release and the unmitigated release.

Selection of Safety-Class and Safety-Significant Equipment

The selection of potential safety-significant systems, structures, and components (SSCs) was based on the following:

Safety Class	Basis
Safety-class	Protection of the public
Safety-significant	• Defense-in-depth • Additional emphasis placed on prevention versus mitigation • Process-level controls for worker safety and defense-in-depth

The appendices (3E and 3D) to Chapter 3 of the FSAR were prepared for processes that survived the screening. These appendices evaluate the affect that each control has on the frequency or consequence of the unmitigated accident scenario for that process. These appendices were the basis for the designation as potentially safety-significant. Refer to Section 3.3.2.3.2 for additional information. Tables 8-A and 8-B show the corresponding tables for ROBOCAL and Dimensional Gauge Inspection.

Continued on next page

Selection of Safety-Class and Safety-Significant Equipment (continued)

Safety-Significant	Facility	Process	Current	Upgrade
PF-4 Confinement	X		X	X
Ventilation System	X		X	X
Uninterruptible Power Supply	X		X	X
Electrical Distribution System, Power Distribution System	X		X	X
Gloveboxes	X		X	X
Facility Control System	X		X	X
Fire Suppression System	X		X	X
Criticality Alarm System	X		X	X
Vault Racks and Shelves	X		X	X
H_2 Detector GB-116		X	X	
Instrument Air System	X		X	X
Paging System	X		X	X
HNO_3 Tank Berms		X	X	X
Intake and Exhaust HEPAs			X	X
Fire Sprinklers			X	X
Room Fire Barriers (process specific)			X	X
Type A containers PF-185		X		X
AIRES reactor vessel		X		X
Round Bottom Crucible		X	X	X
AQCP Piping/Vessel Integrity		X		X
Non-nitrated Resins		X		X
PREP Nonreactive Crucible		X		X
Furnace and Piping Integrity		X		X
Isotopic Fuel Impact Test (IFIT) Facility				
Ceiling Armor	X	X	X	X
Outer Catch Tube and Projectile Can		X		X
Inner Catch Tube		X		X
Facility Containment	X		X	X
Pit Burst Test Unit PRV		X		X
Lexan Shielding		X		X
Pump Pressure		X		X
Pump Houses	X		X	X
40 mm SS Catch Tank		X	X	X

Safety-Significant	Facility	Process	Current	Upgrade
Full-Scale Test Facility (FSTF) Blow-Out Diaphragm		X	X	
Reaction Chamber		X	X	
Flow Control Valve		X	X	X
H_2 Piping		X		X
Manual Isolation Valve		X		X
H_2 Detector		X	X	
Radiography Source Shielding		X	X	X
Lead, Tungsten Shielding		X	X	X
Hydrothermal Processing Reactor Tie		X	X	X
Lean Shield		X	X	X
PRV		X	X	X
Pigma PRV		X	X	X
Pressure Vessel		X	X	X

New Processes

USQD Number	USQD Title	Controls
96-008	Cold Welder Process	The structures and components that make up the confinement system are required to be operational to mitigate the consequences of accidents. During normal operation, the ventilation system must maintain airflow from areas of least probability of contamination to areas of higher probability of contamination (minimum requirement is laboratory pressure to be <0.05 in. wc with respect to outside air). Otherwise, the facility is required to go into MODE 2 (standby) within 2 hours.
		NOTE: The previous requirements are from the Technical Safety Requirements (TSRs) for TA-55 operation.
		Conditions stipulated in the DOE approval memo: 1. The unreviewed safety question (USQ), hazard analysis, design drawings, installation design criteria, criticality analysis, pressure calculations, and calculation files that support the USQ comprise the approved authorization basis for this activity in the interim until the TA55 FSAR and TSRs can be revised. 2. Revision of the FSAR and TSRs to incorporate the analyses and margins of safety as specified in the memo shall not exceed 1 year from the approval date of this USQ. 3. A cyclic fatigue evaluation should be performed on the unit to support a basis statement or administrative control on this potential failure mode before the revision of the FSAR and TSRs. 4. Installation of a third 300 Area, Zone 1 HEPA filter on each of the three stages, which must be completed before start up of the welder. 5. The ASME-certified pressure release valve and the pressure vessel itself be identified as safety-significant.

USQD Number	USQD Title	Controls
97-006	Radiography Operations at TA-55	Administrative controls are given in the PrHA: **(give number and title)** • Follow safe operating procedures, flow sheets, accountability, and inventory controls. • Operator training. • Glovebox header is checked once per shift; filter plenum pressure differences are checked daily. • Worker evacuation procedure for criticality incidents; quarterly testing and monthly checks of alarms for criticality alarm system. • Spill response procedures; fire brigade response; emergency management.
		Conditions that are stipulated in the DOE approval memo: (No more than five are operations allowed) The following four controls are in the TA-55 Interim TSRs under the Radiation Protection Program and in the implementing special work permits. 1. Ceasing all other operations attended by personnel in PF-4. 2. Ceasing all unattended operations in Room 319. 3. Performing the radiography operations during operational off-hours. 4. Evacuating all nonessential personnel (defined as ESA-MT radiographers, NMT-5 material handlers, radiological control technicians (RCTs), and personnel directly related to quality assurance oversight of the process). The NMT Division shall verify that PF-4 has been evacuated of non-essential personnel and shall have security verify that the roof has been completely evacuated, with the NMT Division retaining ultimate responsibility. PF-4 shall be secured **before** operations are started and for the duration of radiography operations.

USQD Number	USQD Title	Controls
		The following four are required as modified: 5. The shielding provided for the source and lead collimator (4-in. source tube) must be designated as a passive safety-significant design feature. This includes the Ir-192 source shielding cask, tungsten, and lead shielding for the lead collimator. 6. The components necessary to ensure operability of the reel mechanism (to include the crank assembly and the drive cable) are defense-in-depth features. 7. For the first five interim radiography operations authorized under the memo, a DOE/LAAO Safety Authorization Basis Team member shall be present to observe the operation. (Open issues remain with regard to the readiness assessment findings; they will be addressed as part of the readiness assessment for long-term operations.) 8. Limiting conditions of operation (LCO) statements, LCO basis statements, administrative controls, and design features for radiography operations shall be developed for the TA-55 TSR revision The following actions shall be implemented for the interim radiography operations: 1. Radiography operations shall be conducted in accordance with the special work permits. This specifically includes removing and placing back into operation criticality detector head 319E. Placing the criticality alarm system back into service shall be independently verified and signed off. 2. Long-term radiography operations are dependent on successfully addressing the following two requirements: – Radiography operations depend on having a single radiography procedure, most likely an NMT Division administrative procedure. – The NMT Division shall conduct a limited, scoped readiness assessment with DOE involvement evaluating the specific technical issues that are required to support operations.
98-052	ARIES Direct Metal Oxidation	Administrative controls are given in the PrHA: 1. Low combustible loading within the glovebox mitigates possible fire scenarios in the glovebox. 2. Operator training and procedures mitigate the potential molten metal scenarios in the reactor vessel.

