ENGINEERING CHANGE NOTICE

1. ECN 656344

Proj. ECN

2. ECN Category (mark one)		3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental	[ ]	T. B. Powers, Nuclear Safety, B4-47, 372-2509	[ ] Yes [x] No	
Direct Revision	[x]	6. Project Title/No./Work Order No.	7. Bldg./Sys./Fac. No.	8. Approval Designator
Change ECN	[ ]	Spent Nuclear Fuel Project	W-379	E, S^{N}, Q
Temporary	[ ]	9. Document Numbers Changed by this ECN (includes sheet no. and rev.)	10. Related ECN No(s).	11. Related PO No.
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Cancel/Void	[ ]			

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[ ] Yes (fill out Blk. 12b)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date
[x] No (NA Blks. 12b, 12c, 12d)			

13a. Description of Change

13b. Design Baseline Document? [ ] Yes [x] No

The changes to this Hazard Analysis were made to incorporate the following:

- Drop and Shear Results
- DOE Comments

14a. Justification (mark one)

Criteria Change	[ ]	Design Improvement	[x]	Environmental	[ ]	Facility Deactivation	[ ]
As-Found	[ ]	Facilitate Const	[ ]	Const. Error/Omission	[ ]	Design Error/Omission	[ ]

14b. Justification Details

See block 13a.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution coversheet.

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ENGINEERING CHANGE NOTICE	Page 2 of 2	1. ECN (use no. from pg. 1) 656344

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)		
	ENGINEERING		CONSTRUCTION				
[ ] Yes	Additional	[ ] N/A	Additional	[ ]	Improvement	[ ]	N/A
[x] No	Savings	[ ]	Savings	[ ]	Delay	[ ]	

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[ ]	Seismic/Stress Analysis	[ ]	Tank Calibration Manual	[ ]
Functional Design Criteria	[ ]	Stress/Design Report	[ ]	Health Physics Procedure	[ ]
Operating Specification	[ ]	Interface Control Drawing	[ ]	Spares Multiple Unit Listing	[ ]
Criticality Specification	[ ]	Calibration Procedure	[ ]	Test Procedures/Specification	[ ]
Conceptual Design Report	[ ]	Installation Procedure	[ ]	Component Index	[ ]
Equipment Spec.	[ ]	Maintenance Procedure	[ ]	ASME Coded Item	[ ]
Const. Spec.	[ ]	Engineering Procedure	[ ]	Human Factor Consideration	[ ]
Procurement Spec.	[ ]	Operating Instruction	[ ]	Computer Software	[ ]
Vendor Information	[ ]	Operating Procedure	[ ]	Electric Circuit Schedule	[ ]
OM Manual	[ ]	Operational Safety Requirement	[ ]	ICRS Procedure	[ ]
FSAR/SAR	[x]	IEFD Drawing	[ ]	Process Control Manual/Plan	[ ]
Safety Equipment List	[ ]	Cell Arrangement Drawing	[ ]	Process Flow Chart	[ ]
Radiation Work Permit	[ ]	Essential Material Specification	[ ]	Purchase Requisition	[ ]
Environmental Impact Statement	[ ]	Fac. Proc. Samp. Schedule	[ ]	Tickler File	[ ]
Environmental Report	[ ]	Inspection Plan	[ ]		[ ]
Environmental Permit	[ ]	Inventory Adjustment Request	[ ]		[ ]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision

HNF-3553 Annex A, Rev. 0 – Canister Storage Building Final Safety Analysis Report

21. Approvals

	Signature	Date
Design Authority G. D. Bazinet	G D Bazinet	3/15/00
Cog. Eng. T. B. Powers	T. B. Powers	3/14/00
Cog. Mgr. R. L. Garrett	R L Garrett	3/15/00
QA S. S. Moss	Stephen Scott Moss	3-14-2000
Safety R. L. Garrett	R L Garrett	3/15/00
Environ. J. E. Turnbaugh	J E Turnbaugh	3/14/00

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature: N/A

ADDITIONAL

HNF-SD-SNF-HIE-001
Revision 3

Canister Storage Building Hazard Analysis Report

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
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Fluor Hanford
P.O. Box 1000
Richland, Washington

HNF-SD-SNF-HIE-001
Revision 3

Canister Storage Building Hazard Analysis Report

T. B. Powers
Fluor Hanford, Inc.

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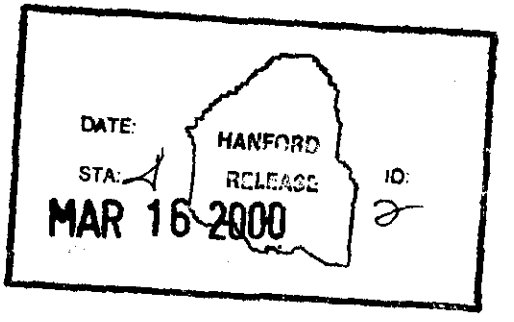

Date Published
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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Fluor Hanford
P.O. Box 1000
Richland, Washington

Abstract: This report describes the methodology used in conducting the Canister Storage Building (CSB) Hazard Analysis to support the final CSB Safety Analysis Report and documents the results.

Key Words: Hazard Analysis, Canister Storage Building

INFORMATION CLEARANCE FORM

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CANISTER STORAGE BUILDING HAZARD ANALYSIS REPORT

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Responsible Manager (Print and Sign)
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Information Clearance Approval
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K. If Additional Comments, Please Attach Separate Sheet

A-6001-401 (02/98)

RELEASE AUTHORIZATION

Document Number:	HNF-SD-SNF-HIE-001, REV 3
Document Title:	CANISTER STORAGE BUILDING HAZARD ANALYSIS REPORT

This document, reviewed in accordance with DOE Order 241.1, "Scientific and Technical Information Management," and 241.1-1, "Guide to the Management of Scientific and Technical Information," does not contain classified or sensitive unclassified information and is:

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RECORD OF REVISION	(1) Document Number HNF-SD-SNF-HIE-001, Rev. 3	Page 1
(2) Title Canister Storage Building Hazard Analysis Report		

CHANGE CONTROL RECORD			
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CANISTER STORAGE BUILDING
HAZARD ANALYSIS REPORT

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TERMS

AIChE	American Institute of Chemical Engineers
CSB	Canister Storage Building
FSAR	final safety analysis report
MCO	multi-canister overpack
MHM	multi-canister overpack handling machine

CANISTER STORAGE BUILDING HAZARD ANALYSIS REPORT

1.0 INTRODUCTION

This report describes the methodology used in conducting the Canister Storage Building (CSB) hazard analysis to support the CSB final safety analysis report (FSAR) and documents the results. The hazard analysis was performed in accordance with the DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, and implements the requirements of DOE Order 5480.23, *Nuclear Safety Analysis Reports*.

The hazard analysis process identified hazardous conditions and material-at-risk, determined causes for potential accidents, identified preventive and mitigative features, and qualitatively estimated the frequencies and consequences of specific occurrences. The hazard analysis was performed by a team of cognizant CSB operations and design personnel, safety analysts familiar with the CSB, and technical experts in specialty areas. The material included in this report documents the final state of a nearly two-year long process. Attachment A provides two lists of hazard analysis team members and describes the background and experience of each. The first list is a complete list of the hazard analysis team members that have been involved over the two-year long process. The second list is a subset of the first list and consists of those hazard analysis team members that reviewed and agreed to the final hazard analysis documentation.

The material included in this report documents the final state of a nearly two-year long process involving formal facilitated group sessions and independent hazard and accident analysis work. The hazard analysis process led to the selection of candidate accidents for further quantitative analysis. New information relative to the hazards, discovered during the accident analysis, was incorporated into the hazard analysis data in order to compile a complete profile of facility hazards. Through this process, the results of the hazard and accident analyses led directly to the identification of safety structures, systems, and components, technical safety requirements, and other controls required to protect the public, workers, and environment.

2.0 SCOPE OF THE HAZARD ANALYSIS

The CSB hazard analysis covered normal, intended, CSB operations for handling and storing a sealed multi-canister overpack (MCO). Potential hazards associated with storing an off-normal MCO in an overpack storage tube following undetermined accident recovery actions were also identified and analyzed. Chapter 3.0 of this report describes the hazard analysis for normal conditions, and Chapter 4.0 describes the hazard analysis for the off-normal MCO storage.

The following normal CSB operations and conditions were analyzed using the method described in Chapter 3.0:

- Receiving the transporter containing the cask–MCO and moving it into the facility
- Moving the cask–MCO to the load-in/load-out area and removing the cask lid at the cask receiving pit
- Loading an empty MCO into an empty cask and returning the empty cask–MCO to the trailer
- Performing MCO handling operations with the MCO handling machine (MHM)
  - Transporting the MCO from the load-in/load-out area to a storage tube or the sampling/weld area
  - Transporting the MCO from the sampling/weld area to a storage tube
  - Removing the MCO from a storage tube and transporting the MCO to the sampling/weld area and returning it to the storage tube after sampling
  - Removing the MCO from a storage tube and transporting the MCO to the sampling/weld area and returning it to the storage tube after welding
- Conducting normal facility operations during MCO sampling, welding, staging and interim storage.

The following abnormal MCO storage operations and conditions were analyzed using the method described in Chapter 4.0:

- The event or accident leading to MCO damage or MCO out-of-specification has been terminated and recovery actions completed
- The off-normal MCO is in place in the overpack storage tube
- The overpack storage tube plug cover is installed
- An inert atmosphere has been established in the overpack tube.

The hazard analysis was based on the design and operations described in HNF-3553, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report." The analysis also included review of a draft operating procedure and flow diagram. The following key sources of information were used to evaluate the hazards:

- HNF-3553, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report"
  - Chapters A2.0 and A4.0 for facility design and operations information
  - Chapter A3.0 for the facility radioactive materials inventory
  - Chapter A6.0 for evaluating the potential for hazards from nuclear criticality events
- WHC-SD-SNF-FHA-002, *Fire Hazard Analysis for the Canister Storage Building*; ARES Report 951107-001, *Canister Storage Building Fire Code Equivalency Evaluation*; ARES Report 951107-002, *White Paper Presenting Recommended Approach to Fire Protection of the Operating Area of the Canister Storage Building*; Letter 9655218, *Project W-379, Spent Nuclear Fuel Canister Storage Building Request for Deviation from the United States Department of Energy Order 6430.1A — Automatic Sprinkler Protection Requirements* (Williams 1996a); and Letter 9655233, *Project W-379, Spent Nuclear Fuel Canister Storage Building Request for Exemption from the United States Department of Energy Order 5480.7A — Automatic Fire Suppression System Requirements* (Williams 1996b) for fire protection information
- HNF-SD-TP-SARP-017, *Safety Analysis Report for Packaging, Onsite, Multi-Canister Overpack Cask*, for coverage of accidents involving the transporter and transportation cask and for definition of assumptions inherent in defining the transportation window
- HNF-SD-SNF-SARR-005, *Multi-Canister Overpack Topical Report*, for criteria and assumptions related to the MCO design
- Representatives from the design authority and from facility operations for details of design, operating modes, and procedures.

3.0 HAZARD ANALYSIS METHODOLOGY FOR NORMAL OPERATIONS

This chapter presents the methodology used to perform the CSB hazard analysis for normal operations. The hazard identification process systematically and comprehensively identified hazards that can contribute to the uncontrolled release of radioactive or hazardous materials or that can threaten the safety of facility workers. In addition to DOE Order 5480.23 and DOE-STD-3009-94, guidance provided in HNF-PRO-704, *Hazard and Accident Analysis Process*, and *Guidelines for Hazard Evaluation Procedures* (AIChE 1985) was used to develop

the CSB hazard analysis process. Specifically, the CSB hazard analysis followed the American Institute of Chemical Engineers (AIChE) Preliminary Hazard Analysis method and included elements of the Process/Systems Checklist and "What-If" Analysis methods.

3.1 HAZARD IDENTIFICATION

The hazard analysis identified hazards associated with CSB design and operations. Hazards were defined as radioactive or hazardous materials, system or process characteristics, or energy sources that represent a potential for an accident that could have an adverse effect on facility workers, the CSB facility, the environment, or the public.

Hazard identification for the CSB was based on examination of the facility and operations descriptions provided in Chapters A2.0 and A4.0 of HNF-3553, Annex A; on an operation flow diagram and operating procedures; and on discussions with design representatives from Fluor Daniel, Incorporated. The facility was divided into seven areas (see Figure 1):

1. Trailer vestibule (TV)
2. Load-in/load-out area [formerly known as service area] (SA)
3. Operating area, including overpack storage tubes and tube vent and purge cart (OA)
4. Sampling/weld area [formerly known as weld station] (WS)
5. Vault (VL)
6. Support building (SB)
7. Outside (OU).

A standardized checklist, Table 1, was used to identify potentially hazardous materials and energy sources present in each of the seven areas. Tables 2 through 9 show the hazard identification results for each area.

Each identified hazard was assigned a unique designator based on the checklists to allow for tracking. The checklist designators reflect the facility area, type of hazard, and specific situation within the hazard type (e.g., a designator TV-J-06 refers to a hazard in the trailer vestibule found under J. Explosives/Pyrophorics, item 6 Hydrogen). The checklist designators are noted on both the industrial hazard and hazard analysis tables described in Section 3.2. The hazard identification checklists were developed by a subgroup of the hazard analysis team and reviewed and accepted by the entire team.

3.2 HAZARD EVALUATION

The hazard evaluation was a structured and systematic examination of the CSB facility and its operations using standard industry (AIChE) hazard evaluation techniques. The hazard evaluation process included screening the identified hazards to determine which ones present standard industrial hazards. The remaining identified hazards, which are those with potential for

release of radioactive or hazardous material, were characterized and evaluated to develop potential accident descriptions.

Once the hazards had been identified, the potentially hazardous materials and energy sources were screened for those that presented only standard industrial hazards. These hazards are defined in DOE-STD-3009-94 as those that "are routinely encountered in general industry and construction, and for which national consensus codes and/or standards (e.g., Occupational Safety and Health Administration, transportation safety) exist to guide safe design and operation without the need for special analysis to define safe design and/or operational parameters." Tables 10 through 16 list by facility area the standard industrial hazards that do not contribute to the uncontrolled release of radioactive or hazardous material. The standard industrial hazards listed are controlled through the implementation of institutional safety programs as described in the programmatic sections of HNF-3553, Annex A. The hazard analysis team agreed by consensus to the results of the screening for standard industrial hazard items.

The next step was to characterize and evaluate those hazardous conditions, materials and energy sources (i.e., materials-at-risk) not identified as standard industrial hazards. A summary of the materials-at-risk, in terms of hazard type, form, quantity, and location, is included in this report as Table 17.

Next, the team met in facilitated sessions to characterize each hazard. Hazard analysis worksheets were designed to capture the required information. Each hazard was assigned a unique identifier for tracking. Using the worksheets and the hazard summary as a guide, each hazardous condition was assessed to identify potential accidents, causes, frequencies, and consequences, and to determine a qualitative likelihood of occurrence of the initiating event and the resulting consequence. The assessment of likelihood and consequence for each hazardous condition was a collective, qualitative judgment made by the hazard analysis team. The assessment estimated the likelihoods and consequences of each hazardous condition scenario in two cases. The first case considered designed passive features only. The second case considered designed passive features as well as credited active features and administrative features.

The completed hazard analysis worksheets, included in this report as Tables 18 through 23, show the results of the hazard evaluation as compiled by the hazard analysis team. The evaluation results are based on the hazard identification results, material-at-risk summaries, reviews of the systems designs and planned operations, existing safety documentation, and the experience of hazard analysis team members. Each column of the hazard analysis tables is explained below to aid in understanding the information contained therein.

Location/checklist entry. This column contains each hazard's unique identifier, which indicates the facility area, the hazard checklist category, and the specific hazard. For example, a designator of TV-F-01 would represent the trailer vestibule (TV), a linear kinetic hazard (F) from a car, truck, or bus (01).

Hazard energy source/material. This column further defines the specific hazard under consideration (e.g., a moving transporter).

Hazardous condition. This column describes the hazardous condition that the energy source or material represents (e.g., transporter collision).

Cause. This column identifies initiators of the potential accident (e.g., transporter collision *with facility structure [the potential accident] could* be caused by human error on the driver's part, by mechanical failure of the vehicle, or by misplaced equipment). Typical potential causes include equipment failures, operational errors, abnormal operating conditions, poor operating practices, and environmental conditions. The causes of a potential accident are identified to support a qualitative frequency evaluation.

Potential accident. This column identifies potential accidents that could result from the identified hazardous conditions (e.g., transporter collision with facility structures, systems, or components or with personnel).

Consequence. This column identifies the potential effects of the hazardous condition and potential accident in terms of radioactive or hazardous material releases, and impact to personnel and facility systems, structures, and components.

Credited prevention. This column lists preventive safety features present within the facility that are credited with reducing the frequency of the hazard or accident. The credited features listed in this column (both engineered and administrative) include only the controls the accident analyst required to be implemented to support the actual accident analysis. These preventive controls (along with the mitigative controls) are those controls necessary to meet evaluation guidelines.

Frequency code. Two evaluations of the likelihood of occurrence of the hazardous condition and potential accident are listed in the column labeled "Frequency Code." The first frequency code subcolumn ranks the hazard and accident frequency by considering the impact of any passive features (e.g., structures, barriers) listed in the table but not the impact of active features or planned controls (e.g., valves, shipping restrictions). The second frequency code subcolumn ranks the hazardous condition and potential accident frequency considering preventive controls, including passive controls. The assessment of likelihood was a collective, qualitative judgment made by the hazard analysis team. The likelihood assessments resulted in frequency rankings based on the initiating event frequencies and subsequent failures on a per year basis. The qualitative criteria for likelihood assessments are as follows:

F3 The hazardous condition based on the causes postulated is likely to occur during facility lifetime.

F2 The hazardous condition based on the causes postulated is foreseeable, but unlikely.

F1 The hazardous condition based on the causes postulated is perhaps possible, but extremely unlikely.

F0 The hazardous condition based on the causes postulated is considered too improbable to warrant further consideration.

Credited mitigation. This column lists mitigative safety features present within the facility that are credited with reducing the consequence of the hazard. The credited features listed in this column (both engineered and administrative) include only the controls the accident analyst required to be implemented to support the actual accident analysis. These mitigative controls (along with the preventive controls) are those controls necessary to meet evaluation guidelines. In some cases a control may reduce both the frequency and the consequence of a hazard.

Consequence code. Two evaluations of the potential effects of the hazardous condition on the health and safety of people and on the environment are listed in the column labeled "Consequence Code." The first consequence code subcolumn ranks the hazard and accident consequence by considering the impact of any passive features (e.g., structures, barriers) listed in the table but not the impact of active features or planned controls (e.g., valves, shipping restrictions). The second consequence code subcolumn ranks the hazardous condition and potential accident consequence with mitigative controls, including passive controls. The assessment of the consequence for each hazardous condition was a collective, qualitative judgment made by the hazard analysis team. The qualitative criteria for consequence assessments are as follows:

S3 On the basis of material at risk and causes postulated, there is sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.

S2 On the basis of material at risk and causes postulated, there is sufficient material and energy available to cause a high or moderate impact to the maximum onsite individual.

S1 On the basis of material at risk and causes postulated, there is sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.

S0 On the basis of material at risk and causes postulated, there is insufficient material and energy to adversely impact facility workers.

The more severe consequence categories encompass the less severe consequence categories. For example, a hazardous condition assessed as having onsite consequences (S2) is also considered to have facility worker consequences (S1).

Defense-in-depth for worker safety features. This column contains any additional controls that will reduce the likelihood or consequences even further, but no specific credit is taken for them in the quantitative analysis.

3.3 CANDIDATE ACCIDENT SELECTION

The hazardous conditions identified by the hazard evaluation have been used to select candidate accidents for a more detailed, quantitative analysis in the CSB FSAR (HNF-3553, Annex A). The general selection criteria used were consistent with DOE-STD-3009-94: "The range of accident scenarios analyzed in a SAR should be such that a complete set of bounding conditions to define the envelope of accident conditions to which the operation could be subjected are evaluated and documented."

The team used the four-step process described below to identify specific hazardous conditions that, together, represented the "complete set of bounding conditions" requiring further analysis. In summary, the process involved creating representative sets (or "bins") of hazardous conditions having similar release characteristics, similar initiators, and/or similar controls, and identifying (using a ranking matrix shown in Figure 2) the hazardous condition that represented the most severe consequences and the highest risk in each bin. The highest-ranking hazardous condition in each bin bounded the other hazardous conditions in the bin and, therefore, led to candidate accidents needing further analysis. These hazardous conditions and candidate accidents represent the "complete set of bounding conditions" for the CSB accident analysis.

The following four-step process was used by the evaluation team to select the CSB bounding accidents:

1. Initial screening
2. Assignment of release attributes
3. Creation of hazardous material release bins
4. Selection of representative bounding hazardous conditions for each release attribute category.

In order to capture and record the relational nature of the data developed in the four steps, the results have been organized into two tables, Table 25 and Table 26. The following sections describe each step, and identify where in Table 25 and Table 26 the related information is located.