USQD Number	USQD Title	Controls
		Conditions stipulated in DOE approval memo: 1. Oxygen Mass-Flo Controller (active safety significant). 2. At least two calibrated thermocouples. 3. Programmable Logic Controller that shuts down the DMO glovebox oxygen flow if any thermocouple exceeds 6000 °C. 4. Argon blanket outside the reaction vessel. 5. Quartz crucible that act as a barrier to capture molten Pu

Hazard Scenarios

The screening was done according to the procedure given in Section 2.3 of the *Hazard Analysis Input Document*. First the hazard tables from the PrHAs were compiled. Table 1-A represents ROBOCAL and Table 1-B represents Dimensional Gage Inspection.

Table 1-A. Hazard Scenarios for ROBOCAL

R	F	C	Facility	Cause/Scenarios	Consequences P	Consequences W	Consequences E	Protective Features	Protective Systems	Administrative Controls
3	IV	B	PF-4, NMT-4	Sample container ruptured during handling (during staging, loading, positioning, unloading)	Radiation exposure C	B	C	Containers, canisters, double containment	Confinement ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement	HazMat and Rad Prot, admin., criticality limits, SOPs, operator training, uncontaminated items

Table 1-A. Hazard Scenarios for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
3	V	A	PF-4, NMT-4	Calorimeter overfilled with assay items; excess SNM (>4500 g) is present and event occurs to place items in unsafe configuration	Criticality C A C	SCV, PCV (double confinement) limited container dimensions, geometry/material forms do not favor criticality, cal. Cans give separation	Confinement Ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement CAS	Criticality Safety HazMat and Rad Prot (SNM weight limits; items must be in standard calorimeter canisters, CSLA limits)
3	IV	B	PF-4, NMT-4	Defective can seal permits leakage between two crimped/ damaged cans, causing rupture after item is removed from primary vessel	Radiation exposure C B C	SCV, PCV	HEPAs/HVAC, Zones 1 and 2 neg. pressure, CAMs, facility confinement	HazMat and Rad Prot, admin., criticality limits, SOPs, operator training, operators verify items are uncontaminated and container integrity
3 3	IV IV	A B	PF-4, NMT-4	SNM leaks into water bath or can dropped by operator or robot and SNM leaks into water bath (possible multiple can failures or use of large, 10.5-in. calorimeter)	a. Criticality C A C b. Radiation exposure C B C	SCV, PCV a. Limited container dimensions/ geometry, separation given by cal. cans (passive control) b. Remote handling for most operations/ assays	a. Building confinement, CAS b. HEPAs/HVAC, ventilation neg. pressure, CAMs, facility confinement	Admin., crit. limits, MASS accountability, crit. safety, SOPs, operator training Evacuation/emerg. resp.
3	IV	B	PF-4, NMT-4	Sharp equipment or tool breaches primary containment vessel	Radiation exposure C B C	SCV, PCV, double confinement, no glass parts in system, remote handling for assays/ most operations	Building confinement HVAC, HEPAs, ventilation confinement, CAMs, neg. pressure	SOPs, operator training (visual inspections) TA-55 fire/fire dept. response, maintenance Combustible controls

Table 1-A. Hazard Scenarios for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
2	III	A	PF-4, NMT-4	ROBOCAL electrical short ignites combustibles, causes PCV failures, dispersal of material	Radiation exposure A A B	Insulation, grounding PCV/SCV/confinement, separation of canisters	Building confinement, HEPAs/HVAC, ventilation, neg. pressure, CAMs, room sprinklers, fire supp. material.	SOPs, operator training Combust. control (rags in steel cans, low loading) Emergency/fire response
3	IV	A	PF-4, NMT-4	Earthquake/external event; equipment failure (wall/fence fall, cans/storage units fail) disperses material	Radiation exposure A A B	PCV/SCV integrity, confinement, separation of canisters, seismically qualified Kardex unit	Building confinement, HEPAs/HVAC, CAMs, neg. pressure	SOPs, operator training Emergency response
3 3	IV IV	B A	PF-4, NMT-4	Dewar failure; cryogenic nitrogen leak (industrial accident)	a. Operator inj. (cryo.) D B D b. Op. Inj. (asphyxiation) D A D	a. SS unpressurized dewar b. Limited volume (30-l)	a. Building confinement, HEPAs/HVAC, ventilation, neg. pressure b. Room volume (~500 m^3)	Cryogenic safety training SOPs, operator training Combustible/ignition source control Emergency response

Table 1-B. Hazard Scenarios for Dimensional Gage Inspection								
R	**F**	**F**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
3	II	C	PF-4	Glovebox gloves not withdrawn; torn or melted glove; loss of confinement	Radiation exposure D C D	Glovebox confinement Protective clothing	Building confinement HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training

Table 1-B. Hazard Scenarios for Dimensional Gage Inspection									
R	**F**	**F**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**		**Protective Features**	**Protective Systems**	**Administrative Controls**
3	II	C	PF-4	CMM/rotocon control fails/ misaligned; glove caught, torn by sharp tools or in moving parts causes loss of confinement	Radiation exposure D C D		Glovebox confinement Protective clothing	Building confinement HVAC (neg. pressure, HEPAs), CAMs	SOP; operator training Lack of sharp parts on components or machines
4 4	IV IV	C B	PF-4	Pyrophoric material burns when exposed to O_2 in glovebox or ignition of combustibles in glovebox (rags, alcohol) affects components	a. Operator injury/burn C C C b. Radiation exposure C B C		Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing.
3	III	C		Zone 1 ventilation failure/loss of neg. pressure; contamination	Radiation exposure D C D		Glovebox differential pressure indication; glovebox confinement	Building confinement HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training
4	V	A	PF-4	Criticality mass limits; exceeded for Pu metal or oxide	Criticality C A C		Glovebox confinement and shielding "Dry" process	Building confinement CAS, HVAC (HEPAs)	SOP; operator training; criticality safety limits; MASS
2	III	A	PF-4	Operator touches deteriorated power cord/ maintenance personnel are exposed to energized equipment; injury occurs	Electrical shock D A D		Electric insulation Insulated gloves, grounding	Shut-off switches	SOP, operator training Emergency/medical response

Table 1-B. Hazard Scenarios for Dimensional Gage Inspection									
R	**F**	**F**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**			**Protective Features**	**Protective Systems**	**Administrative Controls**
4 4	IV IV	C B	PF-4	Fire, earthquake, or other external event damages inspection glovebox	a. Operator injury C C C b. Radiation exposure C B C			Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing.
4 3	II II	D C	PF-4	Component incorrectly positioned or mishandled; glovebox gloves damaged; component breached or damaged	a. Operator injury D D D b. Radiation exposure D C D			Glovebox confinement	Building confinement HVAC, HEPAs	SOP, operator training Use of protective clothing, tools

Initial Screening

From this compiled table, accident scenarios with consequences A to C for the public or environment were identified and retained. Accident scenarios with consequences A and B for workers were also identified and retained. Scenarios not meeting these criteria were eliminated from further consideration.

Tables 2A and 2B show the results of this initial screening. The highlighted letters show which hazard scenarios meet the initial criteria. In this example, it happens that every scenario was kept. This was not the case for all screenings.

Continued on next page

Table 2-A. Initial Screening Hazard Scenarios for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
3	IV	B	PF-4, NMT-4	Sample container ruptured during handling (during staging, loading, positioning, unloading)	Radiation exposure C B C	Containers, canisters, double containment	Confinement ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement	HazMat & Rad Prot, admin., criticality limits, SOPs, operator training, uncontaminated items
3	V	A	PF-4, NMT-4	Calorimeter overfilled with assay items; excess SNM (>4500 g) is present and event occurs to place items in unsafe configuration	Criticality C A C	SCV, PCV, (double confinement) limited container dimensions, geometry/material forms do not favor criticality, cal. Cans give separation	Confinement Ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement CAS	Criticality Safety HazMat & Rad Prot (SNM weight limits; items must be in standard calorimeter canisters, CSLA limits)
3	IV	B	PF-4, NMT-4	Defective can seal permits leakage between two crimped/ damaged cans, causing rupture after item is removed from primary vessel	Radiation exposure C B C	SCV, PCV	HEPAs/HVAC, Zone ½ neg. pressure, CAMs, facility confinement	HazMat & Rad Prot, admin., criticality limits, SOPs, operator training, operators verify items are uncontaminated & container integrity
3 3	IV IV	A B	PF-4, NMT-4	SNM leaks into water bath or can dropped by operator or robot and SNM leaks into water bath (possible multiple can failures or use of large, 10.5-in. calorimeter)	a. Criticality C A C b. Radiation exposure C B C	SCV, PCV a. Limited container dimensions/geometry, separation given by cal. cans (passive control) b. Remote handling for most operations/ assays	a. Building confinement, CAS b. HEPAs/HVAC, ventilation neg. pressure, CAMs, facility confinement	Admin., crit. limits, MASS accountability, crit. safety, SOPs, operator training Evacuation/emerg. resp.

Table 2-A. Initial Screening Hazard Scenarios for ROBOCAL									
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**			**Protective Features**	**Protective Systems**	**Administrative Controls**
3	IV	B	PF-4, NMT-4	Sharp equipment or tool breaches primary containment vessel	Radiation exposure C B C			SCV, PCV, double confinement, no glass parts in system, remote handling for assays/ most operations	b. Building confinement HVAC, HEPAs, ventilation confinement, CAMs, neg. pressure	SOPs, operator training (visual inspections) TA-55 fire/fire dept. response, maintenance Combustible controls
2	III	A	PF-4, NMT-4	ROBOCAL electrical short ignites combustibles, causes PCV failures, dispersal of material	Radiation exposure A A B			Insulation, grounding PCV/SCV/confinement, separation of canisters	Building confinement, HEPAs/HVAC, ventilation, neg. pressure, CAMs, room sprinklers, fire supp. material.	SOPs, operator training Combust. control (rags in steel cans, low loading) Emergency/fire response
3	IV	A	PF-4, NMT-4	Earthquake/external event; equipment failure (wall/fence fall, cans/storage units fail) disperses material	Radiation exposure A A B			PCV/SCV integrity, confinement, separation of canisters, seismically qualified Kardex unit	Building confinement, HEPAs/HVAC, CAMs, neg. pressure	SOPs, operator training Emergency response
3 3	IV IV	B A	PF-4, NMT-4	Dewar failure; cryogenic nitrogen leak (industrial accident)	a. Operator inj. (cryo.) D B D b. Op. inj. (asphyxiation) D A D			SS unpressurized dewar b. Limited volume (30-l)	Building confinement, HEPAs/HVAC, ventilation, neg. pressure b. Room volume (~500 m^3)	Cryogenic safety training SOPs, operator training Combustible/ignition source control Emergency response

Table 2-B. Initial Screening Hazard Scenarios for Dimensional Gage Inspection								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
4 4	IV IV	C B	PF-4	Pyrophoric material burns when exposed to O_2 in glovebox or ignition of combustibles in glovebox (rags, alcohol) affects components	a. Operator injury/burn C C C b. Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing.
4	V	A	PF-4	Criticality mass limits; exceeded for Pu metal or oxide	Criticality C A C	Glovebox confinement and shielding "Dry" process	Building confinement CAS, HVAC (HEPAs)	SOP; operator training; criticality safety limits; MASS
2	III	A	PF-4	Operator touches deteriorated power cord/maintenance personnel are exposed to energized equipment; injury occurs	Electrical shock D A D	Electric insulation Insulated gloves, grounding	Shut-off switches	SOP, operator training Emergency/medical response
4	IV	B	PF-4	Fire, earthquake, or other external event damages inspection glovebox	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. Fire dept. response; combustible control use of protect. clothing.

Intermediate Screening

The following methods were applied to further screen the accident scenarios:

All worker consequence scenarios with associated "B" severities of consequences were reviewed against their risk ranking to ensure that their risk ranking was not changed from a 2 to a 3 according to the risk ranking Table 2.3 of the hazard methodology (See Section 2.0 for a discussion of this). If so, the risk ranking was changed to the higher one, i.e., risk rank 2.

Tables 3A and 3B show the results of this intermediate step.

Table 3-A. Intermediate Screening for ROBOCAL

R	F	C	Facility	Cause/Scenarios	Consequences P W E	Protective Features	Protective Systems	Administrative Controls
2	IV	B	PF-4, NMT-4	Sample container ruptured during handling (during staging, loading, positioning, unloading)	Radiation exposure C B C	Containers, canisters, double containment	Confinement ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement	HazMat & Rad Prot, admin., criticality limits, SOPs, operator training, uncontaminated items
3	V	A	PF-4, NMT-4	Calorimeter overfilled with assay items; excess SNM (>4500 g) is present and event occurs to place items in unsafe configuration	Criticality C A C	SCV, PCV, (double confinement) limited container dimensions, geometry/material forms do not favor criticality, cal. Cans give separation	Confinement Ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement CAS	Criticality Safety HazMat & Rad Prot (SNM weight limits; items must be in standard calorimeter canisters, CSLA limits)

Table 3-A. Intermediate Screening for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
2	IV	B	PF-4, NMT-4	Defective can seal permits leakage between two crimped/damaged cans, causing rupture after item is removed from primary vessel	Radiation exposure C B C	SCV, PCV	HEPAs/HVAC, Zones 1 and 2 neg. pressure, CAMs, facility confinement	HazMat & Rad Prot, admin., criticality limits, SOPs, operator training, operators verify items are uncontaminated & container integrity
3 2	IV IV	A B	PF-4, NMT-4	SNM leaks into water bath or can dropped by operator or robot and SNM leaks into water bath (possible multiple can failures or use of large, 10.5-in. calorimeter)	a. Criticality C A C b. Radiation exposure C B C	SCV, PCV a. Limited container dimensions/geometry, separation given by cal. cans (passive control) b. remote handling for most operations/assays	a. Building confinement, CAS b. HEPAs/HVAC, ventilation neg. pressure, CAMs, facility confinement	Admin., crit. limits, MASS accountability, crit. safety, SOPs, operator training Evacuation/emerg. resp.
3	IV	B	PF-4, NMT-4	Sharp equipment or tool breaches primary containment vessel	Radiation exposure C B C	SCV, PCV, double confinement, no glass parts in system, remote handling for assays/ most operations	b. Building confinement HVAC, HEPAs, ventilation confinement, CAMs, neg. pressure	SOPs, operator training (visual inspections) TA-55 fire/fire dept. response, maintenance Combustible controls
2	III	A	PF-4, NMT-4	ROBOCAL electrical short ignites combustibles, causes PCV failures, dispersal of material	Radiation exposure A A B	Insulation, grounding PCV/SCV/confinement, separation of canisters	Building confinement, HEPAs/HVAC, ventilation, neg. pressure, CAMs, room sprinklers, fire supp. material.	SOPs, operator training Combust. control (rags in steel cans, low loading) Emergency/fire response
3	IV	A	PF-4, NMT-4	Earthquake/external event; equipment failure (wall/fence fall, cans/storage units fail) disperses material	Radiation exposure A A B	PCV/SCV integrity, confinement, separation of canisters, seismically qualified Kardex unit	Building confinement, HEPAs/HVAC, CAMs, neg. pressure	SOPs, operator training Emergency response