Initial Screening. All hazardous conditions with a frequency of F1 (extremely unlikely) or greater and unmitigated consequences assessed as S3 (offsite consequences) or S2 (collocated worker consequences) were chosen for consideration as representative accidents. These hazardous conditions are listed in Table 25, with their frequency and consequence rankings listed under the column entitled "Frequency/consequence codes." There were some hazardous

conditions assessed as S1 (facility worker consequences) involving radiological hazards that received detailed consideration only in the detailed accident analysis. The remainder of the S1 hazardous conditions are addressed qualitatively in the CSB FSAR (HNF-3553, Annex A). Hazard conditions having no consequences (S0) were dropped from consideration.

Assignment of Release Attributes. Each S2 or S3 hazardous condition was evaluated and described in terms of certain release attributes related to uncontrolled release of the material at risk. This description was assembled to ensure that at least one candidate accident was selected to represent each unique set of release conditions. The following hazardous material release attributes were used:

- Energy available to release the hazardous material (high, medium, or low) (Table 25, "Release energy" column)
- Release location (Table 25, "Designator" column)
- Release initiator (Table 25, "Hazardous condition and initiators" column).

Creation of Hazardous Material Release Bins. As the S2 or S3 hazardous condition release attributes were identified, each hazardous condition was assigned to a bin category. Assignment to a bin category was based upon the potential accident release characteristics, initiators, and/or proposed mitigative or preventative controls. Table 25 lists the bin category assignment for each hazardous condition under the "Bin" column heading. The final step in creating the release attribute bins was to assemble hazardous conditions having the same bin category into a listing. This listing is the basis for Table 26, in which the hazardous conditions are grouped into their bin categories under the "Candidate accident" column.

Selection of Representative Bounding Hazardous Conditions for each Release Attribute Category. Within each bin category, the most severe hazardous condition, considering consequences, and the highest risk accident were identified using the three-by-three likelihood and consequence ranking matrix described in DOE-STD-3009-94 (see Figure 2). In Table 26 the bin category hazardous conditions are listed in descending order with the highest ranking hazardous condition at the top. More than one condition may have been required to provide the necessary bounding conditions for a bin. Table 26 identifies the bounding condition, or when necessary, bounding conditions for each bin.

Unique hazardous conditions were identified and selected as a part of the accident analysis process. However, the binning process described here provided the basis for identification and selection of those unique conditions. Briefly, at the completion of design basis accident analysis for each bin category, the results were compared with the other hazardous conditions in the original bin to ensure that no unique and unanalyzed conditions existed.

3.4 HAZARD ANALYSIS SUMMARY

The final list of candidate accidents includes all hazardous conditions with a frequency of F1 (extremely unlikely) or greater and whose unmitigated consequences were assessed as S3 (offsite consequences) or S2 (collocated worker consequences). Table 26 provides the final list of candidate accidents sorted first by risk ranking and then by release energy. The table also identifies the hazardous condition, or conditions, chosen as representative and bounding of all other conditions listed in the bin.

4.0 HAZARD ANALYSIS FOR OFF-NORMAL MULTI-CANISTER OVERPACK STORAGE

This section presents the methodology used to perform the CSB hazard analysis for off-normal MCO storage as a facility function. The off-normal MCO storage function requires analysis because a potential exists for MCO damage to occur during normal facility operations or during an accident. If an MCO were damaged, it would be declared off-normal and placed into an overpack storage tube. The hazard identification and evaluation process for off-normal MCO storage was essentially identical to the process described in Chapter 3.0; therefore, the process description is not repeated in this chapter. One difference of note, however, is in the hazardous condition frequency and consequences ranking, which is described in Section 4.3.

4.1 OFF-NORMAL MULTI-CANISTER OVERPACK STORAGE HAZARD ANALYSIS SCOPE

The scope of the analysis for off-normal MCO storage operations included the following conditions:

- The event or accident leading to MCO damage has been terminated and recovery actions completed.
- The off-normal MCO is in place in the overpack storage tube.
- The overpack storage tube plug cover is installed.
- An inert atmosphere has been established in the overpack tube.

This scope is consistent with DOE-STD-3009-94, which does not require hazard analysis of accidents and recovery sequences, but does require analysis for anticipated facility operations.

4.2 TECHNICAL SAFETY REQUIREMENTS COVERAGE

Potentially hazardous materials and energy sources associated with the off-normal MCO storage function are identified in Table 9. The hazards associated with off-normal MCO storage for specific facility areas are listed in Table 27 and are identified by their unique designator.

4.3 OFF-NORMAL MULTI-CANISTER OVERPACK STORAGE HAZARD EVALUATION

Table 27 presents the results of the hazard evaluation for each of the identified off-normal MCO storage hazards. Standard industrial hazards for this activity were assumed to be identical to those for normal facility operations because no new hazards were identified, and worker activities were similar to normal operations and performed in previously analyzed facility areas.

Frequency and consequence rankings for the off-normal MCO storage function involve two new considerations in addition to those described in Chapter 3.0. These considerations are incorporated into the ranking in Table 27 and are described as follows.

FR — FR (frequency of recovery event) describes the undetermined likelihood of the "off-normal hazardous condition" developing following termination and recovery of the initial event. Therefore, the off-normal frequency ranking is a product of FR and the frequency of the initial event (e.g., F3, F2, F1).

SR — SR (severity of the recovery event) describes the undetermined magnitude of the release caused by the unanalyzed condition of the damaged MCO. Therefore, the off-normal consequence ranking is a product of SR and the consequence of the initial event (e.g., S3, S2, or S1).

4.4 OFF-NORMAL MULTI-CANISTER OVERPACK STORAGE HAZARD BINS

Table 28 lists the off-normal MCO storage hazardous conditions in bins relative to potential accident type and initiator.

4.5 OFF-NORMAL MULTI-CANISTER OVERPACK STORAGE HAZARD ANALYSIS SUMMARY

System and equipment design changes have resulted from early hazard and accident analysis activities. Installation of these passive preventative features reduces the likelihood of MCO damage (i.e., drops leading to MCO cracks, which provide an open path to the atmosphere). These preventative design features, when introduced into the hazard analysis process for off-normal MCO storage, reduced the risk ranking to below requirements for further analysis. However, the information is retained in this report for historical reference.

5.0 REFERENCES

AIChE, 1985, *Guidelines for Hazard Evaluation Procedures*, American Institute of Chemical Engineers, New York, New York.

ARES Report 951107-001, 1996, *Canister Storage Building Fire Code Equivalency Evaluation*, Rev. 0, ARES Corporation, Richland, Washington.

ARES Report 951107-002, 1996, *White Paper Presenting Recommended Approach to Fire Protection of the Operating Area of the Canister Storage Building*, Rev. 0, ARES Corporation, Richland, Washington.

DOE Order 5480.23, *Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C.

DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C.

HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.

HNF-PRO-704, *Hazard and Accident Analysis Process*, Fluor Daniel Hanford, Incorporated, Richland, Washington.

HNF-SD-SNF-SARR-005, 1998, *Multi-Canister Overpack Topical Report*, Rev.1, Draft, Fluor Daniel Hanford, Incorporated, Richland, Washington.

HNF-SD-TP-SARP-017, 1997, *Safety Analysis Report for Packaging, Onsite, Multi-Canister Overpack Cask*, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

WHC-SD-SNF-FHA-002, 1996, *Phase 2 Fire Hazard Analysis for the Canister Storage Building*, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

Williams, N. H., 1996a, *Project W-379, Spent Nuclear Fuel Canister Storage Building Request for Deviation from the United States Department of Energy Order 6430.1A — Automatic Sprinkler Protection Requirements* (Letter 9655218 to E. D. Sellers, U.S. Department of Energy, Richland Operations Office, November 14), Fluor Daniel Hanford, Incorporated, Richland, Washington.

Williams, N. H., 1996b, *Project W-379, Spent Nuclear Fuel Canister Storage Building Request for Exemption from the U.S. Department of Energy Order 5480.7A — Automatic Fire Suppression System Requirements* (Letter 9655233 to E. D. Sellers, U.S. Department of Energy, Richland Operations Office, November 14), Fluor Daniel Hanford, Incorporated, Richland, Washington.

Figure 1. Main Areas of the Canister Storage Building.

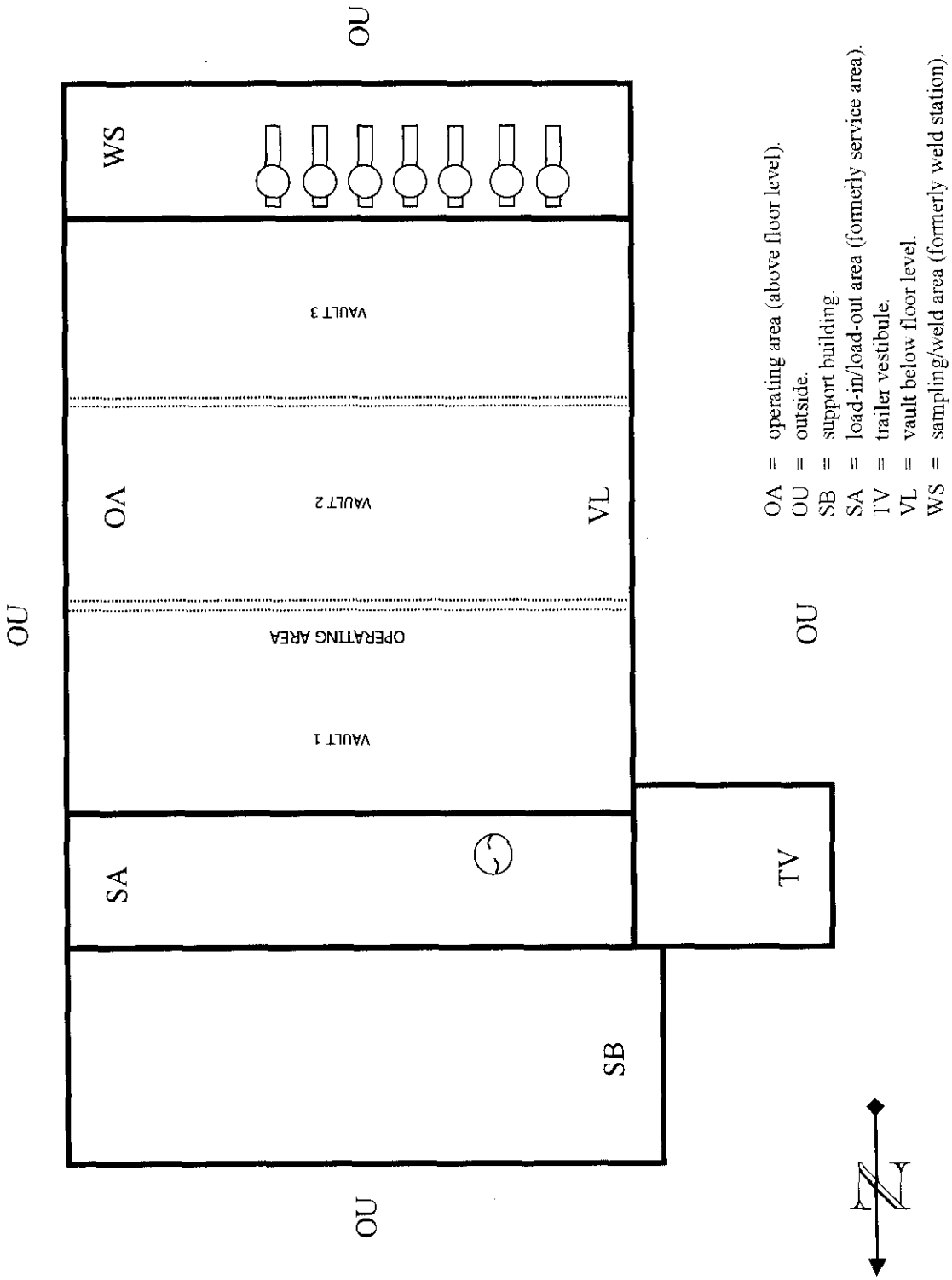

Figure 2. Three-by-Three Likelihood and Consequence Ranking Matrix.

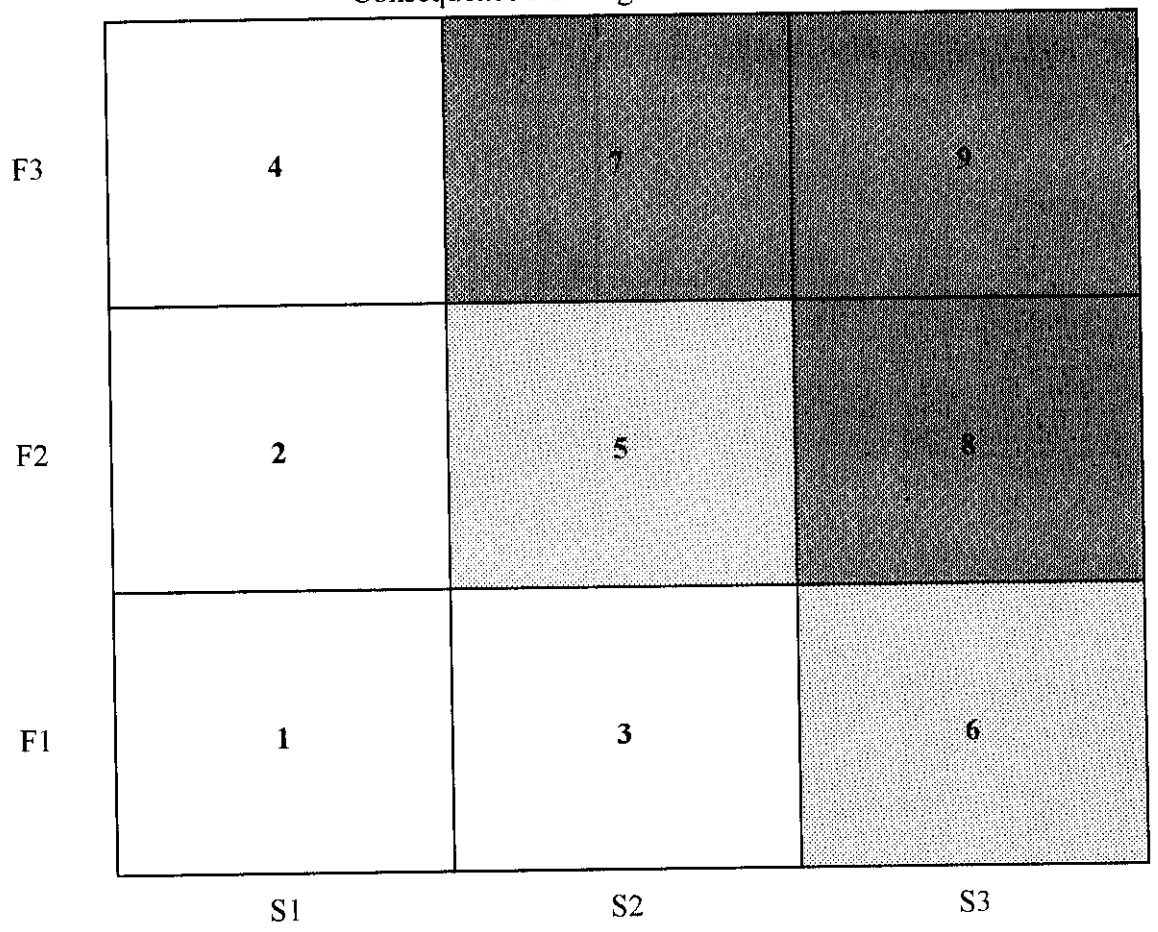

Table 1. Hazardous Material/Energy Source Checklist: Example.

Location: _____

Y	N	A. Electrical
☐	☐	1. Battery banks
☐	☐	2. Cable runs
☐	☐	3. Generators
☐	☐	4. Electrical equipment
☐	☐	5. HVAC heaters
☐	☐	6. High voltage
☐	☐	7. Motors
☐	☐	8. Pumps
☐	☐	9. Power tools
☐	☐	10. Switchgear
☐	☐	11. Service outlets, fittings
☐	☐	12. Transformers
☐	☐	13. Transmission lines
☐	☐	14. Underground wires
☐	☐	15. Wiring
☐	☐	16. Other _____

Y	N	B. Thermal
☐	☐	1. Bunsen burner/hot plates
☐	☐	2. Electrical equipment
☐	☐	3. Furnaces/boilers/heater
☐	☐	4. Steam lines
☐	☐	5. Welding torch/arc
☐	☐	6. Diesel units/fire box/exhaust line
☐	☐	7. Radioactive decay heat
☐	☐	8. Exposed components
☐	☐	9. Power tools
☐	☐	10. Convective
☐	☐	11. Solar
☐	☐	12. Cryogenic
☐	☐	13. Other _____

Y	N	C. Friction
☐	☐	1. Belts
☐	☐	2. Bearings
☐	☐	3. Fans
☐	☐	4. Gears
☐	☐	5. Motors
☐	☐	6. Power tools
☐	☐	7. Other _____

Y	N	D. Corrosives
☐	☐	1. Acids
☐	☐	2. Caustics
☐	☐	3. Natural chemicals
☐	☐	4. Decon solution
☐	☐	5. High temperature waste
☐	☐	6. Other _____

Y	N	E. Kinetic - Rotational
☐	☐	1. Centrifuges
☐	☐	2. Motors
☐	☐	3. Pumps
☐	☐	4. Fans
☐	☐	5. Laundry equipment
☐	☐	6. Shop equipment
☐	☐	7. Other _____

Y	N	F. Kinetic - Linear
☐	☐	1. Cars, trucks, buses
☐	☐	2. Forklifts, dollies, carts
☐	☐	3. Railroad
☐	☐	4. Obstructions
☐	☐	5. Crane loads
☐	☐	6. Pressure vessel blowdown
☐	☐	7. Other _____

Y	N	G. Mass, Gravity, Height
☐	☐	1. Human effort
☐	☐	2. Stairs
☐	☐	3. Lifts and cranes
☐	☐	4. Bucket and ladder
☐	☐	5. Trucks
☐	☐	6. Slings
☐	☐	7. Hoists
☐	☐	8. Elevators
☐	☐	9. Jacks
☐	☐	10. Scaffold and ladders
☐	☐	11. Pits and excavations
☐	☐	12. Elevated doors
☐	☐	13. Vessels
☐	☐	14. Other _____

Y	N	H. Pressure - Volume
☐	☐	1. Boilers
☐	☐	2. Surge tanks
☐	☐	3. Autoclave
☐	☐	4. Test loops
☐	☐	5. Gas bottles
☐	☐	6. Pressure vessels
☐	☐	7. Gas receivers
☐	☐	8. Vacuum
☐	☐	9. Steam headers and lines
☐	☐	10. Confined spaces
☐	☐	11. Other _____

Y	N	J. Explosives/Pyrophorics
☐	☐	1. Caps
☐	☐	2. Primer cord
☐	☐	3. Dynamite
☐	☐	4. Scrub chemicals
☐	☐	5. Dusts
☐	☐	6. Hydrogen
☐	☐	7. Gases, others
☐	☐	8. Nitrates
☐	☐	9. Peroxides
☐	☐	10. Pu and U metal
☐	☐	11. Sodium
☐	☐	12. Other _____

Y	N	K. Nuclear Criticality
☐	☐	1. Vaults
☐	☐	2. Temporary storage areas
☐	☐	3. Shipping and receiving area
☐	☐	4. Filters
☐	☐	5. Casks
☐	☐	6. Burial ground
☐	☐	7. Storage racks
☐	☐	8. Canals and basins
☐	☐	9. Decon solution
☐	☐	10. Trucks, forklifts, dollies
☐	☐	11. Hand carry
☐	☐	12. Cranes/lifts
☐	☐	13. Hot cells, assembly, inspection
☐	☐	14. Laboratories
☐	☐	15. Other _____

Y	N	L. Flammable Materials
☐	☐	1. Packing materials
☐	☐	2. Rags
☐	☐	3. Gasoline
☐	☐	4. Lube oil
☐	☐	5. Coolant oil
☐	☐	6. Paints/solvents
☐	☐	7. Diesel fuel
☐	☐	8. Buildings & contents
☐	☐	9. Trailers & contents
☐	☐	10. Grease
☐	☐	11. Hydrogen
☐	☐	12. Nitric acid
☐	☐	13. Organics
☐	☐	14. Gases - others
☐	☐	15. Liquids - others
☐	☐	16. Other _____

Y	N	M. Hazardous Materials
☐	☐	1. Alkali metals
☐	☐	2. Asphyxiants
☐	☐	3. Biologicals
☐	☐	4. Carcinogens
☐	☐	5. Corrosives
☐	☐	6. Oxidizers
☐	☐	7. Toxics
☐	☐	8. Heavy metals
☐	☐	9. Other _____

Y	N	N. Ionizing Radiation Sources
☐	☐	1. Fissile material
☐	☐	2. Radiography equipment
☐	☐	3. Radioactive material
☐	☐	4. Radioactive sources
☐	☐	5. Other _____

Y	N	P. External Events
☐	☐	1. Explosion
☐	☐	2. Fire
☐	☐	3. Events at other sites
☐	☐	4. Loss of power

Y	N	Q. Vehicles in Motion (external to facility)
☐	☐	1. Airplane
☐	☐	2. Helicopter
☐	☐	3. Train
☐	☐	4. Truck/bus/car
☐	☐	5. Other _____

Y	N	R. Natural Phenomena
☐	☐	1. Earthquake
☐	☐	2. Flood
☐	☐	3. Lightning
☐	☐	4. Rain
☐	☐	5. Snow, freezing weather
☐	☐	6. Straight wind
☐	☐	7. Dust devil
☐	☐	8. Tornado
☐	☐	9. Ashfall
☐	☐	10. Range fire

Table 2. Hazardous Material/Energy Source Checklist: Trailer Vestibule.