Table 3-A. Intermediate Screening for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
2	III	B	PF-4, NMT-4	Dewar failure; cryogenic nitrogen leak (industrial accident)	a. Operator inj. (cryo.) D B D	SS unpressurized dewar b. Limited volume (30-l)	Building confinement, HEPAs/HVAC, ventilation, neg. pressure.	Cryogenic safety training SOPs, operator training Combustible/ignition source control Emergency response

Table 3-B. Intermediate Screening for Dimensional Gage Inspection								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
3	IV	B	PF-4	Pyrophoric material burns when exposed to O_2 in glovebox or ignition of combustibles in glovebox (rags, alcohol) affects components	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing.
3	V	A	PF-4	Criticality mass limits; exceeded for Pu metal or oxide	Criticality C A C	Glovebox confinement and shielding "Dry" process	Building confinement CAS, HVAC (HEPAs)	SOP; operator training; criticality safety limits; MASS
2	III	A	PF-4	Operator touches deteriorated power cord/maintenance personnel are exposed to energized equipment; injury occurs	Electrical shock D A D	Electric insulation Insulated gloves, grounding	Shut-off switches	SOP, operator training Emergency/medical response

Table 3-B. Intermediate Screening for Dimensional Gage Inspection								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
3	IV	B	PF-4	Fire, earthquake, or other external event damages inspection glovebox	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. Fire Dept. response; combustible control use of protect. clothing.

Screening Standard Industrial Hazards

Those accident scenarios with nonradiological consequences caused by industrial or commonly accepted hazards, e.g., electrocution, falls, severe burns, etc. were screened out. These standard industrial hazards are those hazards that are routinely encountered in general industry and construction, and for which national consensus codes and/or standards (e.g., OSHA, transportation safety) exist to guide safe design and operation without the need for special analysis to define safe design and/or operational parameters.

Tables 4Aand 4B show these results.

Table 4-A. Screening of Standard Industrial Hazards for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
2	IV	B	PF-4, NMT-4	Sample container ruptured during handling (during staging, loading, positioning, unloading)	Radiation exposure C B C	Containers, canisters, double containment	Confinement ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement	HazMat & Rad Prot, admin., criticality limits, SOPs, operator training, uncontaminated items

Table 4-A. Screening of Standard Industrial Hazards for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
3	V	A	PF-4, NMT-4	Calorimeter overfilled with assay items; excess SNM (>4500 g) is present and event occurs to place items in unsafe configuration	Criticality C A C	SCV, PCV, (double confinement) limited container dimensions, geometry/material forms do not favor criticality, cal. Cans give separation	Confinement Ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement CAS	Criticality Safety HazMat & Rad Prot (SNM weight limits; items must be in standard calorimeter canisters, CSLA limits)
2	IV	B	PF-4, NMT-4	Defective can seal permits leakage between two crimped/ damaged cans, causing rupture after item is removed from primary vessel	Radiation exposure C B C	SCV, PCV	HEPAs/HVAC, Zone ½ neg. pressure, CAMs, facility confinement	HazMat & Rad Prot, admin., criticality limits, SOPs, operator training, operators verify items are uncontaminated & container integrity
3 2	IV IV	A B	PF-4, NMT-4	SNM leaks into water bath or can dropped by operator or robot and SNM leaks into water bath (possible multiple can failures or use of large, 10.5-in. calorimeter)	a. Criticality C A C b. Radiation exposure C B C	SCV, PCV a. Limited container dimensions/geometry, separation given by cal. cans (passive control) b. remote handling for most operations/assays	a. Building confinement, CAS b. HEPAs/HVAC, ventilation neg. pressure, CAMs, facility confinement	Admin., crit. limits, MASS accountability, crit. safety, SOPs, operator training Evacuation/emerg. resp.
3	IV	B	PF-4, NMT-4	Sharp equipment or tool breaches primary containment vessel	Radiation exposure C B C	SCV, PCV, double confinement, no glass parts in system, remote handling for assays/ most operations	b. Building confinement HVAC, HEPAs, ventilation confinement, CAMs, neg. pressure	SOPs, operator training (visual inspections) TA-55 fire/fire dept. response, maintenance Combustible controls

Table 4-A. Screening of Standard Industrial Hazards for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
2	III	A	PF-4, NMT-4	ROBOCAL electrical short ignites combustibles, causes PCV failures, dispersal of material	Radiation exposure A A B	Insulation, grounding PCV/SCV/ confinement, separation of canisters	Building confinement, HEPAs/HVAC, ventilation, neg. pressure, CAMs, room sprinklers, fire supp. material.	SOPs, operator training Combust. control (rags in steel cans, low loading) Emergency/fire response
3	IV	A	PF-4, NMT-4	Earthquake/ext. event; equip. failure (wall/ fence fall, cans/storage units fail) disperses material	Radiation exposure A A B	PCV/SCV integrity, confinement, separation of canisters, seismically qualified Kardex unit	Building confinement, HEPAs/HVAC, CAMs, neg. pressure	SOPs, operator training Emergency response

Table 4-B. Screening of Standard Industrial Hazards for Dimensional Gage Inspection								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
3	IV	B	PF-4	Pyrophoric material burns when exposed to O_2 in glovebox or ignition of combustibles in glovebox (rags, alcohol) affects components	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing.
3	V	A	PF-4	Criticality mass limits; exceeded for Pu metal or oxide	Criticality C A C	Glovebox confinement and shielding "Dry" process	Building confinement CAS, HVAC (HEPAs)	SOP; operator training; criticality safety limits; MASS

Table 4-B. Screening of Standard Industrial Hazards for Dimensional Gage Inspection								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
3	IV	B	PF-4	Fire, earthquake, or other external event damages inspection glovebox	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing.

Accident Categories

Accident scenarios are sorted into accident categories: spill/release, worker injury, fire, explosion, criticality, natural phenomena events, and external events.

Table 5-A. Sorting Accident Scenarios into Categories for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
Spill/Releases of Airborne Materials:								
2	IV	B	PF-4, NMT-4	Sample container ruptured during handling (during staging, loading, positioning, unloading)	Radiation exposure C B C	Containers, canisters, double containment	Confinement ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement	HazMat & Rad Prot, admin., criticality limits, SOPs, operator training, uncontaminated items

Table 5-A. Sorting Accident Scenarios into Categories for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
2	IV	B	PF-4, NMT-4	Defective can seal permits leakage between two crimped/damaged cans, causing rupture after item is removed from primary vessel	Radiation exposure C B C	SCV, PCV	HEPAs/HVAC, Zones 1 and 2 neg. pressure, CAMs, facility confinement	HazMat & Rad Prot, admin., criticality limits, SOPs, operator training, operators verify items are uncontaminated and container integrity
3	IV	B	PF-4, NMT-4	Sharp equipment or tool breaches primary containment vessel	Radiation exposure C B C	SCV, PCV, double confinement, no glass parts in system, remote handling for assays/ most operations	b. Building confinement HVAC, HEPAs, ventilation confinement, CAMs, neg. pressure	SOPs, operator training (visual inspections) TA-55 fire/fire dept. response, maintenance Combustible controls
Worker Injury/Exposure: No Scenarios Survived								
Fires:								
2	III	A	PF-4, NMT-4	ROBOCAL electrical short ignites combustibles, causes PCV failures, dispersal of material	Radiation exposure A A B	Insulation, grounding PCV/SCV/confinement, separation of canisters	Building confinement, HEPAs/HVAC, ventilation, neg. pressure, CAMs, room sprinklers, fire supp. material.	SOPs, operator training Combust. control (rags in steel cans, low loading) Emergency/fire response
Explosion: No Scenarios Survived								

Table 5-A. Sorting Accident Scenarios into Categories for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
Criticality:								
3	V	A	PF-4, NMT-4	Calorimeter overfilled with assay items; excess SNM (>4500 g) is present & event occurs to place items in unsafe configuration	Criticality C A C	SCV, PCV, (double confinement) limited container dimensions, geometry/material forms do not favor criticality, cal. Cans give separation	Confinement Ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement CAS	Criticality Safety HazMat & Rad Prot (SNM weight limits; items must be in standard calorimeter canisters, CSLA limits)
3 2	IV IV	A B	PF-4, NMT-4	SNM leaks into water bath or can dropped by operator or robot and SNM leaks into water bath (possible multiple can failures or use of large, 10.5-in. calorimeter)	a. Criticality C A C b. Radiation exposure C B C	SCV, PCV a. Limited container dimensions/geometry, separation given by cal. cans (passive control) b. Remote handling for most operations/assays	a. Building confinement, CAS b. HEPAs/HVAC, ventilation neg. pressure, CAMs, facility confinement	Admin., crit. limits, MASS accountability, crit. safety, SOPs, operator training Evacuation/emerg. resp.
Natural Phenomena Events:								
3	IV	A	PF-4, NMT-4	Earthquake/ external event; equipment failure (wall/fence fall, cans/storage units fail) disperses material	Radiation exposure A A B	PCV/SCV integrity, confinement, separation of canisters, seismically qualified Kardex unit	Building confinement, HEPAs/HVAC, CAMs, neg. pressure	SOPs, operator training Emergency response
External Events: No Scenarios Survived								

Table 5-B. Sorting Accident Scenarios into Categories for Dimensional Gage Inspection								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
Spill/Releases of Airborne Materials: No Scenarios Survived								
Worker Injury/Exposure: No Scenarios Survived								
Fires:								
3	IV	B	PF-4	Pyrophoric material burns when exposed to O_2 in glovebox or ignition of combustibles in glovebox (rags, alcohol) affects components	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing
3	V	A	PF-4	Criticality mass limits; exceeded for Pu metal or oxide	Criticality C A C	Glovebox confinement and shielding "Dry" process	Building confinement CAS, HVAC (HEPAs)	SOP; operator training; criticality safety limits; MASS
3	IV	B	PF-4	Fire, earthquake, or other external event damages inspection glovebox	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing

Final Screening

The purpose of this last screening was to identify those accident scenarios that may challenge the DOE offsite Evaluation Guidelines (i.e., 25 rem EDE, 50-yr. dose committed), or had what was considered to have significant consequences.

The following approach was used to identify such scenarios:

From the list of segregated accident scenarios by accident category and initiating event group, the scenarios with the worst or bounding consequences were selected. As a minimum over two dozen scenarios were identified to represent such combinations of accident categories and initiating event groups. This list of screened accident scenarios will be explicitly identified in the hazard analysis section of the FSAR, i.e., Section 3.3.2.3.5.

These accident scenarios were reviewed to determine if common controls exist; or if their initiating events could be grouped under a single group, or if the source terms and consequences were the same. This grouping could not be predetermined, as knowledge and evaluation from the previous screening process was what yielded the list of accident scenarios.

Table 6-A. Scenarios that Potentially Challenge Offsite Evaluation Guidelines for ROBOCAL

R	F	C	Facility	Cause/Scenarios	Consequences P W E	Protective Features	Protective Systems	Administrative Controls
Fires:								
2	III	A	PF-4, NMT-4	ROBOCAL electrical short ignites combustibles, causes PCV failures, dispersal of material	Radiation exposure A A B	Insulation, grounding PCV/SCV/confine-ment, separation of canisters	Building confinement, HEPAs/HVAC, ventilation, neg. pressure, CAMs, room sprinklers, fire supp. material.	SOPs, operator training Combust. control (rags in steel cans, low loading) Emergency/fire response
This scenario was selected for an EBA as a bounding accident for operations in the basement.								

Table 6-A. Scenarios that Potentially Challenge Offsite Evaluation Guidelines for ROBOCAL								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
Criticality:								
3	V	A	PF-4, NMT-4	Calorimeter overfilled with assay items; excess SNM (>4500 g) is present and event occurs to place items in unsafe configuration	Criticality C A C	SCV, PCV, (double confinement) limited container dimensions, geometry/material forms do not favor criticality, cal. Cans give separation	Confinement Ventilation HVAC, ventilation, HEPAs, CAMs, facility confinement CAS	Criticality Safety HazMat & Rad Prot (SNM weight limits; items must be in standard calorimeter canisters, CSLA limits)
3 2	IV IV	A B	PF-4, NMT-4	SNM leaks into water bath or can dropped by operator or robot and SNM leaks into water bath (possible multiple can failures or use of large, 10.5-in. calorimeter)	a. Criticality C A C b. Radiation exposure C B C	SCV, PCV a. Limited container dimensions/geometry, separation given by cal. cans (passive control) b. Remote handling for most operations/assays	a. Building confinement, CAS b. HEPAs/HVAC, ventilation neg. pressure, CAMs, facility confinement	Admin., crit. limits, MASS accountability, crit. safety, SOPs, operator training Evacuation/emerg. resp.
These scenarios were not selected for an EBA. A solution criticality is considered to be more likely and the consequences of a solution criticality are expected to bound these scenarios.								
Natural Phenomena Events:								
3	IV	A	PF-4, NMT-4	Earthquake/ext. event; equip. failure (wall/fence fall, cans/storage units fail) disperses material	Radiation exposure A A B	PCV/SCV integrity, confinement, separation of canisters, seismically qualified Kardex unit	Building confinement, HEPAs/HVAC, CAMs, neg. pressure	SOPs, operator training Emergency response
This scenario was not selected as an EBA. The facility wide effects of an earthquake were evaluated as the EBA.								