Location: ***Truck Vestibule (TV)***

Y	N	A. Electrical
☐	■	1. Battery banks
■	☐	2. Cable runs (for welding)
☐	■	3. Generators
■	☐	4. Electrical equipment (crane)
☐	■	5. HVAC heaters
■	☐	6. High voltage
■	☐	7. Motors (receiving crane)
☐	■	8. Pumps
■	☐	9. Power tools
☐	■	10. Switchgear
■	☐	11. Service outlets, fittings
■	☐	12. Transformers (for welding)
☐	■	13. Transmission lines
☐	■	14. Underground wires
■	☐	15. Wiring
■	☐	16. Other - crane hot rail conductor

Y	N	B. Thermal
☐	■	*1. Bunsen burner/hot plates*
■	☐	2. Electrical equipment
☐	■	3. Furnaces/boilers/heater
☐	■	4. Steam lines
■	☐	5. Welding torch/arc
■	☐	6. Diesel units/fire box/exhaust line
☐	■	7. Radioactive decay heat
☐	■	8. Exposed components
■	☐	9. Power tools
■	☐	10. Convective
☐	■	11. Solar
☐	■	12. Cryogenic
■	☐	13. Other - brakes

Y	N	C. Friction
■	☐	1. Belts
■	☐	2. Bearings
■	☐	3. Fans
■	☐	4. Gears
■	☐	5. Motors
■	☐	6. Power tools
☐	■	7. Other _____

Y	N	D. Corrosives
■	☐	1. Acids (truck battery)
☐	■	2. Caustics
☐	■	3. Natural chemicals
■	☐	4. Decon solution
☐	■	5. High temperature waste
☐	■	6. Other _____

Y	N	E. Kinetic - Rotational
☐	■	1. Centrifuges
■	☐	2. Motors
■	☐	3. Pumps (crane hydraulics)
■	☐	4. Fans (truck)
☐	■	5. *Laundry equipment*
☐	■	6. Shop equipment
■	☐	7. Other - power tools, hoist system

Y	N	F. Kinetic - Linear
■	☐	1. Cars, trucks, buses
■	☐	2. Forklifts, dollies, carts (for MCOs)
☐	■	3. *Railroad*
☐	■	4. Obstructions
■	☐	5. Crane loads
■	☐	6. Pressure vessel blowdown (missiles)
☐	■	7. Other _____

Y	N	G. Mass, Gravity, Height
■	☐	1. Human effort
☐	■	2. Stairs
■	☐	3. Lifts and cranes (including loads)
■	☐	4. Bucket and ladder (maintenance)
☐	■	5. Trucks (see G9)
■	☐	6. Slings (maintenance)
■	☐	7. Hoists
☐	■	8. Elevators
■	☐	9. Jacks (cask on transporter)
■	☐	10. Scaffold and ladders
☐	■	11. Pits and excavations
■	☐	*12. Elevated doors*
■	☐	13. Vessels (cask)
☐	■	14. Other _____

Y	N	H. Pressure - Volume
☐	■	1. Boilers
☐	■	2. Surge tanks
☐	■	3. *Autoclave*
■	☐	4. Test loops
■	☐	5. Gas bottles
■	☐	6. Pressure vessels (MCO)
☐	■	7. Gas receivers
☐	■	8. Vacuum
☐	■	9. Steam headers and lines
☐	■	10. Confined spaces
☐	■	11. Other _____

Y	N	J. Explosives/Pyrophorics
☐	■	1. Caps
☐	■	2. Primer cord
☐	■	3. Dynamite
☐	■	4. Scrub chemicals
☐	■	5. Dusts
■	☐	6. Hydrogen
■	☐	7. Gases, others (acetylene)
☐	■	8. Nitrates
☐	■	9. *Peroxides*
■	☐	10. Pu and U metal (U hydride)
☐	■	11. Sodium
☐	■	12. Other _____

Y	N	K. Nuclear Criticality
☐	■	1. Vaults
☐	■	2. Temporary storage areas
☐	■	3. Shipping and receiving area
☐	■	4. Filters
☐	■	5. Casks
☐	■	6. Burial ground
☐	■	7. Storage racks
☐	■	8. Canals and basins
☐	■	9. *Decon solution*
☐	■	10. Trucks, forklifts, dollies
☐	■	11. Hand carry
■	☐	12. Cranes/lifts
☐	■	13. Hot cells, assembly, inspection
☐	■	14. Laboratories
■	☐	15. Other - MCO

Y	N	L. Flammable Materials
☐	■	1. Packing materials
☐	■	2. Rags
■	☐	3. Gasoline (new MCO deliveries)
■	☐	4. Lube oil
☐	■	5. Coolant oil
■	☐	6. Paints/solvents
■	☐	7. Diesel fuel
☐	■	8. Buildings & contents
☐	■	9. Trailers & contents
■	☐	10. Grease
■	☐	11. Hydrogen
☐	■	12. Nitric acid
☐	■	13. Organics
■	☐	14. Gases - others (acetylene)
☐	■	15. Liquids - others
■	☐	16. Other - hydraulic fluid

Y	N	M. Hazardous Materials
☐	■	1. Alkali metals
■	☐	2. Asphyxiants (exhaust)
☐	■	3. Biologicals
■	☐	4. Carcinogens
■	☐	5. Corrosives
☐	■	6. Oxidizers
■	☐	7. Toxics
■	☐	8. Heavy metals (battery lead)
■	☐	9. Other - used decon rags

Y	N	N. Ionizing Radiation Sources
■	☐	1. Fissile material
☐	■	2. Radiography equipment
■	☐	3. Radioactive material
■	☐	4. Radioactive sources (HPT instruments)
☐	■	5. Other _____

Y	N	P. External Events
■	☐	1. Explosion
■	☐	2. Fire
■	☐	3. Events at other sites
■	☐	4. Loss of power

Y	N	Q. Vehicles in Motion (external to facility)
■	☐	1. Airplane
■	☐	2. Helicopter
■	☐	3. *Train*
■	☐	4. Truck/bus/car
☐	■	5. Other _____

Y	N	R. Natural Phenomena
■	☐	1. Earthquake
☐	■	2. Flood
■	☐	3. Lightning
■	☐	4. Rain
■	☐	5. Snow, freezing weather
■	☐	6. Straight wind
■	☐	7. Dust devil
■	☐	8. Tornado
■	☐	9. Ashfall
■	☐	*10. Range fire*

Table 3. Hazardous Material/Energy Source Checklist: Load-In/Load-Out Area.

Location: *MCO Service Area (SA)*

Y	N	A. Electrical
■	□	1. Battery banks (vent/purge cart)
■	□	2. Cable runs (welding, festooning)
□	■	3. Generators
■	□	4. Electrical equipment
□	■	5. HVAC heaters
■	□	6. High voltage
■	□	7. Motors
□	■	8. Pumps
■	□	9. Power tools
□	■	10. Switchgear
■	□	11. Service outlets, fittings
■	□	12. Transformers (for welding, MHM)
□	■	13. Transmission lines
□	■	14. Underground wires
■	□	15. Wiring
■	□	16. Other - blowers, hot rail conductor

Y	N	B. Thermal
□	■	1. Bunsen burner/hot plates
■	□	2. Electrical equipment
□	■	3. Furnaces/boilers/heater
□	■	4. Steam lines
■	□	5. Welding torch/arc
□	■	6. Diesel units/fire box/exhaust line
■	□	7. Radioactive decay heat
■	□	8. Exposed components (on cart)
■	□	9. Power tools
■	□	10. Convective
□	■	11. Solar
□	■	12. Cryogenic
■	□	13. Other - crane and MHM brakes

Y	N	C. Friction
■	□	1. Belts
■	□	2. Bearings
■	□	3. Fans
■	□	4. Gears
■	□	5. Motors
■	□	6. Power tools
■	□	7. Other - crane and MHM brakes

Y	N	D. Corrosives
■	□	1. Acids (vent/purge cart battery)
□	■	2. Caustics
□	■	3. Natural chemicals
■	□	4. Decon solution
□	■	5. High temperature waste
□	■	6. Other _____

Y	N	E. Kinetic - Rotational
□	■	1. Centrifuges
■	□	2. Motors
■	□	3. Pumps (crane/clamp hydraulics)
■	□	4. Fans (MHM, service tent)
□	■	5. Laundry equipment
□	■	6. Shop equipment
■	□	7. Other - MHM turret, hoist, power tools

Y	N	F. Kinetic - Linear
□	■	1. Cars, trucks, buses
■	□	2. Forklifts, dollies, carts (hand trolley)
□	■	3. Railroad
■	□	4. Obstructions (frogs, rails, carts)
■	□	5. Crane loads
■	□	6. Pressure vessel blowdown (missiles)
■	□	7. Other - MHM, 5-ton gantry

Y	N	G. Mass, Gravity, Height
■	□	1. Human effort
□	■	2. Stairs
■	□	3. Lifts and cranes (including loads)
■	□	4. Bucket and ladder (maintenance)
□	■	5. Trucks
■	□	6. Slings (maintenance)
■	□	7. Hoists
□	■	8. Elevators
■	□	9. Jacks (MHM jack in maint. pit)
■	□	10. Scaffold and ladders
■	□	11. Pits and excavations
■	□	12. Elevated doors
■	□	13. Vessels (cask, MCO)
□	■	14. Other _____

Y	N	H. Pressure - Volume
□	■	1. Boilers
□	■	2. Surge tanks
□	■	3. Autoclave
■	□	4. Test loops (cask pressure check)
■	□	5. Gas bottles
■	□	6. Pressure vessels (MCO)
■	□	7. Gas receivers (accumulator, cart)
□	■	8. Vacuum
□	■	9. Steam headers and lines
■	□	10. Confined spaces
■	□	11. Other - inert gas line, inflatable seals

Y	N	J. Explosives/Pyrophorics
□	■	1. Caps
□	■	2. Primer cord
□	■	3. Dynamite
□	■	4. Scrub chemicals
□	■	5. Dusts
■	□	6. Hydrogen
■	□	7. Gases, others (acetylene)
□	■	8. Nitrates
□	■	9. Peroxides
■	□	10. Pu and U metal (U hydride)
□	■	11. Sodium
□	■	12. Other _____

Y	N	K. Nuclear Criticality
□	■	1. Vaults
□	■	2. Temporary storage areas
□	■	3. Shipping and receiving area
□	■	4. Filters
□	■	5. Casks
□	■	6. Burial ground
□	■	7. Storage racks
□	■	8. Canals and basins
□	■	9. Decon solution
□	■	10. Trucks, forklifts, dollies
□	■	11. Hand carry
■	□	12. Cranes/lifts
□	■	13. Hot cells, assembly, inspection
□	■	14. Laboratories
■	□	15. Other - MCO

Y	N	L. Flammable Materials
■	□	1. Packing materials (MCO)
■	□	2. Rags
□	■	3. Gasoline
■	□	4. Lube oil
□	■	5. Coolant oil
■	□	6. Paints/solvents
□	■	7. Diesel fuel
□	■	8. Buildings & contents
□	■	9. Trailers & contents
■	□	10. Grease
■	□	11. Hydrogen
□	■	12. Nitric acid
■	□	13. Organics (MHM neutron absorber, tent enclosure)
■	□	14. Gases - others (acetylene)
□	■	15. Liquids - others
■	□	16. Other - hydraulic fluid

Y	N	M. Hazardous Materials
□	■	1. Alkali metals
■	□	2. Asphyxiants (helium)
□	■	3. Biologicals
□	■	4. Carcinogens
■	□	5. Corrosives (batteries)
□	■	6. Oxidizers
■	□	7. Toxics (fuels)
■	□	8. Heavy metals (battery lead)
□	■	9. Other

Y	N	N. Ionizing Radiation Sources
■	□	1. Fissile material
□	■	2. Radiography equipment
■	□	3. Radioactive material
■	□	4. Radioactive sources (HPT instruments)
□	■	5. Other _____

Y	N	P. External Events
■	□	1. Explosion
■	□	2. Fire
■	□	3. Events at other sites
■	□	4. Loss of power

Y	N	Q. Vehicles in Motion (external to facility)
■	□	1. Airplane
■	□	2. Helicopter
■	□	3. Train
■	□	4. Truck/bus/car
□	■	5. Other _____

Y	N	R. Natural Phenomena
■	□	1. Earthquake
□	■	2. Flood
■	□	3. Lightning
■	□	4. Rain
■	□	5. Snow, freezing weather
■	□	6. Straight wind
□	■	7. Dust devil
■	□	8. Tornado
■	□	9. Ashfall
■	□	10. Range fire

Table 4. Hazardous Material/Energy Source Checklist: Operating Area, Without Overpack (See Table 9 for Overpack Storage), With Tube Vent and Purge Cart.

Location: ***Operating Area (including storage tubes and contents) (OA)***

Y N **A. Electrical**
- ■ □ 1. Battery banks (TV&P carts)
- ■ □ 2. Cable runs (welding, festooning)
- □ ■ 3. Generators
- ■ □ 4. Electrical equipment
- □ ■ 5. HVAC heaters
- ■ □ 6. High voltage
- ■ □ 7. Motors
- □ ■ 8. Pumps
- ■ □ 9. Power tools (maintenance)
- □ ■ 10. Switchgear
- ■ □ 11. Service outlets, fittings
- ■ □ 12. Transformers (for welding)
- □ ■ 13. Transmission lines
- □ ■ 14. Underground wires
- ■ □ 15. Wiring
- ■ □ 16. Other - e.g., lights, CAMs, cameras

Y N **B. Thermal**
- □ ■ 1. Bunsen burner/hot plates
- ■ □ 2. Electrical equipment (for welding)
- ■ □ 3. Heater (sample lines on cart)
- □ ■ 4. Steam lines
- ■ □ 5. Welding torch/arc
- □ ■ 6. Diesel units/fire box/exhaust line
- ■ □ 7. *Radioactive decay heat*
- ■ □ 8. Exposed components (on cart)
- ■ □ 9. Power tools
- ■ □ 10. Convective (heat exchanger on cart)
- □ ■ 11. Solar
- □ ■ 12. Cryogenic
- ■ □ 13. Other - operating deck floor

Y N **C. Friction**
- ■ □ 1. Belts
- ■ □ 2. Bearings
- ■ □ 3. Fans
- ■ □ 4. Gears
- ■ □ 5. Motors
- ■ □ 6. *Power tools*
- ■ □ 7. Other - brakes on MHM, cart

Y N **D. Corrosives**
- ■ □ 1. Acids (service cart battery)
- □ ■ 2. Caustics
- □ ■ 3. Natural chemicals
- ■ □ 4. *Decon solution*
- □ ■ 5. High temperature waste
- □ ■ 6. Other _____

Y N **E. Kinetic - Rotational**
- □ ■ 1. Centrifuges
- ■ □ 2. Motors
- ■ □ 3. Pumps (service cart, seismic clamp)
- □ ■ 4. Fans
- □ ■ 5. Laundry equipment
- □ ■ 6. Shop equipment
- ■ □ 7. Other - MHM turret, hoist, tools

Y N **F. Kinetic - Linear**
- □ ■ 1. Cars, trucks, buses
- ■ □ 2. *Forklifts, dollies, carts (* TV&P carts)
- □ ■ 3. Railroad
- ■ □ 4. Obstructions (rail frogs, tube covers)
- ■ □ 5. Crane loads (vent/purge cart)
- ■ □ 6. Pressure vessel blowdown (missiles)
- ■ □ 7. Other - MHM movement

Y N **G. Mass, Gravity, Height**
- ■ □ 1. Human effort
- □ ■ 2. Stairs
- ■ □ 3. Lifts and cranes (including loads)
- ■ □ 4. Bucket and ladder (maintenance)
- □ ■ 5. Trucks
- ■ □ 6. Slings (tube cover removal)
- ■ □ 7. Hoists (vent/purge cart)
- □ ■ 8. Elevators
- ■ □ 9. Jacks (MHM shield ring jacks)
- ■ □ 10. Scaffold and ladders (MHM access)
- ■ □ 11. Pits and excavations
- □ ■ 12. Elevated doors
- ■ □ 13. Vessels (MCO)
- ■ □ 14. Other - tube plugs, impact absorbers

Y N **H. Pressure - Volume**
- □ ■ 1. Boilers
- □ ■ 2. *Surge tanks*
- □ ■ 3. Autoclave
- ■ □ 4. Test loops (validation MCO mon.)
- ■ □ 5. Gas bottles
- ■ □ 6. Pressure vessels (MCO)
- ■ □ 7. Gas receivers (MHM, service cart)
- ■ □ 8. Vacuum (sampling)
- □ ■ 9. *Steam headers and lines*
- □ ■ 10. Confined spaces
- ■ □ 11. Other - inert gas lines, seismic clamp

Y N **J. Explosives/Pyrophorics**
- □ ■ 1. Caps
- □ ■ 2. Primer cord
- □ ■ 3. Dynamite
- □ ■ 4. *Scrub chemicals*
- □ ■ 5. Dusts
- ■ □ 6. Hydrogen
- ■ □ 7. Gases, others (acetylene)
- □ ■ 8. Nitrates
- □ ■ 9. Peroxides
- ■ □ 10. Pu and U metal (U hydride)
- □ ■ 11. Sodium
- □ ■ 12. Other _____

Y N **K. Nuclear Criticality**
- □ ■ 1. *Vaults*
- □ ■ 2. Temporary storage areas
- □ ■ 3. Shipping and receiving area
- □ ■ 4. Filters
- □ ■ 5. Casks
- □ ■ 6. Burial ground
- □ ■ 7. Storage racks
- □ ■ 8. *Canals and basins*
- □ ■ 9. Decon solution
- □ ■ 10. Trucks, forklifts, dollies
- □ ■ 11. Hand carry
- ■ □ 12. Cranes/lifts
- □ ■ 13. Hot cells, assembly, inspection
- □ ■ 14. Laboratories
- ■ □ 15. *Other - MCO*

Y N **L. Flammable Materials**
- □ ■ 1. Packing materials
- □ ■ 2. Rags
- □ ■ 3. Gasoline
- ■ □ 4. Lube oil
- □ ■ 5. Coolant oil
- ■ □ 6. Paints/solvents
- □ ■ 7. Diesel fuel
- □ ■ 8. Buildings & contents
- □ ■ 9. Trailers & contents
- ■ □ 10. Grease
- ■ □ 11. Hydrogen
- □ ■ 12. Nitric acid
- ■ □ 13. Organics (MHM neutron absorber)
- ■ □ 14. Gases - others (acetylene)
- ■ □ 15. Liquids - others (hydraulic fluid)
- □ ■ 16. Other _____

Y N **M. Hazardous Materials**
- □ ■ 1. *Alkali metals*
- ■ □ 2. Asphyxiants (cart, inert gas line)
- □ ■ 3. Biologicals
- □ ■ 4. Carcinogens
- ■ □ 5. Corrosives (batteries)
- □ ■ 6. Oxidizers
- ■ □ 7. Toxics (fuels)
- ■ □ 8. Heavy metals (lead batteries)
- □ ■ 9. Other _____

Y N **N. Ionizing Radiation Sources**
- ■ □ 1. Fissile material
- □ ■ 2. Radiography equipment
- ■ □ 3. Radioactive material
- ■ □ 4. Radioactive sources (HPT instruments)
- □ ■ 5. Other _____

Y N **P. External Events**
- ■ □ 1. Explosion
- ■ □ 2. Fire
- ■ □ 3. Events at other sites
- ■ □ 4. Loss of power

Y N **Q. Vehicles in Motion** (external to facility)
- ■ □ 1. Airplane
- ■ □ 2. *Helicopter*
- ■ □ 3. Train
- ■ □ 4. Truck/bus/car
- □ ■ 5. Other _____

Y N **R. Natural Phenomena**
- ■ □ 1. Earthquake
- □ ■ 2. *Flood*
- ■ □ 3. Lightning
- ■ □ 4. Rain
- ■ □ 5. Snow, freezing weather
- ■ □ 6. Straight wind
- □ ■ 7. Dust devil
- ■ □ 8. Tornado
- ■ □ 9. *Ashfall*
- ■ □ 10. Range fire

Table 5. Hazardous Material/Energy Source Checklist: Sampling/Weld Area.

Location: ***Weld Station (WS)***

Y	N	A. Electrical
☐	■	1. Battery banks
■	☐	2. Cable runs (welding, power track)
☐	■	3. Generators
■	☐	4. Elec equip (welder, *mass spec*)
☐	■	5. HVAC heaters
☐	■	6. High voltage (> 600 V)
■	☐	7. Motors (crane, weld pit)
■	☐	8. Pumps (welder cooler pump)
■	☐	9. Power tools (grinder)
■	☐	10. Switchgear (welder, MHM)
■	☐	11. Service outlets, fittings
■	☐	12. Transformers (MHM, port. welder)
☐	■	13. Transmission lines
☐	■	14. Underground wires
■	☐	15. Wiring
■	☐	16. Other - vent fan

Y	N	B. Thermal
☐	■	1. Bunsen burner/hot plates
■	☐	2. Elec equip (welder, mass spec)
☐	■	3. Furnaces/boilers/heater
☐	■	4. Steam lines
■	☐	5. Welding torch/arc
☐	■	6. Diesel units/fire box/exhaust line
■	☐	7. Radioactive decay heat (MCO)
■	☐	8. Exposed components
■	☐	9. Power tools (grinder)
■	☐	10. Convective (welder cooler)
☐	■	11. Solar
■	☐	12. Cryogenic (glycol cooling)
■	☐	13. Other - brakes, mettal spatter

Y	N	C. Friction
■	☐	1. Belts (vent fan)
■	☐	2. Bearings (auto welder, MCO rotary)
■	☐	3. Fans (MHM, vent fan)
■	☐	4. Gears (auto welder, hoists)
■	☐	5. Motors (welder, MCO rotary, crane)
■	☐	6. Power tools (grinder - weldc repair)
■	☐	7. Other - brakes on MHM, crane

Y	N	D. Corrosives
☐	■	1. Acids
☐	■	2. Caustics
☐	■	3. Natural chemicals
■	☐	4. Decon solution
☐	■	5. High temperature waste
■	☐	6. Other - Dye penetrant cleaners

Y	N	E. Kinetic - Rotational
☐	■	1. Centrifuges
■	☐	2. Motors (welder, MCO rotary, crane)
■	☐	3. Pumps (welder cooler, vacuum pump)
■	☐	4. Fans (vent fant, MHM)
☐	■	5. Laundry equipment
■	☐	6. Shop equipment (crane hoists)
■	☐	7. Other - MHM turret, MCO

Y	N	F. Kinetic - Linear
☐	■	1. Cars, trucks, buses
■	☐	2. Forklifts, dollies, carts (three carts)
☐	■	3. *Railroad*
■	☐	4. Obstructions (handrails)
■	☐	5. Crane loads (hoist, gantry collision)
■	☐	6. Pressure vessel blowdown (missiles)
■	☐	7. Other - MHM movement

Y	N	G. Mass, Gravity, Height
■	☐	1. Human effort
■	☐	2. Stairs
■	☐	3. Lifts and cranes (including loads)
■	☐	4. Bucket and ladder (maintenance)
☐	■	5. Trucks
■	☐	6. *Slings (covers)*
■	☐	7. Hoists (gantry crane)
☐	■	8. Elevators
☐	■	9. Jacks
■	☐	10. Scaffold and ladders (MHM access)
■	☐	11. Pits and excavations (samp./weld pit)
■	☐	12. Elevated doors
■	☐	13. Vessels (MCO)
☐	■	14. Other _____

Y	N	H. Pressure - Volume
☐	■	1. Boilers
☐	■	2. Surge tanks
☐	■	3. Autoclave
■	☐	4. Test loops
■	☐	5. Gas bottles (portable welder)
■	☐	6. Pressure vessels (MCO)
■	☐	7. Gas receivers (accumulators)
■	☐	8. Vacuum
☐	■	9. Steam headers and lines
■	☐	10. Confined spaces (trench)
■	☐	11. Other - inert gas line, glycol in pit

Y	N	J. Explosives/Pyrophorics
☐	■	1. Caps
☐	■	2. Primer cord
☐	■	3. Dynamite
☐	■	4. Scrub chemicals
☐	■	5. Dusts
■	☐	6. Hydrogen (MCO, samples)
■	☐	7. Gases, others (acetylene)
☐	■	8. Nitrates
☐	■	9. Peroxides
■	☐	10. Pu and U metal (U hydride)
☐	■	11. Sodium
☐	■	12. Other _____

Y	N	K. Nuclear Criticality
☐	■	1. Vaults
☐	■	2. *Temporary storage areas*
☐	■	3. Shipping and receiving area
☐	■	4. Filters
☐	■	5. Casks
☐	■	6. Burial ground
☐	■	7. Storage racks
☐	■	8. Canals and basins
☐	■	9. Decon solution
☐	■	10. Trucks, forklifts, dollies
☐	■	11. Hand carry
■	☐	12. Cranes/lifts
☐	■	13. Hot cells, assembly, inspection
☐	■	14. *Laboratories*
■	☐	15. Other - MCO, glycol

Y	N	L. Flammable Materials
☐	■	1. Packing materials
■	☐	2. Rags
☐	■	3. Gasoline
■	☐	4. Lube oil (crane, hoists)
☐	■	5. Coolant oil
■	☐	6. Paints/solvents
☐	■	7. Diesel fuel
☐	■	8. Buildings & contents
☐	■	9. *Trailers & contents*
■	☐	10. Grease
■	☐	11. Hydrogen
☐	■	12. Nitric acid
■	☐	13. Organics (MHM neutron absorber)
■	☐	14. Gases - others (acetylene)
☐	■	15. Liquids - others
■	☐	16. Other - dye pen solvents, cart wheels, temp. greenhouse for weld repair, weld head bonnet

Y	N	M. Hazardous Materials
☐	■	1. Alkali metals
■	☐	2. Asphyxiants (helium, argon)
☐	■	3. Biologicals
☐	■	4. Carcinogens
☐	■	5. Corrosives
☐	■	6. Oxidizers
■	☐	7. Toxics (welding fumes, U, Pu)
■	☐	8. Heavy metals (welding fumes)
☐	■	9. Other - glycol cooling

Y	N	N. Ionizing Radiation Sources
■	☐	1. Fissile material
☐	■	2. Radiography equipment
■	☐	3. Radioactive material
■	☐	4. Radioactive sources (HPT instruments)
☐	■	5. Other _____

Y	N	P. External Events
■	☐	1. Explosion
■	☐	2. Fire
■	☐	3. Events at other sites
■	☐	4. Loss of power

Y	N	Q. Vehicles in Motion (external to facility)
■	☐	1. Airplane
■	☐	2. Helicopter
■	☐	3. Train
■	☐	4. Truck/bus/car
☐	■	5. Other _____

Y	N	R. Natural Phenomena
■	☐	1. Earthquake
☐	■	2. Flood
■	☐	3. Lightning
■	☐	4. Rain
■	☐	5. *Snow, freezing weather*
■	☐	6. Straight wind
■	☐	7. Dust devil
■	☐	8. Tornado
■	☐	9. Ashfall
■	☐	10. Range fire

Table 6. Hazardous Material/Energy Source Checklist: Vault.

Location: ***Vault (including intake structure and exhaust stack) (VL)***

Y N **A. Electrical**
- ☐ ■ 1. Battery banks
- ☐ ■ 2. Cable runs
- ☐ ■ 3. Generators
- ☐ ■ 4. Electrical equipment
- ☐ ■ 5. HVAC heaters
- ☐ ■ 6. High voltage
- ☐ ■ 7. Motors
- ☐ ■ 8. Pumps
- ☐ ■ 9. *Power tools*
- ☐ ■ 10. Switchgear
- ☐ ■ 11. Service outlets, fittings
- ☐ ■ 12. Transformers
- ☐ ■ 13. Transmission lines
- ☐ ■ 14. Underground wires
- ☐ ■ 15. Wiring
- ☐ ■ 16. Other _____

Y N **B. Thermal**
- ☐ ■ 1. Bunsen burner/hot plates
- ☐ ■ 2. Electrical equipment
- ☐ ■ 3. Furnaces/boilers/heater
- ☐ ■ 4. Steam lines
- ☐ ■ 5. *Welding torch/arc*
- ☐ ■ 6. Diesel units/fire box/exhaust line
- ■ ☐ 7. Radioactive decay heat
- ☐ ■ 8. Exposed components
- ☐ ■ 9. Power tools
- ■ ☐ 10. Convective
- ■ ☐ 11. Solar
- ☐ ■ 12. Cryogenic
- ☐ ■ 13. Other _____

Y N **C. Friction**
- ☐ ■ 1. Belts
- ☐ ■ 2. Bearings
- ☐ ■ 3. Fans
- ☐ ■ 4. Gears
- ☐ ■ 5. Motors
- ☐ ■ 6. Power tools
- ☐ ■ 7. Other _____

Y N **D. Corrosives**
- ☐ ■ 1. Acids
- ☐ ■ 2. Caustics
- ☐ ■ 3. Natural chemicals
- ☐ ■ 4. Decon solution
- ☐ ■ 5. High temperature waste
- ☐ ■ 6. Other _____

Y N **E. Kinetic - Rotational**
- ☐ ■ 1. Centrifuges
- ☐ ■ 2. Motors
- ☐ ■ 3. Pumps
- ☐ ■ 4. Fans
- ☐ ■ 5. Laundry equipment
- ☐ ■ 6. Shop equipment
- ☐ ■ 7. Other _____

Y N **F. Kinetic - Linear**
- ☐ ■ 1. Cars, trucks, buses
- ☐ ■ 2. Forklifts, dollies, carts
- ☐ ■ 3. Railroad
- ☐ ■ 4. Obstructions
- ☐ ■ 5. Crane loads
- ☐ ■ 6. Pressure vessel blowdown
- ☐ ■ 7. Other _____

Y N **G. Mass, Gravity, Height**
- ☐ ■ 1. Human effort
- ☐ ■ 2. Stairs
- ☐ ■ 3. Lifts and cranes
- ☐ ■ 4. Bucket and ladder
- ☐ ■ 5. Trucks
- ☐ ■ 6. Slings
- ☐ ■ 7. Hoists
- ☐ ■ 8. Elevators
- ☐ ■ 9. *Jacks*
- ☐ ■ 10. Scaffold and ladders
- ☐ ■ 11. Pits and excavations
- ☐ ■ 12. Elevated doors
- ☐ ■ 13. Vessels
- ☐ ■ 14. Other _____

Y N **H. Pressure - Volume**
- ☐ ■ 1. Boilers
- ☐ ■ 2. Surge tanks
- ☐ ■ 3. Autoclave
- ☐ ■ 4. Test loops
- ☐ ■ 5. Gas bottles
- ☐ ■ 6. Pressure vessels
- ☐ ■ 7. *Gas receivers*
- ☐ ■ 8. Vacuum
- ☐ ■ 9. Steam headers and lines
- ☐ ■ 10. Confined spaces
- ☐ ■ 11. Other _____

Y N **J. Explosives/Pyrophorics**
- ☐ ■ 1. Caps
- ☐ ■ 2. Primer cord
- ☐ ■ 3. Dynamite
- ☐ ■ 4. Scrub chemicals
- ☐ ■ 5. Dusts
- ☐ ■ 6. Hydrogen
- ☐ ■ 7. Gases, others
- ☐ ■ 8. Nitrates
- ☐ ■ 9. Peroxides
- ☐ ■ 10. Pu and U metal
- ☐ ■ 11. Sodium
- ☐ ■ 12. Other _____

Y N **K. Nuclear Criticality**
- ☐ ■ 1. Vaults
- ☐ ■ 2. Temporary storage areas
- ☐ ■ 3. Shipping and receiving area
- ☐ ■ 4. Filters
- ☐ ■ 5. Casks
- ☐ ■ 6. Burial ground
- ☐ ■ 7. Storage racks
- ☐ ■ 8. Canals and basins
- ☐ ■ 9. Decon solution
- ☐ ■ 10. Trucks, forklifts, dollies
- ☐ ■ 11. Hand carry
- ☐ ■ 12. Cranes/lifts
- ☐ ■ 13. Hot cells, assembly, inspection
- ☐ ■ 14. Laboratories
- ■ ☐ 15. Other - storage tubes

Y N **L. Flammable Materials**
- ☐ ■ 1. Packing materials
- ☐ ■ 2. Rags
- ☐ ■ 3. Gasoline
- ☐ ■ 4. Lube oil
- ☐ ■ 5. Coolant oil
- ☐ ■ 6. Paints/solvents
- ☐ ■ 7. *Diesel fuel*
- ☐ ■ 8. Buildings & contents
- ☐ ■ 9. Trailers & contents
- ☐ ■ 10. Grease
- ☐ ■ 11. Hydrogen
- ☐ ■ 12. Nitric acid
- ☐ ■ 13. Organics
- ☐ ■ 14. *Gases - others*
- ☐ ■ 15. Liquids - others
- ☐ ■ 16. Other _____

Y N **M. Hazardous Materials**
- ☐ ■ 1. Alkali metals
- ☐ ■ 2. Asphyxiants
- ☐ ■ 3. Biologicals
- ☐ ■ 4. Carcinogens
- ☐ ■ 5. Corrosives
- ☐ ■ 6. *Oxidizers*
- ☐ ■ 7. Toxics
- ☐ ■ 8. Heavy metals
- ☐ ■ 9. Other _____

Y N **N. Ionizing Radiation Sources**
- ☐ ■ 1. Fissile material
- ☐ ■ 2. Radiography equipment
- ■ ☐ 3. Radioactive material
- ☐ ■ 4. Radioactive sources (st. tube contents)
- ☐ ■ 5. Other _____

Y N **P. External Events**
- ☐ ■ 1. Explosion
- ☐ ■ 2. Fire
- ■ ☐ 3. Events at other sites (water line break)
- ☐ ■ 4. Loss of power

Y N **Q. Vehicles in Motion** *(external to facility)*
- ■ ☐ 1. Airplane
- ■ ☐ 2. Helicopter
- ☐ ■ 3. Train
- ☐ ■ 4. Truck/bus/car
- ☐ ■ 5. Other _____

Y N **R. *Natural Phenomena***
- ■ ☐ 1. Earthquake
- ☐ ■ 2. Flood
- ☐ ■ 3. Lightning
- ■ ☐ 4. Rain
- ■ ☐ 5. Snow, freezing weather
- ☐ ■ 6. Straight wind
- ■ ☐ 7. Dust devil
- ☐ ■ 8. Tornado
- ■ ☐ 9. Ashfall
- ■ ☐ 10. Range fire

Table 7. Hazardous Material/Energy Source Checklist: Support Building.

Location: ***Support Building (SB)***

Y N **A. Electrical**
- ■ □ 1. Battery banks (UPS)
- ■ □ 2. Cable runs
- □ ■ 3. Diesel generators
- ■ □ 4. Electrical equipment
- ■ □ 5. HVAC heaters
- ■ □ 6. High voltage (13.8 kV)
- ■ □ 7. Motors
- ■ □ 8. Pumps
- ■ □ 9. Power tools
- ■ □ *10. Switchgear (440 V)*
- ■ □ 11. Service outlets, fittings
- ■ □ 12. Transformers
- □ ■ 13. Transmission lines
- □ ■ 14. Underground wires
- ■ □ 15. Wiring
- ■ □ 16. Other (AC invertors)

Y N **B. Thermal**
- □ ■ 1. Bunsen burner/hot plates
- ■ □ 2. Electrical equipment
- ■ □ 3. Furnaces/boilers/heater
- □ ■ 4. Steam lines
- ■ □ *5. Welding torch/arc*
- □ ■ 6. Diesel units/fire box/exhaust line
- □ ■ 7. Radioactive decay heat
- □ ■ 8. Exposed components
- ■ □ 9. Power tools
- □ ■ 10. Convective
- □ ■ 11. Solar
- □ ■ 12. Cryogenic
- ■ □ 13. Other (soldering in shop)

Y N **C. Friction**
- ■ □ 1. Belts (exhaust fans)
- ■ □ 2. Bearings
- ■ □ 3. Fans
- ■ □ 4. Gears
- ■ □ 5. Motors
- ■ □ 6. Power tools
- □ ■ 7. Other

Y N **D. Corrosives**
- ■ □ 1. Acids (battery banks)
- □ ■ 2. Caustics
- □ ■ *3. Natural chemicals*
- ■ □ 4. Decontamination solution
- □ ■ 5. High temperature waste
- □ ■ 6. Other

Y N **E. Kinetic - Rotational**
- □ ■ 1. Centrifuges
- ■ □ 2. Motors
- ■ □ 3. Pumps
- ■ □ 4. Fans (HVAC fans)
- □ ■ 5. Laundry equipment
- □ ■ 6. Shop equipment
- ■ □ 7. Other - compressors, power tools

Y N **F. Kinetic - Linear**
- ■ □ 1. Cars, trucks, buses
- ■ □ 2. Forklifts, dollies, carts
- □ ■ 3. Railroad
- ■ □ 4. Obstructions
- ■ □ 5. Crane loads
- ■ □ 6. Pressure vessel blowdown (missiles)
- □ ■ 7. Other

Y N **G. Mass, Gravity, Height**
- ■ □ *1. Human effort*
- □ ■ 2. Stairs
- □ ■ 3. Lifts and cranes
- □ ■ 4. Bucket and ladder
- □ ■ 5. Trucks
- ■ □ 6. Slings
- ■ □ 7. Hoists
- □ ■ 8. Elevators
- □ ■ 9. Jacks
- ■ □ 10. Scaffold and ladders
- ■ □ 11. Pits and excavations (sumps)
- ■ □ 12. Elevated doors
- □ ■ 13. Vessels
- □ ■ *14. Other*

Y N **H. Pressure - Volume**
- □ ■ 1. Boilers
- □ ■ 2. Surge tanks
- □ ■ 3. Autoclave
- □ ■ 4. Test loops
- ■ □ 5. Gas bottles (maintenance, HP)
- ■ □ 6. Pressure vessels (air receiver @ 125 psig)
- ■ □ 7. Gas receivers (air)
- ■ □ 8. Vacuum (small pumps)
- □ ■ 9. Steam headers and lines
- □ ■ 10. Confined spaces
- ■ □ 11. Other (high pressure gas line)

Y N **J. Exothermic Reactions**
- □ ■ 1. Caps
- □ ■ 2. Primer cord
- □ ■ 3. Dynamite
- □ ■ 4. Scrub chemicals
- □ ■ 5. Dusts
- ■ □ *6. Hydrogen (batteries)*
- ■ □ 7. Gases, others (propane, acetylene)
- □ ■ 8. Nitrates
- □ ■ 9. Peroxides
- □ ■ 10. Pu and U
- □ ■ 11. Sodium
- □ ■ 12. Other

Y N **K. Nuclear Criticality**
- □ ■ 1. Vaults
- □ ■ 2. Temporary storage areas
- □ ■ 3. Shipping and receiving area
- □ ■ 4. Filters
- □ ■ 5. Casks
- □ ■ 6. Burial ground
- □ ■ 7. Storage racks
- □ ■ 8. Canals and basins
- □ ■ 9. Decontamination solution
- □ ■ 10. Trucks, forklifts, dollies
- □ ■ 11. Hand carry
- □ ■ 12. Cranes/lifts
- □ ■ 13. Hot cells, assembly, inspection
- □ ■ *14. Laboratories*
- □ ■ 15. Other

Y N **L. Flammable Materials**
- ■ □ 1. Packing materials
- ■ □ 2. Rags
- □ ■ 3. Gasoline (vehicle entry)
- ■ □ 4. Lube oil
- □ ■ 5. Coolant oil
- □ ■ 6. Paints/solvents
- ■ □ 7. Diesel fuel (vehicle entry)
- ■ □ 8. Buildings & contents (HVAC filters)
- □ ■ 9. Trailers and contents
- ■ □ *10. Grease*
- ■ □ 11. Hydrogen (batteries)
- □ ■ 12. Nitric acid
- ■ □ 13. Organics (maintenance)
- □ ■ 14. Gases - others (propane, acetylene)
- □ ■ 15. Liquids - others (degreasers)
- ■ □ 16. Other (clothing)

Y N **M. Hazardous Materials**
- □ ■ 1. Alkali metals
- ■ □ *2. Asphyxiants (inert gas lines, exhaust)*
- □ ■ 3. Biologicals
- ■ □ 4. Carcinogens (fumes)
- ■ □ 5. Corrosives (decon solution, batteries)
- □ ■ 6. Oxidizers
- □ ■ 7. Toxics
- ■ □ 8. Heavy metals (lead from batteries)
- ■ □ 9. Other (cleaning supplies)

Y N **N. Ionizing Radiation Sources**
- □ ■ 1. Fissile material
- □ ■ 2. Radiography equipment
- ■ □ 3. Radioactive material (decon rags, filters)
- ■ □ *4. Radioactive sources (instrument calibration source)*
- □ ■ 5. Other

Y N **P. External Events**
- ■ □ 1. Explosion
- ■ □ 2. Fire
- ■ □ 3. Events at other sites
- ■ □ 4. Loss of power

Y N **Q. Vehicles in Motion** (external to facility)
- □ ■ 1. Airplane
- □ ■ 2. Helicopter
- □ ■ 3. Train
- □ ■ 4. Truck/bus/car
- □ ■ 5. Other

Y N **R. Natural Phenomena**
- ■ □ 1. Earthquake
- □ ■ 2. Flood
- ■ □ 3. Lightning
- ■ □ 4. Rain
- ■ □ 5. Snow, freezing weather
- ■ □ 6. Straight wind
- □ ■ 7. Dust devil
- ■ □ 8. Tornado
- ■ □ 9. Ashfall
- ■ □ 10. Range fire

Table 8. Hazardous Material/Energy Source Checklist: Outside.