Table 6-B. Scenarios that Potentially Challenge Offsite Evaluation Guidelines for Dimensional Gage Inspection								
R	**F**	**C**	**Facility**	**Cause/Scenarios**	**Consequences** **P W E**	**Protective Features**	**Protective Systems**	**Administrative Controls**
Fire:								
3	IV	B	PF-4	Pyrophoric material burns when exposed to O_2 in glovebox or ignition of combustibles in glovebox (rags, alcohol) impacts components	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. Clothing
This scenario was not selected as an EBA. The PREP furnace fire is bounding with respect to this fire.								
Criticality:								
3	V	A	PF-4	Criticality mass limits; exceeded for Pu metal or oxide	Criticality C A C	Glovebox confinement and shielding "Dry" process	Building confinement CAS, HVAC (HEPAs)	SOP; operator training; criticality safety limits; MASS
This scenario was not selected for an EBA. A solution criticality is considered to be more likely and the consequences of a solution criticality are expected to bound this scenario								
Natural Phenomena Events:								
3	IV	B	PF-4	Fire, earthquake, or other external event damages inspection glovebox	Radiation exposure C B C	Glovebox confinement a. Fire suppress. agents (graphite), heat detectors	Building confinement a. Isolation dampers, room sprinklers, interlock with supply air b. HVAC (neg. pressure), HEPAs, CAMs	SOP; operator training; a. fire dept. response; combustible control use of protect. clothing
This scenario was not selected as an EBA. The facility wide effects of an earthquake were evaluated as the EBA.								

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Misassembly of Launcher (IFIT Facility) Current FSAR	Three scenarios were identified that could cause the assembly to fail: (1) failure to install the reaction mass, (2) failure to secure tie rods, and (3) failure to install the hardware setup on the muzzle of the launcher. Only the last scenario could result in a release. It was assumed that the facility supply ventilation is shut down during the launch, and that there is a small exhaust flow through the HEPAs. It was assumed that the maximum overpressure caused by the release of propulsion gas is below the structural capacity of the IFIT Facility and HEPA filters. It was found that the ceiling armor is capable of dissipating the impact of an unrestrained launch. The distance from PF-4 to the MOI is 900 m.	1 kg of heat source Pu	1	2E-6 with normal ventilation 2.75E-5 with a ventilation failure and propulsion gas release	Respirable airborne release fraction was used (RARF = RF*ARF), and was taken to be 8E-3		8 g of heat source Pu (before LPF is applied)	325 323	5.2 mrem 71 mrem

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Spills/release of airborne material – IFIT Facility – Overpressur-ization Upgraded FSAR	MELCOR was used to determine the LPFs, and the MELCOR models were based on the following assumptions: (1) 3 g of 1-micrometer diameter Pu powder is dispersed into the IFIT Facility upper room over the first 0.005 sec of the run, (2) 9.978 m^3 of N_2 gas is released into the room, all of the IFIT Facility and PF-4 doors are closed, (3) IFIT Facility utility penetrations are intact, and (4) no filters or fans were modeled for the IFIT Facility (airflow is through PF-4 ventilation flow path). The MELCOR model considered the operability of the fans and the HEPA filters separately. The distance from PF-4 to the MOI is 1024 m.	1 kg of heat source Pu	1	0.99 exhaust fans operating without HEPAs 9.6E-4 HEPAs working without exhaust fans (1.25E-5 with fans)	5E-3 Therefore, RARF = 3E-3	6E-1	3 g for exhaust fans without HEPAs 0.0029 g with HEPAs and no fans (1.25E-5 g with fans)	44.4 The lower conver-sion factor is due to the nature of the MACCS2 dispersion models used. An explan-ation of the model, and the assump-tions used is given in Appendix 3G of the updated FSAR	133.2 rem 129 mrem (1.6 mrem)
Plutonium release from a degraded storage container Current FSAR	No credit was taken for the inner and outer containers, even though their individual failure rates were considered. The distance from PF-4 to the MOI is 1024 m.	4.5 kg WG Pu oxide	1	1	2E-3	0.3	2.7 g Reduced to 2.2×10^{-12}g when reduction factors for the ventilation system are considered	3	8.1 rem 6.6×10^{-12} rem

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Plutonium release from a degraded storage container Upgraded FSAR	No credit was taken for the inner and outer containers, even though their individual failure rates were considered. The distance from PF-4 to the MOI is 1024 m.	4.5 kg WG Pu oxide	1	0.98 Determined using MELCOR, to be worst case of the unmitigated 0.519 with HEPAs and no fans (0.246 HEPAs and fans)	2E-3	0.3	2.7 g 1.4g (0.66g)	0.75 (non-buoyant elevated release) 0.52 (0.36) See comments regarding MACCS2 from above	2.0 rem 0.73 rem 0.5 rem
Nuclear Criticality in the U/Pu Separations Process Current FSAR	The criticality accident was assumed to occur in the uranium/plutonium separation process in a glovebox containing a deep well. It was assumed that external doses from exposures to neutron and gamma radiation outside PF-4 would be negligible because of the distances involved and shielding effects from PF-4. The distance from PF-4 to the MOI is 900 m. This calculation used 5 x 10^{17} fissions.	4.2 kg of Pu as plutonium nitrate	1	1	1	1	0.53g (unmiti-gated) 2.1 x 10^{-9}g (miti-gated)*		1.6 rem unmiti-gated 3.5 x 10^{-2} rem mitigated

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
			*The MAR was reduced by 0.05% to account for the salt content that evaporates to an aerosol. This release was based on approximately 25% of the initial solution being evaporated. The mitigated source term is further reduced by 4×10^{-9} to account for the HEPA filters.						
Nuclear criticality Upgraded FSAR	The criticality scenario is postulated to occur in the nitrate ion exchange, the nitric acid dissolution, or other operations in which fissile-rich solution may be present. The distance from PF-4 to the MOI is 1024 m. This calculation used 10^{19} fissions.	4.2 kg of Pu as plutonium nitrate	0.25	1 for gases 2×10^{-6} for particulates	1 for noble gases 0.25 for halogens 5×10^{-4} for fissile material	1	3.9E-2 Ci – 0.52 g (unmiti-gated) 7.9E-8 Ci – $1E^{-6}$ g (miti-gated)		54 rem (unmit-igated) 0.2 rem (miti-gated)
Laboratory Fire in the Heat Source Production Area Current FSAR	The fire is postulated to occur in Room 207 adjacent to GB-218. It was assumed that 70 g of powder is lost during a 3 kg campaign. This lost powder was assumed to be evenly deposited on the interior walls of the glovebox. It was assumed that each of the 12 gloves has 1.7 g of powder on it, and the gloves burned completely. The distance from PF-4 to the MOI is 900 m.	20.4 g heat source Pu powder	1	1 (initial leak path factor) 0.011 (final LPF due to building leakages)	0.01	1	0.20 g 2.2 mg	320 318	64 rem 0.7 rem