Location: ***Outside (OU)***

Y N **A. Electrical**
- ☐ ■ 1. Battery banks
- ☐ ■ 2. Cable runs
- ☐ ■ 3. Generators
- ■ ☐ 4. Electrical equipment
- ☐ ■ 5. HVAC heaters
- ■ ☐ 6. High voltage
- ■ ☐ 7. Motors (air handler, rolling gate)
- ☐ ■ 8. Pumps
- ■ ☐ 9. *Power tools*
- ■ ☐ 10. Switchgear
- ■ ☐ 11. Service outlets, fittings
- ■ ☐ 12. Transformers
- ■ ☐ 13. Transmission lines
- ■ ☐ 14. Underground wires
- ■ ☐ 15. Wiring
- ■ ☐ 16. *Other - lighting, grounding cable*

Y N **B. Thermal**
- ☐ ■ 1. Bunsen burner/hot plates
- ■ ☐ 2. Electrical equipment
- ☐ ■ 3. Furnaces/boilers/heater
- ☐ ■ 4. Steam lines
- ■ ☐ 5. *Welding torch/arc*
- ■ ☐ 6. Diesel units/fire box/exhaust line
- ☐ ■ 7. Radioactive decay heat
- ■ ☐ 8. Exposed components
- ■ ☐ 9. Power tools
- ■ ☐ 10. Convective (transformer, vault)
- ■ ☐ 11. Solar
- ☐ ■ 12. Cryogenic
- ☐ ■ 13. Other _____

Y N **C. Friction**
- ■ ☐ 1. Belts
- ■ ☐ 2. Bearings
- ■ ☐ 3. Fans
- ■ ☐ 4. Gears
- ■ ☐ 5. Motors
- ■ ☐ 6. Power tools
- ☐ ■ 7. Other _____

Y N **D. Corrosives**
- ■ ☐ 1. Acids (vehicle batteries)
- ☐ ■ 2. Caustics
- ☐ ■ 3. Natural chemicals
- ☐ ■ 4. Decon solution
- ☐ ■ 5. High temperature waste
- ☐ ■ 6. Other _____

Y N **E. Kinetic - Rotational**
- ☐ ■ 1. Centrifuges
- ■ ☐ 2. *Motors*
- ☐ ■ 3. Pumps
- ■ ☐ 4. Fans
- ☐ ■ 5. Laundry equipment
- ☐ ■ 6. Shop equipment
- ■ ☐ 7. Other - HVAC units

Y N **F. Kinetic - Linear**
- ■ ☐ 1. Cars, trucks, buses
- ■ ☐ 2. Forklifts, dollies, carts
- ☐ ■ 3. Railroad
- ☐ ■ 4. Obstructions
- ■ ☐ 5. Crane loads
- ■ ☐ 6. Pressure vessel blowdown (missiles)
- ☐ ■ 7. Other _____

Y N **G. Mass, Gravity, Height**
- ■ ☐ 1. Human effort
- ■ ☐ 2. Stairs (stack)
- ■ ☐ 3. Lifts and cranes
- ■ ☐ 4. Bucket and ladder
- ■ ☐ 5. Trucks
- ■ ☐ 6. Slings
- ■ ☐ 7. Hoists
- ☐ ■ 8. Elevators
- ☐ ■ 9. *Jacks*
- ■ ☐ 10. Scaffold and ladders
- ■ ☐ 11. Pits and excavations (intake structure)
- ■ ☐ 12. Elevated doors
- ■ ☐ 13. Vessels (cylinder loading/unloading)
- ☐ ■ 14. Other _____

Y N **H. Pressure - Volume**
- ☐ ■ 1. Boilers
- ☐ ■ 2. Surge tanks
- ☐ ■ 3. Autoclave
- ☐ ■ 4. Test loops
- ■ ☐ 5. Gas bottles
- ■ ☐ 6. Pressure vessels (He Supply)
- ☐ ■ 7. *Gas receivers*
- ☐ ■ 8. Vacuum
- ☐ ■ 9. Steam headers and lines
- ☐ ■ 10. Confined spaces
- ■ ☐ 11. Other - portable compressors

Y N **J. Explosives/Pyrophorics**
- ☐ ■ 1. Caps
- ☐ ■ 2. Primer cord
- ☐ ■ 3. Dynamite
- ☐ ■ 4. Scrub chemicals
- ☐ ■ 5. Dusts
- ☐ ■ 6. Hydrogen
- ■ ☐ 7. Gases, others (acetylene, propane)
- ☐ ■ 8. Nitrates
- ☐ ■ 9. Peroxides
- ☐ ■ 10. Pu and U metal
- ☐ ■ 11. Sodium
- ☐ ■ 12. Other _____

Y N **K. Nuclear Criticality**
- ☐ ■ 1. Vaults
- ☐ ■ 2. Temporary storage areas
- ☐ ■ 3. Shipping and receiving area
- ☐ ■ 4. Filters
- ■ ☐ 5. Casks (see SARP)
- ☐ ■ 6. *Burial ground*
- ☐ ■ 7. Storage racks
- ☐ ■ 8. Canals and basins
- ☐ ■ 9. Decon solution
- ☐ ■ 10. Trucks, forklifts, dollies
- ☐ ■ 11. Hand carry
- ☐ ■ 12. Cranes/lifts
- ☐ ■ 13. Hot cells, assembly, inspection
- ☐ ■ 14. Laboratories
- ☐ ■ 15. Other _____

Y N **L. Flammable Materials**
- ■ ☐ 1. Packing materials (dumpster)
- ■ ☐ 2. Rags
- ■ ☐ 3. Gasoline (vehicles)
- ■ ☐ 4. Lube oil
- ■ ☐ 5. Coolant oil (transformers)
- ■ ☐ 6. Paints/solvents
- ■ ☐ 7. Diesel fuel (vehicles)
- ☐ ■ 8. Buildings & contents
- ■ ☐ 9. Trailers & contents
- ■ ☐ 10. Grease
- ☐ ■ 11. Hydrogen
- ☐ ■ 12. Nitric acid
- ☐ ■ 13. Organics
- ■ ☐ 14. *Gases - others (acetylene, propane)*
- ■ ☐ 15. Liquids - others (degreasers)
- ■ ☐ 16. Other - tumbleweeds

Y N **M. Hazardous Materials**
- ☐ ■ 1. Alkali metals
- ☐ ■ 2. Asphyxiants
- ■ ☐ 3. Biologicals (snakes, spiders)
- ☐ ■ 4. Carcinogens
- ■ ☐ 5. Corrosives (battery acid)
- ☐ ■ 6. *Oxidizers*
- ☐ ■ 7. Toxics
- ■ ☐ 8. Heavy metals (battery lead)
- ☐ ■ 9. Other _____

Y N **N. Ionizing Radiation Sources**
- ☐ ■ 1. Fissile material
- ☐ ■ 2. Radiography equipment
- ☐ ■ 3. Radioactive material
- ■ ☐ 4. Radioactive sources (cask - see SARP)
- ☐ ■ 5. Other _____

Y N **P. External Events**
- ■ ☐ 1. Explosion
- ■ ☐ 2. Fire
- ■ ☐ 3. Events at other sites
- ■ ☐ 4. Loss of power
- ■ ☐ 5. Other - water line breaks

Y N **Q. Vehicles in Motion** (external to facility)
- ■ ☐ 1. Airplane
- ■ ☐ 2. Helicopter
- ☐ ■ 3. Train
- ■ ☐ 4. Truck/bus/car
- ☐ ■ 5. Other _____

Y N **R. Natural Phenomena**
- ■ ☐ 1. Earthquake
- ☐ ■ 2. Flood
- ■ ☐ 3. Lightning
- ■ ☐ 4. Rain
- ■ ☐ 5. Snow, freezing weather
- ■ ☐ 6. *Straight wind*
- ■ ☐ 7. Dust devil
- ■ ☐ 8. Tornado
- ■ ☐ 9. Ashfall
- ■ ☐ 10. Range fire

Table 9. Hazardous Material/Energy Source Checklist: Off-Normal Multi-Canister Overpack Storage in Overpack Tube, With Tube Vent and Purge Cart.

Location: *Operating Area (including storage tubes and contents) (OA)*

Y N **A. Electrical**
- ■ □ 1. Battery banks (TV&P carts)
- ■ □ 2. Cable runs (welding, festooning)
- □ ■ 3. Generators
- ■ □ 4. Electrical equipment
- □ ■ 5. HVAC heaters
- ■ □ 6. *High voltage*
- ■ □ 7. Motors
- □ ■ 8. Pumps
- ■ □ 9. Power tools (maintenance)
- □ ■ 10. *Switchgear*
- ■ □ 11. Service outlets, fittings
- ■ □ 12. Transformers (for welding)
- □ ■ 13. Transmission lines
- □ ■ 14. Underground wires
- ■ □ 15. Wiring
- ■ □ 16. Other - e.g., lights, CAMs, cameras

Y N **B. Thermal**
- □ ■ 1. Bunsen burner/hot plates
- ■ □ 2. Electrical equipment (for welding)
- ■ □ 3. Heater (sample lines on cart)
- □ ■ 4. *Steam lines*
- ■ □ 5. Welding torch/arc
- □ ■ 6. Diesel units/fire box/exhaust line
- ■ □ 7. Radioactive decay heat
- ■ □ 8. Exposed components (on cart)
- ■ □ 9. Power tools
- ■ □ 10. Convective (heat exchanger on cart)
- □ ■ 11. Solar
- □ ■ 12. Cryogenic
- ■ □ 13. Other - operating deck floor

Y N **C. Friction**
- ■ □ 1. Belts
- ■ □ 2. Bearings
- ■ □ 3. Fans
- ■ □ 4. Gears
- ■ □ 5. Motors
- ■ □ 6. Power tools
- ■ □ 7. Other - brakes on MHM, cart

Y N **D. Corrosives**
- ■ □ 1. Acids (service cart battery)
- □ ■ 2. Caustics
- □ ■ 3. Natural chemicals
- ■ □ 4. Decon solution
- □ ■ 5. High temperature waste
- □ ■ 6. Other _____

Y N **E. Kinetic - Rotational**
- □ ■ 1. Centrifuges
- ■ □ 2. Motors
- ■ □ 3. Pumps (service cart, seismic clamp)
- □ ■ 4. Fans
- □ ■ 5. Laundry equipment
- □ ■ 6. Shop equipment
- ■ □ 7. Other - MHM turret, hoist, tools

Y N **F. Kinetic - Linear**
- □ ■ 1. Cars, trucks, buses
- ■ □ 2. Forklifts, dollies, carts (
- □ ■ 3. Railroad TV&P carts)
- ■ □ 4. Obstructions (rail frogs, tube covers)
- ■ □ 5. *Crane loads (vent/purge cart)*
- ■ □ 6. Pressure vessel blowdown (missiles)
- ■ □ 7. Other - MHM movement

Y N **G. Mass, Gravity, Height**
- ■ □ 1. Human effort
- □ ■ 2. Stairs
- ■ □ 3. Lifts and cranes (including loads)
- ■ □ 4. Bucket and ladder (maintenance)
- □ ■ 5. Trucks
- ■ □ 6. Slings (tube cover removal)
- ■ □ 7. Hoists (vent/purge cart)
- □ ■ 8. *Elevators*
- ■ □ 9. Jacks (MHM shield ring jacks)
- ■ □ 10. Scaffold and ladders (MHM access)
- ■ □ 11. Pits and excavations
- □ ■ 12. Elevated doors
- ■ □ 13. Vessels (MCO)
- ■ □ 14. Other - tube plugs, impact absorbers

Y N **H. Pressure - Volume**
- □ ■ 1. Boilers
- □ ■ 2. Surge tanks
- □ ■ 3. Autoclave
- ■ □ 4. *Test loops (validation MCO mon.)*
- ■ □ 5. Gas bottles
- ■ □ 6. Pressure vessels (MCO)
- ■ □ 7. Gas receivers (MHM, service cart)
- ■ □ 8. Vacuum (sampling)
- □ ■ 9. Steam headers and lines
- □ ■ 10. Confined spaces
- ■ □ 11. Other - inert gas lines, seismic clamp

Y N **J. Explosives/Pyrophorics**
- □ ■ 1. Caps
- □ ■ 2. Primer cord
- □ ■ 3. Dynamite
- □ ■ 4. Scrub chemicals
- □ ■ 5. Dusts
- ■ □ 6. Hydrogen
- □ ■ 7. Gases, others (acetylene)
- □ ■ 8. Nitrates
- □ ■ 9. Peroxides
- ■ □ 10. Pu and U metal (U hydride)
- □ ■ 11. Sodium
- □ ■ 12. Other _____

Y N **K. Nuclear Criticality**
- □ ■ 1. Vaults
- □ ■ 2. Temporary storage areas
- □ ■ 3. Shipping and receiving area
- □ ■ 4. Filters
- □ ■ 5. Casks
- □ ■ 6. Burial ground
- □ ■ 7. Storage racks
- □ ■ 8. Canals and basins
- □ ■ 9. Decon solution
- □ ■ 10. Trucks, forklifts, dollies
- □ ■ 11. Hand carry
- □ ■ 12. Cranes/lifts
- □ ■ 13. Hot cells, assembly, inspection
- □ ■ 14. Laboratories
- □ ■ 15. Other _____

Y N **L. Flammable Materials**
- □ ■ 1. Packing materials
- □ ■ 2. Rags
- □ ■ 3. *Gasoline*
- □ ■ 4. Lube oil
- □ ■ 5. Coolant oil
- □ ■ 6. Paints/solvents
- □ ■ 7. Diesel fuel
- □ ■ 8. Buildings & contents
- □ ■ 9. Trailers & contents
- □ ■ 10. Grease
- □ ■ 11. *Hydrogen*
- □ ■ 12. Nitric acid
- □ ■ 13. Organics (MHM neutron absorber)
- □ ■ 14. Gases - others (acetylene)
- □ ■ 15. *Liquids - others (hydraulic fluid)*
- □ ■ 16. Other _____

Y N **M. Hazardous Materials**
- □ ■ 1. Alkali metals
- ■ □ 2. Asphyxiants (cart, inert gas line)
- □ ■ 3. *Biologicals*
- □ ■ 4. Carcinogens
- ■ □ 5. Corrosives (batteries)
- □ ■ 6. Oxidizers
- □ ■ 7. Toxics (fuels)
- ■ □ 8. Heavy metals (lead batteries)
- □ ■ 9. Other _____

Y N **N. Ionizing Radiation Sources**
- ■ □ 1. Fissile material
- □ ■ 2. Radiography equipment
- ■ □ 3. Radioactive material
- ■ □ 4. Radioactive sources (HPT instruments)
- □ ■ 5. Other _____

Y N **P. External Events**
- ■ □ 1. Explosion
- ■ □ 2. Fire
- ■ □ 3. Events at other sites
- ■ □ 4. Loss of power

Y N **Q. Vehicles in Motion** (external to facility)
- ■ □ 1. Airplane
- ■ □ 2. Helicopter
- ■ □ 3. Train
- ■ □ 4. Truck/bus/car
- □ ■ 5. Other _____

Y N **R. Natural Phenomena**
- ■ □ 1. Earthquake
- □ ■ 2. Flood
- ■ □ 3. Lightning
- ■ □ 4. Rain
- ■ □ 5. Snow, freezing weather
- ■ □ 6. Straight wind
- □ ■ 7. Dust devil
- ■ □ 8. Tornado
- ■ □ 9. Ashfall
- ■ □ 10. Range fire

Table 10. Standard Industrial Hazards: Trailer Vestibule. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Crane cabling (for welding)	TV	A	2
	Electrical equipment (crane)	TV	A	4
	High voltage	TV	A	6
	Motors (receiving crane)	TV	A	7
	Power tools	TV	A	9
	Service outlets, fittings	TV	A	11
	Transformers (for welding)	TV	A	12
	Wiring	TV	A	15
	Other — crane hot rail conductor	TV	A	16
Thermal	Electrical equipment	TV	B	2
	Welding, torch/arc (maintenance)	TV	B	5
	Diesel units; exhaust lines on vehicles	TV	B	6
	Power tools	TV	B	9
	Convective heat from transportation cask	TV	B	10
	Vehicle brakes	TV	B	13
Friction	Belts	TV	C	1
	Bearings	TV	C	2
	Fans	TV	C	3
	Gears	TV	C	4
	Motors	TV	C	5
	Power tools	TV	C	6
Corrosives	Vehicle battery acid	TV	D	1
	Decontamination solution	TV	D	4
Kinetic - rotational	Crane motor	TV	E	2
	Pumps (crane hydraulics)	TV	E	3
	Fans (truck)	TV	E	4
	Other — power tools, hoist system	TV	E	7
Kinetic linear	Carts for empty MCOs	TV	F	2

Table 10. Standard Industrial Hazards: Trailer Vestibule. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Mass, gravity, height	Human effort (dropped items)	TV	G	1
	Lifts and cranes (including loads)	TV	G	3
	Bucket and ladder (maintenance)	TV	G	4
	Slings (maintenance)	TV	G	6
	Hoists	TV	G	7
	Scaffold and ladders	TV	G	10
	Elevated doors	TV	G	12
Pressure - volume	Test loops	TV	H	4
	Gas bottles	TV	H	5
Hazardous materials	Asphyxiants (exhaust, helium line)	TV	M	2
	Carcinogens	TV	M	4
	Corrosives (battery acid)	TV	M	5
	Heavy metals (battery lead)	TV	M	8
	Other — used decontamination solution	TV	M	9
Ionizing radiation sources	Radioactive sources	TV	N	4

Table 11. Standard Industrial Hazards: Load-In/Load-Out Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Battery banks (vent and purge cart)	SA	A	1
	Cable runs (welding, festooning)	SA	A	2
	Electrical equipment	SA	A	4
	High voltage	SA	A	6
	Motors	SA	A	7
	Power tools	SA	A	9
	Service outlets, fittings	SA	A	11
	Transformers (for welding)	SA	A	12
	Wiring	SA	A	15
	Other (blowers, hot rail conductor)	SA	A	16
Thermal	Electrical equipment	SA	B	2
	Welding, torch/arc	SA	B	5
	Exposed components (on cart)	SA	B	8
	Power tools (no cutting tools)	SA	B	9
	Convective	SA	B	10
	Other (crane and MHM brakes)	SA	B	13
Friction	Belts	SA	C	1
	Bearings	SA	C	2
	Fans	SA	C	3
	Gears	SA	C	4
	Motors	SA	C	5
	Power tools	SA	C	6
	Other (crane and MHM brakes)	SA	C	7
Corrosives	Acids (vent and purge cart battery)	SA	D	1
	Decontamination solution	SA	D	4
Kinetic - rotational	Motors	SA	E	2
	Pumps (crane and clamp hydraulics)	SA	E	3
	Fans (MHM, service tent)	SA	E	4
	Other — 5-ton hoist	SA	E	7
Kinetic - linear	Forklifts, dollies, carts (hand trolley)	SA	F	2
	Obstructions (frogs)	SA	F	4

Table 11. Standard Industrial Hazards: Load-In/Load-Out Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Mass, gravity, height	Human effort	SA	G	1
	Bucket and ladder (maintenance)	SA	G	4
	Slings (maintenance)	SA	G	6
	Hoists	SA	G	7
	Jacks (MHM jack in maintenance pit)	SA	G	9
	Scaffolds and ladders	SA	G	10
	Elevated doors	SA	G	12
Pressure - volume	Test loops (cask service cart, MHM)	SA	H	4
	Gas bottles	SA	H	5
	Gas receivers (accumulator, cart)	SA	H	7
	Confined spaces	SA	H	10
	Other — pressurized inert gas line	SA	H	11
Hazardous materials	Asphyxiants (helium)	SA	M	2
	Corrosives (batteries)	SA	M	5
	Heavy metals (battery lead)	SA	M	8
Ionizing radiation Sources	Radioactive sources (hand-held equipment)	SA	N	4

MHM = multi-canister overpack handling machine.