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Plutonium-238 Oxide Fuel Pellet Operations Upgraded FSAR	The distance from PF-4 to the MOI is 1024 m. MELCOR was used to calculate the LPFs. This analysis assumed 1200 g powder because more than 1 glovebox was involved in this entire room fire. Additional MAR of 9600 g is assumed to be in the other glovebox, but is not ball-milled powder. It was also shown that ignition of across aisle PMMA caused by radiant heat flux is not feasible if the entire PMMA on a glovebox train was consumed. However, it was also shown that flashover conditions could occur if more than 3 gloveboxes of PMMA were ignited.	1200 g of ball milled ^{238}Pu 9600 g ^{238}Pu	1 0.5 unmiti-gated 1 miti-gated	3.308E-1 unmitigated 5.491E-2 mitigated (2.768E-2 with fans)	1E-3	1 for ball milled 0.05 for other glove-boxes	0.397 g +0.079 g = 0.47g for unmiti-gated 0.066 g+0.026 g = 0.092 g for mitigated (0.046 with fans)	11.9	5.6 rem (6 rem if non-buoyant) unmitigate d 0.55 rem mitigated and with fans
Hydrogen Deflagration in the Hydride/ Dehydride Glovebox Current FSAR	Deflagration is assumed to occur because of multiple equipment failures and operational errors. Process occurs in Room 114. Deflagration concentration was taken to be 6%. The MAR is in a vacuum chamber that is designed to withstand vacuum forces and fail during an overpressure. 900 m to MOI. This process is no longer active so it was replaced by the FSTF.	4500 g of Pu powder in hydride form	1	1 unmiti-gated 3.6×10^{-9} mitigated	5×10^{-3}	0.3	6.75 g WG Pu 2.4×10^{-8} g WG Pu	2.1 3	14.2 rem unmit-igated 7.3×10^{-8} rem miti-gated

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Hydrogen deflagration or explosion in the Full-Scale Test Facility Upgraded FSAR	Deflagration or explosion is postulated to occur because of gas leaks in the hydrogen supply cabinet from the failure of coupling or fitting connections. Deflagration was calculated to occur when the hydrogen concentration reached a stiochiometric mixture of 29 mole % hydrogen. 1024 m to MOI. Two mitigated cases were considered to determine two LPFs. (1) A fully mitigated LPF where the ventilation system is assumed to be working with HEPA filters in place (assume release through two HEPA filters in series only) with a maximum total removal factor of 2.8E-2. (2) Failure of the ventilation system with HEPA in place with a maximum total removal factor of 5.5E-2.	6 kg WG Pu	1	0.82 unmitigated 2.8E-2 mitigated 1 5.5E-2 mitigated 2	5E-3	0.3	7.38 g unmiti-gated 0.252 g mitigated 1 0.495 g mitigated 2	0.2	1.46 rem unmiti-gated There was no miti-gated dose eval-ated since the dose was so small.

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Natural Phenomena-Earthquake Current FSAR	The shell of the PF-4 structure is assumed to remain intact after an EBE. Many gloveboxes are expected to fail, along with process gas lines that service these gloveboxes. The ventilation system is expected to fail because of electrical failure. Some vault racks in the basement are expected to fail. A criticality resulting from a seismic event was found to be unlikely. Any resulting fires were bounded by other scenarios. No MAR was considered for gloveboxes designated as inactive. MAR was considered as Pu if both Pu and U are present. No tritium MAR is used, based on dose conversion factor considerations. 900 m to MOI. Using CSLA MAR.		0 if encapsulation media is designed to survive a 0.3 g EBE 1 if media is not so robust	Unmitgated 0.6 No HEPA Mitigated 0.06 W/Fans & HEPA	1E-3 powder or oxide 2E-5 liquids 5E-4 formation of particles through self-sustained oxidation 3E-5 Pu metal that is self-heating	0.1 powder or oxide 1 liquids 0.5 formation of particles through self-sustained oxidation 0.04 Pu metal that is self-heating	0.114 g heat source Pu 51.1 g WG Pu 2.38 g U unmitigated 1.16 x 10^{-2} g heat source Pu 5.17 g WG Pu 0.241 U mitigated	Not specified for each isotope	149 rem unmitigated 18 mitigated

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Seismic Events within PF-4 Upgraded FSAR	The shell of the PF-4 structure is assumed to remain intact after an EBE. Many gloveboxes are expected to fail, along with process gas lines that service these gloveboxes. The ventilation system is expected to fail because of electrical failure. A criticality resulting from a seismic event was found to be unlikely. Any resulting fires were bounded by other scenarios. No MAR was considered for gloveboxes that are designated as inactive. MAR was considered as Pu if both Pu and U are present. No tritium MAR is used, based on dose conversion factor considerations. 1040 m to MOI. Using CSLA MAR.		0 if encapsul-ation media is designed to survive a 0.3 g EBE 1 if media is not so robust	Unmiti-gated 0.85 W/Fans, No HEPA Mitigated 1E-4 No Fans, W/HEPA 3E-5 W/Fans & HEPA	1E-3 powder or oxide 2E-5 liquids 5E-4 formation of particles through self-sustained oxidation 3E-5 Pu metal that is self-heating	0.1 powder or oxide 1 liquids 0.5 formati on of particles through self-sustain-ed oxi-dation 0.04 Pu metal that is self-heating	unmiti-gated 0.085 g heat source Pu 84.1 g WG Pu mitigated 1.01E-5 g heat source Pu 9.9E-3 g WG Pu W/HEPA, No Fan 3E-6 g heat source Pu 3E-3 g WG Pu W/HEPA & Fans	44 rem/g Heat Source Pu, Non-bouyant Elevated .75 rem/g WG Pu Non-bouyant Elevated	Unmit-igated 67 rem Mitigated 8 mrem W/HEPA, No Fan 2.4 mrem W/HEPA & Fans

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Operational Accident – Tritium Release from the Special Recovery Line (SRL) Current FSAR	A glovebox fire is assumed to heat tritium-contaminated parts in a storage area within a glovebox. Elemental tritium is then oxidized and released as vapor. Consequences were assessed assuming the structure remains intact, but all mitigative features fail. Glovebox confinement is assumed to fail, and the ventilation system draws air into the glovebox through the gloveports. The glovebox atmosphere is then vented through the bubbler pressure relief line, bypassing the tritium collection system, and exits out the south exhaust stack. 900 m to MOI.	20 g tritium in the form of tritiated water vapor (1.94×10^5 Ci)	1	1	1	1	1.94×10^5 Ci	0.0315	0.63 rem

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Tritium Release Accident from SRL Operations Upgraded FSAR	The release is postulated to result from a malfunction of the FGTS metal bellows pump while operating, a fire within GB-1403, or an SRL process room fire that engulfs the glovebox. Consequences were also assessed assuming the structure remains in tact, but all mitigative features fail. A glovebox fire, or a room fire that breaches the glovebox, oxidizes the tritium, and ultimately releases the vapor out the south exhaust stack as in the previous SAR evaluation.	50 g tritium as tritiated water (5×10^5 Ci)	1	1	1	1	$5x10^5$ Ci	8.97x10-7 rem/Ci (at ground release) $1.86x10^{-7}$ rem/Ci (1-MW fire ground release)	0.45 rem spill 0.09 rem fire
Operational Accident – Chlorine Release Current FSAR	The release was modeled using a Gaussian dispersion model, and the consequences were estimated based on 900 m to an MOI. Maximum inventory (150 lbs) was assumed to be released over 15 minutes. No credit was taken for the mixing of the chlorine with the air. The release was assumed to occur as the result of a pipe break outside PF-4. The MIDAS heavy gas dispersion model was used.	150 lbs of chlorine is release at a rate of 0.076 kg/s	1	1	1	1	N/A	N/A	8 ppm