Table 12. Standard Industrial Hazards: Operating Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Battery banks (TV&P carts)	OA	A	1
	Cable runs (welding, festooning)	OA	A	2
	Electrical equipment	OA	A	4
	High voltage	OA	A	6
	Motors	OA	A	7
	Power tools (maintenance)	OA	A	9
	Service outlets, fittings	OA	A	11
	Transformers (welding)	OA	A	12
	Wiring	OA	A	15
	Other — lighting, CAMs, cameras	OA	A	16
Thermal	Electrical equipment (for welding)	OA	B	2
	Heater (sample lines on cart)	OA	B	3
	Welding, torch/arc	OA	B	5
	Exposed components (on cart)	OA	B	8
	Power tools	OA	B	9
	Convective (heat exchanger on cart)	OA	B	10
	Other — operating deck floor	OA	B	13
Friction	Belts	OA	C	1
	Bearings	OA	C	2
	Fans	OA	C	3
	Gears	OA	C	4
	Motors	OA	C	5
	Power tools	OA	C	6
	Other (brakes on the MHM and tube cart)	OA	C	7
Corrosives	Decontamination solution	OA	D	4
Kinetic - rotational	Motors	OA	E	2
	Pumps (TV&P carts, seismic clamp)	OA	E	3
	Other — MHM hoist	OA	E	7
Kinetic - linear	Forklifts, dollies, carts (TV&P carts)	OA	F	2
	Obstructions (rail frogs, tube covers)	OA	F	4
	Crane loads (TV&P carts)	OA	F	5

Table 12. Standard Industrial Hazards: Operating Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Mass, gravity, height	Human effort	OA	G	1
	Bucket and ladder (maintenance)	OA	G	4
	Slings (to remove tube plug cover)	OA	G	6
	Hoists (vent and purge cart)	OA	G	7
	Jacks (MHM shield ring jacks)	OA	G	9
	Scaffold and ladders (MHM access)	OA	G	10
	Pits and excavations	OA	G	11
Pressure - volume	Test Loops (cask service cart, MHM)	OA	H	4
	Gas bottles	OA	H	5
	Gas receivers (MHM, service cart)	OA	H	7
	Vacuum (TV&P cart)	OA	H	8
	Other — inert gas lines, seismic clamp	OA	H	11
Hazardous materials	Asphyxiants (cart, inert gas line)	OA	M	2
	Corrosives (batteries)	OA	M	5
	Heavy metals (lead batteries)	OA	M	8
Ionizing radiation sources	Radioactive sources (hand-held equipment)	OA	N	4

CAM = continuous air monitor.
MHM = multi-canister overpack handling machine.
TV&P = tube vent and purge.

Table 13. Standard Industrial Hazards: Sampling/Weld Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Cable runs (welding, power track pyrometer)	WS	A	2
	Electrical equipment (welder, mass spectrometer)	WS	A	4
	Motors (crane, weld pit)	WS	A	7
	Pumps (welder cooler)	WS	A	8
	Power tools (grinder)	WS	A	9
	Switchgear (welder, MHM)	WS	A	10
	Service outlets, fittings	WS	A	11
	Transformers (MHM, portable welder)	WS	A	12
	Wiring	WS	A	15
	Other — vent fan	WS	A	16
Thermal	Electrical equipment (welder, mass spectrometer)	WS	B	2
	Welding, torch/arc (cover assembly, maintenance)	WS	B	5
	Exposed components (shielding, exposed top of MCO)	WS	B	8
	Power tools (grinder)	WS	B	9
	Convective (welder cooler)	WS	B	10
	Cryogenic (glycol cooling)	WS	B	12
	Other — brakes (MHM, gantry, hoists)	WS	B	13
Friction	Belts (vent fan)	WS	C	1
	Bearings (auto welder, rotary drive)	WS	C	2
	Fans (MHM, fume exhaust)	WS	C	3
	Gears (auto welder)	WS	C	4
	Motors (auto welder, weld pit, vent fan, gantry crane)	WS	C	5
	Power tools (grinder)	WS	C	6
	Other — brakes on the MHM and crane	WS	C	7
Corrosives	Decon Solution	WS	D	4
	Other -- dye penetrant cleaner	WS	D	6
Kinetic - rotational	Motors (auto welder, weld pit)	WS	E	2
	Pumps (welder cooler, vacuum pump)	WS	E	3
	Fans (fume exhaust, MHM)	WS	E	4
	Shop equipment (crane hoist)	WS	E	6
Kinetic - linear	Obstructions (handrails)	WS	F	4

Table 13. Standard Industrial Hazards: Sampling/Weld Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Mass, gravity, height	Human effort	WS	G	1
	Stairs	WS	G	2
	Scaffold and ladders (MHM access)	WS	G	10
	Pits and excavations (sample/weld pit)	WS	G	11
	Elevated doors	WS	G	12
Pressure - volume	Test loops (MHM, sample cart)	WS	H	4
	Gas bottles (portable welder)	WS	H	5
	Vacuum (sample cart)	WS	H	8
	Confined spaces (trench)	WS	H	10
	Other — glycol in pit	WS	H	11
Hazardous materials	Asphyxiants (helium, argon)	WS	M	2
	Heavy metals (welding fumes)	WS	M	8
Ionizing radiation sources	Radioactive sources (hand-held equipment)	WS	N	4
External Vehicles	Truck	WS	Q	4

MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.

Table 14. Standard Industrial Hazards: Support Building. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Battery banks (uninterruptible power supply)	SB	A	1
	Cable runs	SB	A	2
	Electrical equipment	SB	A	4
	HVAC heaters	SB	A	5
	High voltage (>600 V)	SB	A	6
	Motors	SB	A	7
	Pumps	SB	A	8
	Power tools	SA	A	9
	Switchgear (440 V)	SB	A	10
	Service outlets, fittings	SB	A	11
	Transformers	SB	A	12
	Wiring	SB	A	15
	Other (AC invertors)	SB	A	16
Thermal	Electrical equipment	SB	B	2
	Furnaces, boilers, heater	SB	B	3
	Welding, torch/arc (maintenance)	SB	B	5
	Power tools	SB	B	9
	Other (soldering in shop)	SB	B	13
Friction	Belts (exhaust fans)	SB	C	1
	Bearings	SB	C	2
	Fans	SB	C	3
	Gears	SB	C	4
	Motors	SB	C	5
	Power tools	SB	C	6
Corrosives	Acids (battery banks)	SB	D	1
	Decontamination solution	SB	D	4
Kinetic - rotational	Motors	SB	E	2
	Pumps	SB	E	3
	Fans (HVAC fans)	SB	E	4
	Other — compressors, power tools	SB	E	7

Table 14. Standard Industrial Hazards: Support Building. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Kinetic - linear	Cars, trucks, buses	SB	F	1
	Forklifts, dollies, carts	SB	F	2
	Obstructions	SB	F	4
	Crane loads	SB	F	5
	Pressure vessel blowdown (missiles)	SB	F	6
Mass, gravity, height	Human effort	SB	G	1
	Slings	SB	G	6
	Hoists	SB	G	7
	Scaffold and ladders	SB	G	10
	Pits and excavations (sumps)	SB	G	11
	Elevated doors	SB	G	12
Pressure - volume	Gas bottles	SB	H	5
	Pressure vessels (air receiver, 125 lb/in^2 gauge)	SB	H	6
	Gas receivers (air)	SB	H	7
	Vacuum (small pumps)	SB	H	8
	Other (high pressure inert gas line)	SB	H	11
Exothermic reaction	Hydrogen (batteries)	SB	J	6
Hazardous materials	Asphyxiants (vehicle exhaust)	SB	M	2
	Carcinogens (fumes)	SB	M	4
	Corrosives (decontamination solution, batteries)	SB	M	5
	Heavy metals (lead from batteries)	SB	M	8
	Other — cleaning supplies	SB	M	9
Ionizing radiation sources	Radioactive material (decontamination rags, filters)	SB	N	3
	Radioactive sources (instrument calibration sources)	SB	N	4

HVAC = heating, ventilation, and air conditioning.

Table 15. Standard Industrial Hazards: Outside. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Electrical equipment	OU	A	4
	High voltage	OU	A	6
	Motors (air handlers, rolling gate)	OU	A	7
	Power tools	OU	A	9
	Switchgear	OU	A	10
	Service outlets, fittings	OU	A	11
	Transformers	OU	A	12
	Transmission lines	OU	A	13
	Underground wires	OU	A	14
	Wiring	OU	A	15
	Other — lighting, grounding cable	OU	A	16
Thermal	Electrical equipment	OU	B	2
	Welding torch/arc	OU	B	5
	Diesel units, fire box, exhaust line	OU	B	6
	Exposed components	OU	B	8
	Power tools	OU	B	9
	Convective	OU	B	10
	Solar	OU	B	11
Friction	Belts	OU	C	1
	Bearings	OU	C	2
	Fans	OU	C	3
	Gears	OU	C	4
	Motors	OU	C	5
	Power tools	OU	C	6
Corrosives	Acids (vehicle batteries)	OU	D	1
Kinetic - rotational	Motors	OU	E	2
	Fans	OU	E	4
	Other (heating, ventilation, and air conditioning units)	OU	E	7
Kinetic - linear	Cars, trucks, buses	OU	F	1
	Forklifts, dollies, carts	OU	F	2
	Crane loads	OU	F	5
	Pressure vessel blowdown (missiles)	OU	F	6

Table 15. Standard Industrial Hazards: Outside. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Mass, gravity, height	Human effort	OU	G	1
	Stairs (stack)	OU	G	2
	Lifts and cranes	OU	G	3
	Bucket and ladder	OU	G	4
	Trucks	OU	G	5
	Slings	OU	G	6
	Hoists	OU	G	7
	Scaffold and ladders	OU	G	10
	Pits and excavations (air intake structures)	OU	G	11
	Elevated doors	OU	G	12
	Vessels (cylinder loading and unloading)	OU	G	13
Pressure - volume	Gas bottles	OU	H	5
	Pressure vessels (helium supply)	OU	H	6
	Other — portable compressors	OU	H	11
Explosives/pyrophorics	Gases, others (acetylene, propane)	OU	J	7
Flammable materials	Packing materials (dumpster)	OU	L	1
	Rags	OU	L	2
	Gasoline	OU	L	3
	Lube oil	OU	L	4
	Coolant oil (transformers)	OU	L	5
	Paints and solvents	OU	L	6
	Diesel fuel (vehicles)	OU	L	7
	Trailers and contents	OU	L	9
	Grease	OU	L	10
	Gases, others (acetylene, propane)	OU	L	14
	Liquids, others (degreasers)	OU	L	15
	Other — tumbleweeds	OU	L	16
Hazardous materials	Biologicals (snakes, spiders)	OU	M	3
	Corrosives (battery acid)	OU	M	5
	Heavy metals (battery lead)	OU	M	8
Ionizing radiation sources	*Cask–MCO*	OU	N	4

Table 16. Standard Industrial Hazards: Overpack Locations in Operating Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Battery banks (TV&P carts)	OA	A	1
	Cable runs (welding, festooning)	OA	A	2
	Electrical equipment	OA	A	4
	High voltage	OA	A	6
	Motors	OA	A	7
	Power tools (maintenance)	OA	A	9
	Service outlets, fittings	OA	A	11
	Transformers (welding)	OA	A	12
	Wiring	OA	A	15
	Other — lighting, CAMs, cameras	OA	A	16
Thermal	Electrical equipment (for welding)	OA	B	2
	Heater (sample lines on cart)	OA	B	3
	Welding, torch/arc	OA	B	5
	Radioactive decay heat	OA	B	7
	Exposed components (on cart)	OA	B	8
	Power tools	OA	B	9
	Convective (heat exchanger on cart)	OA	B	10
	Other — operating deck floor	OA	B	13
Friction	Belts	OA	C	1
	Bearings	OA	C	2
	Fans	OA	C	3
	Gears	OA	C	4
	Motors	OA	C	5
	Power tools	OA	C	6
	Other (brakes on the MHM and tube cart)	OA	C	7
Corrosives	Decontamination solution	OA	D	4
Kinetic - rotational	Motors	OA	E	2
	Pumps (TV&P carts, seismic clamp)	OA	E	3
	Other — MHM hoist	OA	E	7
Kinetic - linear	Forklifts, dollies, carts (TV&P carts)	OA	F	2
	Obstructions (rail frogs, tube covers	OA	F	4
	Crane loads (TV&P carts)	OA	F	5
	Pressure vessel blowdown (missiles)	OA	F	6

Table 16. Standard Industrial Hazards: Overpack Locations in Operating Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Mass, gravity, height	Human effort	OA	G	1
	Bucket and ladder (maintenance)	OA	G	4
	Slings (to remove tube plug cover)	OA	G	6
	Hoists (vent and purge cart)	OA	G	7
	Jacks (MHM shield ring jacks)	OA	G	9
	Scaffold and ladders (MHM access)	OA	G	10
	Pits and excavations	OA	G	11
Pressure - volume	Test loops	OA	H	4
	Gas bottles	OA	H	5
	Gas receivers (MHM, service cart)	OA	H	7
	Vacuum (TV&P carts)	OA	H	8
	Other — inert gas lines, seismic clamp	OA	H	11
Hazardous materials	Asphyxiants (cart, inert gas line)	OA	M	2
	Corrosives (batteries)	OA	M	5
	Heavy metals (lead batteries)	OA	M	8
Ionizing radiation sources	Radioactive sources (hand-held equipment)	OA	N	4

CAM = continuous air monitor.
MHM = multi-canister overpack handling machine
TV&P = tube vent and purge.

Table 17. Canister Storage Building Material at Risk (Type, Form, and Quantity). (2 sheets)

Field name or location	MAR subject	MAR description	MAR classification	Capacity	Material type	Physical form	Volume or activity	Transient	Quantity	Comments
Trailer vestibule	MCO in cask	SNF and particulate matter in MCO	SNF in MCO	1,000 L per MCO; two loaded scrap baskets and four loaded Mark IA fuel baskets MCO estimated to contain 34 kg of particulate matter after cold vacuum drying and shipping to CSB	Mark IA or Mark IV spent fuel from N Reactor	Solid consisting of fuel and particulate corrosion products	Slightly greater than 6 MTU at 4.11 E+04 Ci/MTU	Yes, particulate is transient	Slightly greater than 6 MTU per MCO including 34 kg particulate per MCO	
		Hydrogen gas	Combustible gas	~1 m^3 of hydrogen gas per MCO	Hydrogen gas	Gas	~1 m^3 of hydrogen gas per MCO	Yes	~1 m^3 of hydrogen gas per MCO	
	Truck fuel tank	Diesel fuel	Diesel fuel	100 gal	NA	Liquid	Up to 100 gal	Yes	100 gal	
Load-in/load-out area	MCO lifted from cask	SNF and particulate matter in MCO	Finely divided particulate matter	MCO estimated to contain 34 kg of particulate matter after cold vacuum drying and shipping to CSB	NA	Solid	34 kg at 4.11 E+04 Ci/MTU	Yes, particulate is transient	34 kg per MCO	
		Hydrogen gas	Combustible gas	~1 m^3 of hydrogen gas per MCO	Hydrogen gas	Gas	~1 m^3 of hydrogen gas per MCO	Yes	~1 m^3 of hydrogen gas per MCO	
Operating area	MCO contents	SNF and particulate matter	Finely divided particulate matter	Two loaded scrap baskets and four loaded Mark IA fuel baskets MCO estimated to contain 34 kg of dispersible particulate matter after cold vacuum drying, shipping to CSB, and sampling	Mark IA or Mark IV spent fuel from N Reactor	Solid consisting of fuel and particulate corrosion products	Slightly greater than 6 MTU at 4.11 E+04 Ci/MTU	Yes, particulate is transient	Slightly greater than 6 MTU per MCO including 34 kg particulate per MCO	
		Hydrogen gas	Combustible gas	~1 m^3 of hydrogen gas per MCO	Hydrogen gas	Gas	~1 m^3 of hydrogen gas per MCO	Yes	~1 m^3 of hydrogen gas per MCO	

Table 17. Canister Storage Building Material at Risk (Type, Form, and Quantity). (2 sheets)

Field name or location	MAR subject	MAR description	MAR classification	Capacity	Material type	Physical form	Volume or activity	Transient	Quantity	Comments
Operating area (contd.)	Contents of a loaded vault tube	SNF and particulate matter in two MCOs	NA	Two MCOs; each loaded with two scrap baskets and four Mark IA fuel baskets	Mark IA or Mark IV spent fuel from N Reactor	Solid consisting of fuel and particulate corrosion products	Slightly greater than 12 MTU at 4.11 E+04 Ci/MTU	Yes, particulate is transient	Slightly greater than 12 MTU including 68 kg particulate per MCO	
		Hydrogen gas	Combustible gas	~2 m^3 of hydrogen gas per MCO	Hydrogen gas	Gas	~2 m^3 of hydrogen gas per MCO	Yes	~2 m^3 of hydrogen gas per MCO	
Sampling/ weld area	MCO in sampling/ weld area pit	SNF and particulate matter in MCO	SNF in MCO	Two loaded scrap baskets and four loaded Mark IA fuel baskets MCO estimated to contain 34 kg of particulate matter after cold vacuum drying and shipping to CSB	Mark IA or Mark IV spent fuel from N Reactor	Solid consisting of fuel and particulate corrosion products	Slightly greater than 6 MTU at 4.11 E+04 Ci/MTU	Yes, particulate is transient	Slightly greater than 6 MTU per MCO including 34 kg particulate per MCO	
		Hydrogen gas	Combustible gas	~1 m^3 of hydrogen gas per MCO	Hydrogen gas	Gas	~1 m^3 of hydrogen gas per MCO	Yes	~1 m^3 of hydrogen gas per MCO	
Vault	Contents of all loaded MCOs in vault 1	SNF and particulate matter in MCOs	NA	220 storage tubes each loaded with two MCOs	Various types of SNF from N Reactor	Solid consisting of fuel and particulate corrosion products	4.11 E+04 Ci/MTU × vault contents	Yes, particulate is transient	Slightly greater than 6 MTU per MCO including 34 kg particulate per MCO	
Support building	Particulate on HVAC filters	Radioactive particulate from MCOs	Radioactive particulate matter	Minimal	NA	Solid	NA	Yes, particulate is transient	Minimal	
Outside area	Inert gas storage	Helium used to inert MCOs and overpack storage tubes	Helium	Transport trailer	Helium gas	Gas	NA	Yes	Transport trailer	

CSB = Canister Storage Building.
HVAC = heating, ventilation, and air conditioning.
MAR = material at risk.
MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.
MTU = metric ton of uranium.
NA = not applicable.
SNF = spent nuclear fuel.

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Trailer vestibule TV-F-01	Linear kinetic - transporter trucks	Transporter collision	Human error Mechanical failure Mislocated equipment	Collision with: - Facility structures, systems, or components - Personnel	Transporter impacts that cause - Damage to the cask, but no MCO breach or fuel rearrangement - Damage to facility structures, systems, or components (e.g., inner overhead door, receiving crane) - Damage to the transporter - Personnel injury	None	F3 The hazard analysis team considered a transportation accident to be an anticipated event.	F3	The cask is a DOT approved container as a design feature. (passive feature) [See SARP[a]]	S1 (DOT approved container as design feature)	S1	The trailer vestibule has wheel stops to alert the driver to his position. The approach into the trailer vestibule is restricted by design and includes speed limits. The drivers of the transporters are trained and qualified to perform their duties safely, which includes following procedures for safe transport and obeying all speed limits. The SARP limits conditions under which a transporter could arrive at the CSB (e.g., weather and road conditions, transporter-cask configurations).[a] Regular maintenance is performed on the transporter to ensure it is in good working order.

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Trailer vestibule TV-F-05	Linear kinetic - receiving crane (with yoke, cask)	Crane collision	Human error Mechanical failure Mislocated equipment	Collision with: - Transporter - Equipment out of place - Personnel - Inner overhead door	Damage to the cask, but no MCO breach Damage to receiving crane, yoke, or other structures, systems, or components Loss of inner overhead door causing a loss of zone between the load-in/load-out area and the trailer vestibule and/or allowing exhaust gases from the transporter cab to enter the load-in/load-out area Personnel injury	None	F3 The hazard analysis team considered a crane collision to be an anticipated event.	F3	The cask is a DOT approved container as a design feature. (passive feature) [See SARP[a]]	S1 (DOT approved container as design feature)	S1	The receiving crane design includes such features as restricted speed, load float, micropositioner, and auditory movement alarms. The operators of the receiving crane are trained and qualified to perform their duties safely, which includes following procedures for safe operation of the crane and handling of the transportation cask. Regular maintenance is performed on the receiving crane to ensure it is in good working order.
Trailer vestibule TV-F-06	Linear kinetic - pressure vessel blowdown (missiles): gas bottle blowdown	Gas cylinders are damaged and become missiles	Earthquake, trailer impacts, forklift impacts	Bottle becomes missile, strikes structure and/or equipment	Personnel injury, structure and/or equipment damage	None	F3	F3	Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity)	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Trailer vestibule TV-G-03a	Mass, gravity, height - lifts and cranes - structure and equipment	Structure (overhead door), rigging, yoke or other lifting equipment positioned over the top of cask	Equipment failure Human error	Structure (overhead door), rigging, yoke or other lifting equipment falls onto top of cask	Breach of MCO and/or cask Loss of criticality contingency (See TV-K-12, -K-15) Personal injury	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F2	F2		S1	S1	Building and structure build to national codes and standards Three over one criteria imposed Crane maintenance program Crane operators are trained Routine maintenance and inspection of structural equipment (door mechanism) Approved procedures control activities Height limiting device (yoke) (SNF-3328, Table 2-1, Line 11[b])
Trailer vestibule TV-G-03b	Mass, gravity, height - lifts and cranes - structure and equipment	Building or equipment not designed to withstand seismic event	Seismic event	Seismic event causes building or equipment to fall onto cask	Breach of MCO and/or cask Loss of criticality contingency (See TV-K-12, -K-15) See OU-R-01 Personal injury	None	F2	F2	The CSB facility is seismically qualified (passive feature)	S1	S1	(SNF-3328, Table 2-1, Line 13[b])

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Trailer vestibule TV-G-09	Mass, gravity, height - jacks (transporter)	Elevated cask sitting on transporter supported by jacks (≈2 ft off ground)	Seismic event Operator error Mechanical failure of transporter jacks	Cask falls off transporter after the clamshell hold downs are removed but before the yoke is attached	Breach of MCO and/or cask Loss of criticality contingency (See TV-K-12, -K-15) Damage to facility structures, systems, or components (e.g., inner overhead door, receiving crane) Damage to the transporter Personnel injury	None	F3	F3	Analysis demonstrates that the cask-MCO will maintain confinement following a drop from a height of 60 in. or less onto the CSB trailer vestibule floor.	S1	S1	The operators of the receiving crane are trained and qualified to perform their duties safely, which includes following procedures for safe handling of the transportation cask. Regular maintenance is performed on the transporter to ensure it is in good working order.

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Trailer vestibule TV-G-13	Mass, gravity, height - vessels (loaded cask-MCO, empty cask-MCO)	Cask-MCO drop	Equipment failure Human error	Cask-MCO drop onto trailer edge with horizontal slap-down onto floor. Cask-MCO vertical drop directly onto concrete floor	Breach of MCO and/or cask Loss of criticality contingency (See TV-K-12, -K-15) Personnel injury		F2	F2	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	The operators of the receiving crane are trained and qualified to perform their duties safely, which includes following procedures for safe handling of the transportation cask. Operations and maintenance procedures are written based on operations and maintenance manuals. Details will be provided by the crane vendor. The hoist design includes - Interlocks to preclude lift and horizontal motion at same time - Dual brakes - No free-fall capacity. Crane design safety features and safety margin Height limiting device (yoke) (SNF-3328, Table 2-1, Lines 2 and 3[b])

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Trailer vestibule TV-H-06	Pressure, volume - pressure vessels (cask–MCO system)	Release of gases under high pressure from the MCO	Mechanical seal failure	MCO leakage past mechanical seal AND Cask leak - Lid seal failure - Drain port ball valve failure - Drain port or vent port cover failure - Vent port failure	Release of MCO gases and particulate into cask annulus (MCO still contained by cask) Release from cask (only a problem if an MCO release or breach occurs)	The MCO, prior to welding on cap, is designed to withstand high pressure (~150 lb/in^2) without catastrophic failure (passive barrier). Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F1	F1		S1	S1	CSB acceptance criteria ensure that MCOs not meeting the minimum requirements for acceptance are not unloaded from the transporter. Receipt survey is conducted (sequence of operations basis for procedures) The cask is designed with materials to prevent release from an MCO breach. CAM sampling lines are present in the trailer vestibule. The drying process at the CVDF ensures MCO pressures are relatively low during the receiving process.
Trailer vestibule TV-J-06	Explosives or pyrophorics - hydrogen	Flammable hydrogen mixture created by pressure release, and ignition source is present	Hydrogen leaks and mixes with air (hydrogen leaks because of MCO seal failure and cask vent or drain connections or cover plates failure), and ignition source is present.	Deflagration (within cask, or outside cask if there is cask leakage)	Personnel injury Low levels of contamination	The MCO is designed to withstand high pressure (~150 lb/in^2) without catastrophic failure (passive barrier). Therefore release from internal hydrogen deflagration is minimal. Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F1	F1		S1	S1	The cask is designed with materials to prevent release from an MCO leak. HVAC provides air exchange. Smoking not allowed within the facility.
Trailer vestibule TV-J-07 TV-L-14	Explosives or pyrophorics - acetylene gas	Flammable gas	Human error Mechanical failure	Flammable gas in the trailer vestibule ignites	Personnel injury	None	F2	F2	The combustible materials in the trailer vestibule are limited by the Fire Hazard Analysis[c] and Implementation Plan and thus use of acetylene is prohibited.	S1	S1	

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Trailer vestibule TV-J-10	Explosives or pyrophorics - uranium and/or plutonium metal (uranium hydride)	Pyrophoric material is exposed to air and sufficient surface area and temperature are present	Leak in MCO mechanical seal	The exposed pyrophoric material reacts with the air, resulting in uranium burn	Personnel injury (burns) Contamination release Damage to cask Damage to MCO	The MCO and the transportation cask have been designed to survive all transportation accidents; such a design reduces the likelihood of breaches or seal leaks leading to the exposure of pyrophoric material to air (passive barrier). Note: A large cask–MCO breach is necessary for this accident to occur.	F0	F0	None	S3 This event meets evaluation guidelines for a beyond extremely unlikely event.	S3	
Trailer vestibule TV-K-12 TV-K-15	Nuclear criticality - cranes and lifts, MCO	This hazard is addressed in HNF-3553, Annex A, Chapter A6.0[d] - no new hazards have been identified.										
Trailer vestibule TV-L-03 TV-L-04 TV-L-06 TV-L-07 TV-L-10 TV-L-16	Flammable materials - gasoline, lubricating oil, paints and solvents, diesel fuel, grease, hydraulic fluid	The combustible materials in the trailer vestibule are limited by the Fire Hazard Analysis[c] and Implementation Plan.										
Trailer vestibule TV-L-11	Flammable materials - hydrogen	Refer to TV-J-06, "Explosives or pyrophorics - hydrogen."										
Trailer vestibule TV-M-07	Hazardous materials - toxic (plutonium and uranium)	Radiological limits are more restricting than toxicological limits for spent nuclear fuel.[e]										

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Trailer vestibule TV-N-01 TV-N-03	Ionizing radiation sources (contents of MCO)	Ionizing radiation	Normal work	Personnel exposure to radiation	Exposure to ionizing radiation	None	F3	F3	The transportation cask is designed to provide shielding to reduce personnel exposures (passive barrier).	S0	S0	See HNF-3553, Annex A, Chapter A7.0[d] for radiological protection controls.
		Surface contamination	Loss of contamination control	Spread of contamination	Increased potential for exposure to ionizing radiation Environmental impact	None	F3	F3	None	S1	S1	See HNF-3553, Annex A, Chapter A7.0[d] for radiological protection controls.
Trailer vestibule TV-P-01 TV-P-02 TV-P-03 TV-P-04	External events	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P).										
Trailer vestibule TV-Q-01 TV-Q-02 TV-Q-03 TV-Q-04	Vehicles in motion	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-Q).										
Trailer vestibule TV-R-01 TV-R-03 TV-R-04 TV-R-05 TV-R-06 TV-R-07 TV-R-08 TV-R-09 TV-R-010	Natural phenomena	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R).										

Table 18. Canister Storage Building Hazard Analysis: Trailer Vestibule. (9 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	

[a] HNF-SD-TP-SARP-017, 1999, *Safety Analysis Report for Packaging (Onsite) Multi-Canister Overpack Cask*, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[b] SNF-3328, 2000, *Canister Storage Building Design Basis Accident Analysis Documentation*, Rev. 2, Fluor Hanford, Incorporated, Richland, Washington.
[c] HNF-SD-SNF-FHA-002, 2000, *Fire Hazard Analysis for the Canister Storage Building*, Rev. 3, Fluor Hanford, Incorporated, Richland, Washington.
[d] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Safety Final Analysis Report," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.
[e] HNF-SD-SNF-TI-059, 1999, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 2, Fluor Daniel Hanford, Incorporated Richland, Washington.

CAM = continuous air monitor.
CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
DOT = U.S. Department of Transportation.
HVAC = heating, ventilation, and air conditioning.
MCO = multi-canister overpack.

F0 = Too improbable to warrant consideration for further accident analysis development.
F1 = Possible, but extremely unlikely.
F2 = Foreseeable, but unlikely.
F3 = Likely to occur during the lifetime of the facility.

S0 = Insufficient material and energy to adversely impact facility workers.
S1 = Sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.
S2 = Sufficient material and energy available to cause a high or moderate impact to the maximum onsite individual.
S3 = Sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-B-07	Thermal - radioactive decay heat (MCO)	Heat up of the MCO in the MHM due to thermal buildup	MHM ventilation system is not functional for at least 6 days with an MCO in the MHM	MCO exceeds design temperature criteria	Violation of design criteria Possible OCRWM violation	None	F2	F2	None	S0	S0	
Load-in/ load-out area SA-E-07	Rotational kinetic	Rotating turret	Equipment failure Human error	MCO shears when turret rotates with MCO only partially retracted into the MHM	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15)		F3	F3	MCO design (passive feature) Analysis shows that the MHM turret rotation motors and drives can not cause a rotational shear of an MCO	S2	S0	Personnel are trained to MHM-specific procedures for safe operation. MHM resolver indicates MCO's relative position within the service station pit and/or MHM while it is being raised. The MHM is provided with backup grapple disengagement capability. The MHM--service station pit interface provides active, HEPA-filtered ventilation. P6 interlock inhibits turret rotation while an MCO is loaded but not fully raised. (SNF-3328, Table 2-1, Line 17a[a])

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-F-05	Linear kinetic - MHM	MHM collides with cask–MCO that is protruding from service pit	Human error in moving the receiving crane and its loads Human error in mislocating equipment where it is susceptible to crane impacts Mechanical failure of the receiving crane Electrical interlock failure of the receiving crane	Impact with - MHM (of particular concern when the MHM is in the process of extracting an MCO from the service station pit) - Subsystems placed in the path of the receiving crane - Personnel - Load-in/load-out area enclosure - 5-ton gantry crane	Breach of MCO and/or cask Loss of criticality contingency (See SA-K-12, -K-15) Personnel injury	None	F3	F3	Cask design (passive feature) Analysis shows that the cask survives the collision.	S2	S0	Electrical interlocks relative to receiving crane and MHM positioning along their respective tracks preclude the presence of both the MHM and the receiving crane in the load-in/load-out area simultaneously. Personnel are trained to procedures detailing the safe sequence of operations. These procedures prohibit interferences between the receiving crane and the MHM. The frogs on the receiving crane's tracks have stops. The receiving crane has auditory indication of its movement (i.e., alarms). The receiving crane is limited to relatively slow movement. (SNF-3328, Table 2-1, Line 10[a])
Load-in/ load-out area SA-F-06	Linear kinetic - pressure vessel blowdown (missiles): gas bottle blowdown	Gas cylinders are damaged and become missiles	Earthquake, trailer impacts, forklift impacts	Bottle becomes missile, strikes MHM or MCO	Personnel injury, structure and/or equipment damage	None	F3	F3	Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity)	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-F-07a	Linear kinetic - other (5-ton gantry and load-in/load-out area enclosure)	5-ton gantry or load-in/ load-out area enclosure collision	Human error in mislocating equipment in the path of the gantry or load in/load out area enclosure Human inattentiveness Crane failure	Collision with - Equipment - Personnel - Transportation cask lid - Shield hatch assembly	Damage to the load-in/load-out area enclosure Damage to the gantry crane Personnel injury	None	F3	F3	None	S1	S1	The 5-ton gantry crane and load-in/load-out area enclosure have a limited movement area. They operate inside the span of both the MHM and the receiving crane rails. The 5-ton gantry crane is limited to relatively slow movement, and the load-in/load-out area enclosure is moved manually. The crane and load-in/load-out area enclosure have been designed to preclude tipping. Personnel are trained to operate the 5-ton gantry and load-in/load-out area enclosure according to facility-specific procedures, which include related activities such as ensuring equipment is not blocking gantry crane and load-in/load-out area enclosure movement.
Load-in/ load-out area SA-F-07b	Linear kinetic	Receiving crane with loaded cask-MCO partially inserted into cask receiving pit moves	Equipment failure Human error	MCO shear	Breach of MCO and/or cask Loss of criticality contingency (See SA-K-12, -K-15)	None	F3	F3	Cask as design feature: Shear forces not sufficient to significantly damage the MCO because of the transportation cask (passive feature) Analysis shows that the cask prevents the shear.	S2	S0	Rail frogs installed whenever receiving crane is in load-in/load-out area by standard operating procedure (SNF-3328, Table 2-1, Line 8[a])

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-F-07c	Linear kinetic	MHM shears the MCO by colliding with the crane and cask-MCO as the cask-MCO is lowered into the cask receiving pit	Equipment failure Human error	MCO shear	Breach of MCO and/or cask Loss of criticality contingency (See SA-K-12, -K-15)	None	F3	F3	Analysis demonstrates that in this accident the transportation cask prevents unacceptable MCO damage (Cask is passive feature) Analysis shows that the cask survives the collision.	S2	S0	The MHM has an auditory indication of its movement (i.e., alarms). The MHM is limited to relatively slow movement. Interlocks (electrical and mechanical) prohibit any horizontal movement, linear or rotational, while an MCO is loaded but not fully raised. MHM resolver indicates MCO's relative position within the storage tube and/or MHM while it is being lowered or raised. Personnel are trained in MHM-specific procedures regarding its safe operation. (SNF-3328, Table 2-1, Line 10[a])
Load-in/ load-out area SA-F-07d	Linear kinetic	MHM shears the MCO by moving with MCO only partially retrieved into the MHM	Equipment failure Human error	MCO shear	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15)		F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Personnel are trained in MHM-specific procedures regarding its safe operation. The MHM has an auditory indication of its movement (i.e., alarms). The MHM is limited to relatively slow movement. The MHM resolver indicates the MCO's relative position within the service station pit and/or MHM while it is being raised. P2 interlock inhibits MHM bridge and trolley travel while an MCO is loaded but not fully raised [no tube plug within plug cask of MHM]. (SNF-3328,Table 2-1, Line 17b[a])

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-F-07e	Linear kinetic	MCO shear while partially inserted into cask receiving pit during an earthquake	Seismic event	MCO shear	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15)		F2	F2	None	S2 Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S1	See OU-R-01 Interlocks P3, P6, P8, P9, P21 and P80 (SNF-3328, Table 2-1, Line 18[a])
Load-in/ load-out area SA-G-03a	Mass gravity, height - lifts and cranes - structure and equipment	Structure rigging, yoke, or other lifting equipment positioned over the top of cask	Equipment failure Human error	Structure, rigging, yoke, or equipment falls onto top of cask	Breach of MCO and/or cask Loss of criticality contingency (See SA-K-12, -K-15) Personal injury		F2	F2	Cask construction withstands impact, protects MCO (passive feature) Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Building and structure built to national codes and standards Three over one criteria imposed Approved procedures control activity Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, gantry, and MHM. A specific testing program is in place for slings, lifting yoke, MHM MCO grapple and hoist. Height limiting device (yoke) (SNF-3328, Table 2-1, Line 11[a])
Load-in/ load-out area SA-G-03b	Mass gravity, height - lifts and cranes - structure and equipment	Building or equipment is not designed to withstand seismic event	Seismic event	Seismic event causes building or equipment to fall onto MCO	Breach of MCO and/or cask Loss of criticality contingency (See SA-K-12, -K-15) See OU-R-01 Personal Injury	None	F2	F2	The CSB facility is seismically qualified (passive feature)	S1	S1	(SNF-3328, Table 2-1, Line 13[a])

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-G-03c	Mass gravity, height - lifts and cranes - structure and equipment	Cask lid falls onto MCO	Equipment failure Human Error	Cask lid falls onto MCO	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15) Personal injury		F2	F2	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Approved procedures control activity Height limiting device (yoke) (SNF-3328, Table 2-1, line 12[a])
Load-in/ load-out area SA-G-03d	Mass gravity, height - lifts and cranes - structure and equipment	Service pit plug falls onto MCO	Equipment failure Human Error	The design of the plug and pit shield plug make it geometrically impossible for this drop to impact the MCO	Damage to MCO Personal injury	None	F2	F2	Design dimensions make it impossible for the center plate to impact the MCO.	S2	S0	Approved procedures control activity (SNF-3328, Table 2-1, line 14[a])
Load-in/ load-out area SA-G-11	Mass, gravity, height - pits and excavations	Refer to SA-G-03a, b, c, and d, "Mass, gravity, height - lifts and cranes."										
Load-in/ load-out area SA-G-13a	Mass, gravity, height - vessels (loaded cask-MCO, empty cask-MCO)	Cask-MCO drop	Equipment failure Human error	Cask-MCO vertical drop directly onto concrete floor. Cask-MCO drop onto edge of service pit with slap-down. Cask-MCO drop onto edge of service pit spanning the pit. Cask-MCO drop onto edge of service pit with cask impact on opposite edge of service pit.	Breach of MCO and/or cask Loss of criticality contingency (See SA-K-12, -K-15) Personal injury		F2	F2	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	The operators of the receiving crane are trained and qualified to perform their duties safely, which includes following procedures for safe handling of the transportation cask. Operations and maintenance procedures are written based on operations and maintenance manuals. Details will be provided by the crane vendor. Height limiting device (yoke) (SNF-3328, Table 2-1, Lines 3, 4, 5, and 6[a])

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-G-13b	Mass, gravity, height - vessels (loaded cask-MCO, empty cask-MCO)	Cask-MCO drop	Equipment failure Human error	Cask-MCO drop into service pit	Breach of MCO and/or cask Loss of criticality contingency (See SA-K-12, -K-15)		F2	F2	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	The operators of the receiving crane are trained and qualified to perform their duties safely, which includes following procedures for safe handling of the transportation cask. Operations and maintenance procedures are written based on operations and maintenance manuals. Details will be provided by the crane vendor. Approved procedures control work Height limiting device (yoke) Impact absorber (SNF-3328, Table 2-1, Line 7[a])
Load-in/ load-out area SA-G-13c	Mass, gravity, height - vessels (loaded cask-MCO, empty cask-MCO)	Cask-MCO drop	Equipment failure Human error	Cask-MCO vertical drop onto edge or into maintenance pit	Breach of MCO and/or cask Loss of criticality contingency (See SA-K-12, -K-15)		F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	The operators of the receiving crane are trained and qualified to perform their duties safely, which includes following procedures for safe handling of the transportation cask. Operations and maintenance procedures are written based on operations and maintenance manuals. Details will be provided by the crane vendor. Approved procedures control work Interlock and fortress key for controlling receiving crane location Receiving crane load path control (E-switch) (SNF-3328, Table 2-1, Line 9a[a])

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-G-13d	Mass, gravity, height - vessels (loaded MCO)	MCO drop	Equipment failure Human error	MCO drops onto edge of cask at service pit, (eccentric onto service pit)	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15)		F2	F2	MCO construction (passive feature) Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design Approved procedures control work Shield hatch and MHM centering guide (SNF-3328, Table 2-1, Line 15[a])
Load-in/ load-out area SA-G-13e	Mass, gravity, height - vessels (loaded MCO)	MCO drop	Equipment failure Human error	MCO drops back into cask at service pit	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15)		F2	F2	MCO shell Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design Approved procedures control work Impact absorber (SNF-3328, Table 2-1, Line 16[a])
Load-in/ load-out area SA-G-13f	Mass, gravity, height - vessels (loaded MCO)	MCO drop	Equipment failure Human error	MCO drops onto or into maintenance pit or tube plug exchange facility	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15)		F1	F1	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design Approved procedures control work MHM interlock (P2) to prevent MHM movement with tube plug in tube cavity MHM interlocks (P26, P85) to prevent turret rotation to MCO hoist position at tube plug exchange facility MHM interlock P99) prevents turret rotation to MCO hoist position without tube plug in tube plug cavity (SNF-3328, Table 2-1, Line 24[a])

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	*Hazard energy* source/material	*Hazardous* condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-G-13g	*Mass, gravity,* height - vessels (loaded MCO)	MCO drop	Equipment failure Human error	MCO drops onto or into FFTF pit	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15)		F1	F1	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design Approved procedures control work MHM interlock (P2) to prevent MHM movement with tube plug in tube cavity MHM interlock P99) prevents turret rotation to MCO hoist position without tube plug in tube plug cavity (SNF-3328, Table 2-1, Line 25[a])

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-H-06	Pressure, volume - pressure vessels (MCO and MCO-transportation cask system)	Pressurized release of gases within the MCO	Improper or insufficient conditioning performed on the MCO before its receipt at the CSB Improper sealing of the MCO process ports at the CVDF Mechanical seal failure due to manufacturing flaws or damage	Gases escape from MCO through failed mechanical seals Transportation cask releases pressurized gases because of - A leak in the seal lid - Drain port ball valve failure - Vent port failure - Failure of pressure test equipment or process	An MCO release inside the cask, by itself, has no safety consequences beyond contamination of the transportation cask (recovery actions are dealt with separately); the transportation cask contains the release. If a transportation cask releases its contents following an MCO leak, or the MCO leak occurs while the transportation cask lid is removed, several consequences are possible: - Hydrogen and small amounts of fission gases released to load-in/load-out area (possible without radioactive particulate if the MCO relieves pressure through a HEPA-filtered relief valve); this could potentially lead to the development of a flammable atmosphere in load-in/load-out area - Radioactive particulate released to the load-in/load-out area - Personnel contamination from radioactive and/or hazardous material releases from the transportation cask.	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F3	F3		S1	S1	Personnel are trained to facility-specific procedures regarding transportation cask shipping, movement, and handling. A load-in/load-out area enclosure can be placed over the service station pit when higher than normal pressures are detected in the transportation cask. The MCO rupture disk is in a recessed location and blanked off with a cover plate. The load-in/load-out area enclosure, if in place, provides HEPA-filtered confinement in the event of an MCO pressure release. The drying process at the CVDF will ensure MCO pressures are relatively low during the receiving process.