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Chlorine Gas Spill Upgraded FSAR	This scenario was postulated to occur inside PF-3 Room 116. A 150-lb cylinder catastrophically fails and leaks outside the facility while the cylinder is being changed. No reaction of the chlorine gas is assumed. ALOHA computer model was used. ALOHA uses a diffusion-based algorithm for heavy gasses. 1024 m to MOI.	150 lbs	1	1	1	1	N/A	N/A	3.72 ppm

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
The following accident scenarios are not in the current FSAR accident analysis. They are in the upgraded FSAR									
Fire – Miscellaneous – ROBOCAL Upgraded FSAR	The unmitigated cases assumed that a small fire only affected one container. A large fire was assumed to affect 1070 kg of material. The mitigated case assumed that the recirculation filter bank contains 12 filters, each filter may contain 3 kg of particulate material, and the filters are assumed to be loaded up to 20% of their capacity. These conditions could then result in plugging of the second bank of filters as the first bank is broken through. A 4.5-MW fire was used to model this. MOI is 1024 m from the facility.	6 kg WG Pu (small fire) 1070 kg (large fire) 33 kg	8E-3 (small fire) 0.76 (large fire) not specified for mitigated case	0.77 (unmiti-gated) 1.2E-2 (mitigated)	6E-3 RARF = 6E-5	1E-2	2.2E-3 g (small fire) 37.6 g (large fire) 0.59 g (mitigated)	1.4E-1 elevated buoyant release 0.198 ground buoyant release 0.198 mitigated with no fans not specified for fans working	0.4 mrem elevated buoyant release 7.4 rem ground buoyant release 116 mrem (no fans and external winds – miti-gated) <3.3 mrem (with exhaust fans – miti-gated)

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Pyrochemical Metal Preparation Process Fire Upgraded FSAR	According to DOE-STD-3013-99, the Pu metal makes up 88% of the weight of Pu oxide. Therefore, the MAR was divided by 0.88 before calculating the source term. The driving force for dispersion was the glovebox fire in which 2 lbs of cellulose was the fuel. MOI is 1024 m from the facility.	4.5 kg ^{239}Pu in molten form	1	0.82 5.4E-4 (mitigated)	5E-4	0.5	1.04 g (unmitigated) 6.9E-4g (mitigated)	0.521 (unmitigated) 0.541 (mitigated)	0.5 rem (unmitigated) 0.37 mrem (mitigated)
External Fire-Gasoline Truck BLEVE Upgraded FSAR	All TRU waste was treated as ^{239}Pu equivalent activity, including ^{238}Pu and uranium isotopes. The BLEVE was considered a fire ignition source, and it was assumed that enough combustible material was present so the fire would burn long enough to affect all the containers or drums within building 185. It was assumed that half the drums are open by the force of the overpressure created by the BLEVE. MOI is 1024 m from the facility.	10,000 FGEs or 2000 PECi	1	1	3.7E-3		37 FGEs or 7.4 PECi	0.198	7.3 rem

Table 7. Comparison of EBA in Current FSAR to Upgraded FSAR									
Process	**Assumptions/Remarks**	**MAR**	**DR**	**LPF**	**ARF**	**RF**	**ST**	**Dose rem/g**	**Total Offsite Dose**
Fire – Non-furnace – Aqueous Chloride Pu Recovery Upgraded FSAR	The scenario is postulated to consist of an unspecified ignition source that makes contact with the organic mixture used in the operation (solution or vapors above the solution). Aqueous chloride Pu recovery operations were assumed to be conducted 5 days a week, 8 hours a day. Cans of Pu were assumed to be introduced into the glovebox trolley line in the materials management area, conveyed to Room 420, and opened in the dissolution box. Pu solution feed transfers between aqueous chloride process are by vacuum transfers. It was assumed that ignition sources and combustible materials are limited to the organic dilutents used within the solvent extraction process, which consists of a mixture of dodecane (70%), decanol (10%), and tributyl phosphate (20%). The radioactive from of combustible material assumed to be in the glovebox is potentially pyrophoric Pu metal in the form of solution. 1024 m to MOI.	1040 g WG Pu	1	8.2E-1 (unmit-gated) 5.4E-4 (mitigated)	1.5E-2	1	12.8 g (unmiti-gated) 0.0085 g (mitigated)	0.19	24 rem (unmiti-gated) 0.0016 rem (miti-gated)

Table 8-A. ROBOCAL Controls

Control Type	Control Name	Control Elements or Description
PPA	Operation controls	Material stored in safe geometry
PPA	Operation controls	Limited amount of distilled water in water bath calorimeters
PPF	Operation controls	No PPCCW or industrial water lines to ROBOCAL apparatus
MPA	Operation control	Separation of canisters
PPA	Operation controls	Remote handling for most operations/assay
PPF	Process Confinement	Double containment (containers and canisters)
PPF	Process Confinement	SCV
PPF	Operation equipment	PCV
PPF	Operation equipment	Limited container dimensions
PPF	Operation equipment	No glass parts in system
PPF	Operation equipment	Seismically qualified Kardex unit
PPF	Operation equipment	Locked access restricts ROBOCAL operation
PPF	Operation equipment	Interlocks shut off robot power if intrusion or collision is detected
PPF	Operation equipment	Light curtain sounds alarm when person enters work envelope
PPF	Operation equipment	Pressure-sensitive pads below work envelope create emergency stop if stepped on or object is dropped on them
PPF	Operation equipment	Fence around work area
PPF	Operation equipment	Process status indicator

Table 8-B. Dimensional Gage Inspection Controls

Control Type	Control Name	Control Elements or Description
PPA	Operation controls	"Dry" process
PPF	Operation equipment	Glovebox heat detectors
MPF	Operation controls	Glovebox fire suppression materials (graphite)
PPF	Operation equipment	Glovebox pressure differential indicators
PPF	Operation equipment	Operational parameters are displayed on associated control panels
PPF	Operation equipment	Magnehelics display differential glovebox pressure

References

Document Number	Title
	Hazard Analysis Impact Document
	NMT-4 Repackaging Plan
DCP-98-089	Install Crack Monitors Per SER
DCP-97-021	Plenum Cool Down Spray/Control Box Wiring Modifications
DCP-99-101	Plenum Cool Down Spray/Control Box Wiring Modifications
DOE-STD-3009	Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, July 1994
DOE-STD-3013-99	Stabilization, Packaging, and Storage of Plutonium Bearing Materials
NMT-AP-588	Preparing Process Hazard Analyses
NMT1-10:99-200	TSR Transition Review Final Report
NMT8:97-066	DOE Memorandum
NMT8-SDD-0110	13.2 kV Power Distribution System
NMT8-SDD-1210	Confinement System
NMT8-SDD-1411	Criticality Alarm System
NMT8-SDD-4100	Electrical Distribution System
NMT8-SDD-5110	Paging System
NMT8-SDD-6110	Glovebox System
NMT8-SDD-3310	Fire Suppression Water Supply System
NMT8-SDD-3320	Fire Suppression Sprinkler System
NMT8-SDD-0121	Uninterruptible Power Supply System
NMT8-SDD-5211-01	Facility Control System Hardware
NMT8-SDD-5211-02	Facility Control System PLCs
NMT8-SDD-6200	Ventilation System
NMT8-SDD-**XXX**	Hydrogen Detection System
TA55-PLAN-007	TA-55 Emergency Plan

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