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-J-06a	Explosives or pyrophorics - hydrogen	A flammable hydrogen-air mixture and an ignition source is present	Hydrogen formation in the MCO is due to corrosion of uranium by water	Deflagration or detonation may occur within the MCO	MCO failure Uncontrolled release of hazardous material		F2	F2		S3 Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S1	The established bounding aluminum hydroxide value of 10.6 kg/MCO (99% confidence level) provides assurance that oxygen concentrations will be below the lower flammability limits during the 40-year interim storage period.[b] MCO is inerted. The drying process at the CVDF will ensure MCO pressures are relatively low during the receiving process.
Load-in/ load-out area SA-J-06b	Explosives or pyrophorics - hydrogen	Hydrogen vents from the cask–MCO into the tent	Hydrogen formation in the MCO is due to corrosion of uranium by water	A flammable hydrogen-air mixture and an ignition source, causing deflagration or detonation within the tent	Uncontrolled release of hazardous material from tent HEPA filter Personnel injury	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F2	F2	None	S1	S1	Radionuclide inventory on the HEPA filter in the portable exhauster is minimized.
Load-in/ load-out area SA-J-07 SA-L-14	Explosives or pyrophorics - acetylene gas	Flammable gas	Human error Mechanical failure	Flammable gas in the load-in/load-out area ignites	Personnel injury	None	F2	F2	The combustible materials in the load-in/load-out area are limited by the Fire Hazard Analysis[c] and Implementation Plan and thus use of acetylene is prohibited.	S1	S1	
Load-in/ load-out area SA-J-10a	Explosives or pyrophorics - plutonium and uranium metal, zirconium (uranium hydride)	Pyrophoric material exposed to air, and sufficient surface area and temperature are present	MCO seal leak	Pyrophoric material ignites	Personnel injury Contamination release Damage to the MCO	Air inleakage is not sufficient for runaway reaction[a]	F0	F0	None	S3 This event meets evaluation guidelines for a beyond extremely unlikely event.	S3	Spontaneous ignition is precluded by the low fuel temperature expected during interim storage (~120 °C). A temperature over 300 °C is needed before spontaneous ignitions occurs.

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-J-10b	Explosives or pyrophorics - plutonium and uranium metal, zirconium (uranium hydride)	Fuel reacts with water	Insufficient drying at CVDF	Pyrophoric material ignites uranium	Personnel injury Contamination release Damage to the MCO	MCO acceptance specification limits free water to less than 200 g	F1	F0 Frequency analysis indicates that this unmitigated scenario frequency is less than 1E-6/yr.	None	S3	S3	The MCO is designed to withstand high pressures (~150 lb/in^2 gauge) without catastrophic failure.
Load-in/ load-out area SA-K-12 SA-K-15	Nuclear criticality - cranes and lifts, MCO	This hazard is addressed in HNF-3553, Annex A, Chapter A6.0[d] — no new hazards have been identified (refer also to SA-G-03b).										
Load-in/ load-out area SA-L-01 SA-L-02 SA-L-04 SA-L-06 SA-L-10 SA-L-13 SA-L-16	Flammable materials - packing materials (MCO), rags, lubricating oil, paints and solvents, grease, organics (MHM neutron absorber, tent enclosure), other (hydraulic fluid)	The combustible materials in the load-in/load-out area are limited by the Fire Hazard Analysis[c] and Implementation Plan.										
Load-in/ load-out area SA-L-11	Flammable materials - hydrogen	Refer to SA-J-06, "Explosives or pyrophorics - hydrogen."										
Load-in/ load-out area SA-M-07	Hazardous materials - toxic (plutonium and uranium)	Radiological limits are more restricting than toxicological limits for spent nuclear fuel.[e]										

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-N-01 SA-N-03	Ionizing radiation sources (contents of MCO)	Ionizing radiation Release of fissile and/or radioactive material entrained in pressurized gases within the MCO	Mechanical seal failure	Gases with radioactive material escape from the MCO through failed or improperly applied mechanical seals	An MCO release inside the cask, by itself, has no safety consequences beyond contamination of the transportation cask with fissile or radioactive materials (recovery actions are dealt with separately); the transportation cask contains the release. If a transportation cask releases its contents following an MCO release or breach, or the MCO release occurs while the transportation cask lid is removed, fissile and/or radioactive materials could be released to the load-in/load-out area. Contamination may spread during MHM or tube plug servicing at the maintenance pit because of prior release from the MCO in the MHM or the storage tube.	None	F3	F3	The transportation cask is designed to provide shielding to reduce personnel exposures (passive barrier). The MCO is designed to withstand high pressures (~150 lb/in^2 gauge) without catastrophic failure (passive barrier). Likely leakage from the MCO is small because of complex potential leak path (passive barrier).	S1	S1	Personnel are trained to facility-specific procedures regarding MCO shipping, movement, handling, and site radiological control. The drying process at the CVDF will ensure MCO pressures are relatively low during the receiving process. A pressure test is performed on the transportation cask before the lid is removed to detect whether an MCO has experienced a pressure leak. The MCO rupture disk is in a recessed location and blanked off with a cover plate. The load-in/load-out area enclosure, if in place, provides HEPA-filtered secondary confinement in the event of an MCO pressure release.
		Surface contamination	Loss of contamination control	Spread of contamination	Increased potential for exposure to ionizing radiation Environmental impact	None	F3	F3	None	S1	S1	See HNF-3553, Annex A, Chapter A7.0,[d] for radiological protection controls.
Load-in/ load-out area SA-P-01 SA-P-02 SA-P-03 SA-P-04	External events	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P).										

Table 19. Canister Storage Building Hazard Analysis: Load-In/Load-Out Area. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Load-in/ load-out area SA-Q-01 SA-Q-02 SA-Q-03 SA-Q-04	Vehicles in motion	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-Q).										
Load-in/ load-out area SA-R-01 SA-R-03 SA-R-04 SA-R-05 SA-R-06 SA-R-08 SA-R-09 SA-R-10	Natural phenomena	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R).										

[a] SNF-3328, 2000, *Canister Storage Building Design Basis Accident Analysis Documentation*, Rev. 2, Fluor Hanford, Incorporated, Richland, Washington.
[b] HNF-1527, 1999, *Estimates of Particulate Mass in Multi-Canister Overpacks*, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[c] HNF-SD-SNF-FHA-002, 2000, *Fire Hazard Analysis for the Canister Storage Building*, Rev. 3, Fluor Hanford, Incorporated, Richland, Washington.
[d] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.
[e] HNF-SD-SNF-TI-059, 1999, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
FFTF = Fast Flux Test Facility.
HEPA = high-efficiency particulate air (filter).
MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.

F0 = Too improbable to warrant consideration for further accident analysis development.
F1 = Possible, but extremely unlikely.
F2 = Foreseeable, but unlikely.
F3 = Likely to occur during the lifetime of the facility.

S0 = Insufficient material and energy to adversely impact facility workers.
S1 = Sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.
S2 = Sufficient material and energy available to cause a high or moderate impact to the maximum onsite individual.
S3 = Sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-D-01	Corrosives - acids (purge cart battery)	Corrosives	Battery acid in storage tubes	Acid causes corrosion of storage tubes and MCOs	Loss of storage tube integrity Loss of MCO integrity SNF exposure to vault atmosphere	Cart battery is located in isolated compartment. (passive feature)	F0	F0	None	S2 This event meets evaluation guidelines for a beyond extremely unlikely event.	S2	Maintenance-free batteries are used on tube vent and purge cart Periodic battery inspections are performed. Written charging procedures are used. Reputable battery vendor is used.
Operating area OA-B-07	Thermal - radioactive decay heat (MCO)	Heat up of the MCO in the MHM due to thermal buildup	MHM ventilation system is not functional for at least 6 days with an MCO in the MHM	MCO exceeds design temperature criteria	Violation of design criteria Possible OCRWM violation	None	F2	F2	None	S0	S0	
Operating area OA-E-07	Rotational kinetic	Rotating turret	Equipment failure Human error	MCO shears when turret rotates with MCO only partially retracted into the MHM	Breach of MCO Loss of criticality contingency (See SA-K-12, -K-15)		F3	F3	MCO design (passive feature) Analysis shows that the MHM turret rotation motors and drives can not cause a rotational shear of an MCO	S2	S0	MHM resolver indicates MCO's relative position within the storage tube and/or MHM while it is being lowered or raised. The MHM is provided with a backup grapple disengagement capability. The MHM-tube plug interface provides active ventilation. Personnel are trained to MHM-specific procedures for safe operation. P6 interlock inhibits turret rotation while an MCO is loaded but not fully raised. (SNF-3328, Table 2-1, Lines 20 and 28[a])

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-F-06	Linear kinetic - pressure vessel blowdown (missiles): gas bottle blowdown	Gas cylinders are damaged and become missiles	Earthquake, trailer impacts, forklift impacts	Bottle becomes missile, strikes structure and/or equipment	Personnel injury, structure and/or equipment damage	None	F3	F3	Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity)	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard
Operating area OA-F-07a	Linear kinetic	MCO sheared by translating MHM with MCO only partially deployed into the storage tube	Equipment failure Human error	MCO shear	Breach of MCO Loss of criticality contingency (See OA-K-12, -K-15)		F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	The MHM has an auditory indication of its movement (i.e., alarms). The MHM is limited to relatively slow movement. MHM resolver indicates MCO's relative position within the storage tube and/or MHM while it is being lowered or raised. Personnel are trained in MHM-specific procedures regarding its safe operation. P2 interlock inhibits MHM bridge and trolley travel while an MCO is loaded but not fully raised [no tube plug within plug cask of MHM]. (SNF-3328, Table 2-1, Line 27[a])

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-F-07b	Linear kinetic	MCO shear while partially inserted into storage tube during an earthquake.	Seismic event	MCO shear	Breach of MCO Loss of criticality contingency (See OA-K-12, -K-15)		F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	See OU-R-01 Interlocks P3, P6, P8, P9, P21 and P80 (SNF-3328, Table 2-1, Line 18[a])
Operating area OA-G-03a	Mass, gravity, height - lifts and cranes - structure and equipment	Seismic event causes MHM carrying an MCO to fall onto the operating deck	Seismic event	Seismic event causes MHM to tip over and fall onto operating deck	Damage to MHM and facility Breach of MCO Loss of criticality contingency (See OA-K-12, -K-15) Personal injury	None	F2	F2	MHM seismic restraints Analysis indicates the MHM does NOT tip over or collapse in a DBE.	S2	S0	See OU-R-01 Seismic detection and MHM power-disconnect (SNF-3328, Table 2-1, Line 19[a])
Operating area OA-G-03b	Mass, gravity, height - lifts and cranes - structure and equipment	Seismic event causes building or equipment to fall onto MCO	Seismic event	Seismic event causes building or equipment to fall onto MCO	Breach of MCO Loss of criticality contingency (See OA-K-12, -K-15) Personal injury	None	F2	F2	The CSB facility is seismically qualified (passive feature) MHM protects MCO (passive feature)	S1	S1	See OU-R-01 (SNF-3328, Table 2-1, Line 13[a])

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-G-13a	Mass, gravity, height - vessels (MCO)	MCO drop	Equipment failure Human error	Drop MCO onto the MHM turret deck	Breach of MCO Loss of criticality contingency (See OA-K-12, -K-15)	None	F2	F2	MCO construction (passive feature) MHM construction (passive feature)	S0	S0	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design The MHM grapple is designed such that it cannot release while a load is being suspended from it. Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM. (SNF-3328, Table 2-1, Line 21[a])
Operating area OA-G-13b	Mass, gravity, height - vessels (MCO)	MCO drop	Equipment failure Human error	Drop MCO onto CSB operating deck Drop MCO onto Vault 2 or 3 storage tube covers Drop MCO onto storage tube plug	Breach of MCO Loss of criticality contingency (See OA-K-12, -K-15)		F1	F1	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design The MHM grapple is designed such that it cannot release while a load is being suspended from it. Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM. (SNF-3328, Table 2-1, Lines 22, 23 and 33[a])

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-G-13c	Mass, gravity, height - vessels (MCO)	MCO drop	Equipment failure Human error	MCO drops to bottom of storage tube (with impact absorber in place)	Breach of MCO Loss of criticality contingency (See OA-K-12, -K-15)		F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design Impact absorbers are placed in intermediate positions. The MHM grapple is designed such that it cannot release while a load is being suspended from it.
				MCO drops onto another MCO in storage tube (with intermediate impact absorber in place)		MCO construction (passive feature)	F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM. Impact absorber (SNF-3328, Table 2-1, Lines 29/30 and 31/32[a])

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-G-13d	Mass, gravity, height - vessels (MCO)	MCO drop	Equipment failure Human error	MCO drops onto edge of storage tube	Breach of MCO Loss of criticality contingency (See OA-K-12, -K-15)	MCO construction (passive feature)	F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Interface guide ring MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design The MHM grapple is designed such that it cannot release while a load is being suspended from it. Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM. Storage tube upper flange and MHM centering guide (SNF-3328, Table 2-1, Line 34[a])

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-G-14a	Mass, gravity, height - lifts and cranes - structure and equipment	Limiter dropped onto MCO in storage tube	Equipment failure Human error	Limiter dropped onto MCO in storage tube	Damage to limiter effectiveness	None	F2	F2	Weight of impact limiter (passive feature) MCO design (passive feature) Analysis shows that there is no breach of an MCO due to the drop of the intermediate impact absorber.	S0	S0	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design The MHM grapple is designed such that it cannot release while a load is being suspended from it. However, miscalibration of limit switches may be a common mode failure of the MHM grapple. Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM. (SNF-3328, Table 2-1, Line 26[a])
Operating area OA-G-14b	Mass, gravity, height - lifts and cranes - structure and equipment	Storage tube plug dropped onto MCO in storage tube	Equipment failure Human error	Storage tube plug dropped onto MCO in storage tube	None	None	F2	F2	Design dimensions make it impossible for the tube plug to impact the MCO.	S0	S0	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design The MHM grapple is designed such that it cannot release while a load is being suspended from it. However, miscalibration of limit switches may be a common mode failure of the MHM grapple. Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM. (SNF-3328, Table 2-1, Line 36[a])

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-H-06	Volume, pressure - pressure vessels (MCO)	Gases under pressure	Mechanical seal failure occurs while MCO is in the tube but before cover cap is welded in place	Gases escape from the MCO through failed mechanical seal, leak into the tube, then leak into the operating area (slow leak)	Personnel injury Spread of contamination Contamination of storage tube Potential flammable atmosphere	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F3	F3		S1	S1	The MCO rupture disk is in a recessed location and blanked off with a cover plate at CVDF. Personnel are trained to facility-specific procedures regarding MCO handling. CSB acceptance criteria ensure that MCOs not meeting the minimum requirements for acceptance are not unloaded from the transporter. The storage tube plugs have filters.
Operating area OA-J-06a	Explosives or pyrophorics - hydrogen (MCO)	A flammable hydrogen-air mixture, and an ignition source is present	Hydrogen formation in the MCO is due to corrosion of uranium by water	Deflagration or detonation may occur within the MCO	MCO failure Uncontrolled release of hazardous material	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F2	F2	None	S2	S2	The established bounding aluminum hydroxide value of 10.6 kg/MCO (99% confidence level) provides assurance that oxygen concentrations will be below the lower flammability limits during the 40-year interim storage period.[b] MCO is inerted. The drying process at the CVDF will ensure MCO pressures are relatively low during the receiving process.
Operating area OA-J-06b	Explosives or pyrophorics - hydrogen (storage tube or MHM)	Flammable mixture and ignition source in MCO	Hydrogen formation in the MCO is due to corrosion of uranium by water	Explosive gas leaks through mechanical seal failure and ignites, creates an explosion	Uncontrolled release of contamination contained in gas Personnel injury	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F3	F3		S1	S1	HEPA filter loading is limited on the MHM exhaust filter
Operating area OA-J-06c	Explosives or pyrophorics - hydrogen (MCO)	Flammable mixture and ignition source in MCO (other than radiolysis)	Breached MCO allows air ingress	Deflagration or detonation may occur within an MCO	Uncontrolled release of hazardous material from an MCO	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	F2	F2	None	S1	S1	MCO breaches caused by drops or shears are minimized by various interlock.

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-J-07 OA-L-14	Explosives or pyrophorics - acetylene gas	Flammable gas	Human error Mechanical failure	Flammable gas in the operating area ignites	Personnel injury	None	F2	F2	The combustible materials in the operating area are limited by the Fire Hazard Analysis[c] and Implementation Plan and thus use of acetylene is prohibited.	S1	S1	
Operating area OA-J-10a	Explosives or pyrophorics -plutonium and uranium metal (uranium hydride)	Pyrophoric material exposed to air, and sufficient surface area and temperature are present	MCO seal leak allows air to enter the MCO	Pyrophoric material ignites uranium inside the MCO	Personnel injury Contamination release Damage to the MCO	Air inleakage is not sufficient for runaway reaction[a]	F0	F0	None	S3 This event meets evaluation guidelines for a beyond extremely unlikely event.	S3	Spontaneous ignition is precluded by the low fuel temperature expected during interim storage (~120 °C). A temperature over 300 °C is needed before spontaneous ignitions occurs.
Operating area OA-J-10b	Explosives or pyrophorics -plutonium and uranium metal (uranium hydride)	Fuel water reaction	CVDF drying is insufficient	Pyrophoric material ignites uranium	Personnel injury Contamination release Damage to the MCO	MCO acceptance specification limits free water to less than 200 g	F1	F0 Frequency analysis indicates that this unmitigated scenario frequency is less than 1E-6/yr.	None	S3	S3	
Operating area OA-K-12 OA-K-15	Nuclear criticality - cranes and lifts, MCO	This hazard is addressed in HNF-3553, Annex A, Chapter A6.0.[d] Refer to OA-G-03 and OA-G-13 for additional information related to criticality parameter violations.										

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	*Frequency code*		Credited mitigation	*Consequence code*		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-L-04 OA-L-06 OA-L-10 OA-L-13 OA-L-15	Flammable materials - lubricating oil, paints and solvents, grease, *organics* (*MHM* neutron absorber), liquids (hydraulic fluid)	The combustible materials in the operating area are limiting by the Fire Hazard Analysis[c] and Implementation Plan.										
Operating area OA-L-11	Flammable materials - hydrogen	Refer to OA-J-06a and OA-J-06b, "Explosives or pyrophorics - hydrogen."										
Operating area OA-M-07	Hazardous materials - toxic (plutonium and uranium)	Radiological limits are more restricting than toxicological limits for spent nuclear fuel.[c]										

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-N-01 OA-N-03	Ionizing radiation sources (MCO contents)	Ionizing radiation Release of fissile and/or radioactive materials entrained in pressurized gases within the MCO Exposure to direct radioactive streaming	Mechanical and (if present) weld seal failure Streaming from adjacent tube if tube plug is not in place	Gases with radioactive material escape from the MCO through failed mechanical seals Worker exposure caused by shine from adjacent tubes during storage or from MCO during transfer into or out of storage tube	An MCO release inside the MHM or storage tube could result in contamination of the MHM, storage tube, and operating area with fissile and/or radioactive materials (recovery actions are dealt with separately) A deflagration could result from the release of hydrogen Increased potential for direct exposure doses caused by missing tube plugs	None	F2	F2	MHM shielding (including shield skirt) , operating deck, and tube plug (passive barrier).	S1	S1	The MCO rupture disk is in a recessed location and blanked off with a cover plate. Personnel are trained to facility-specific procedures regarding MCO shipping, movement, handling, and site radiological control. Interlocks and sensors associated with the MHM are present to ensure the skirt is down before hoist operations are performed, and to ensure storage tube plugs are replaced before the MHM moves away from a storage tube position. The drying process at the CVDF ensures MCO pressures are relatively low until the MCO is installed in the storage tube. ASSUMPTION: The tube plugs will be installed in all tubes before MCO installation in any single tube. With all the storage tube plugs installed, radiation shine from adjacent tubes containing MCOs is not a concern. This idea is carried forward into Chapter A3.0 of the CSB FSAR[d] and as a control in Chapter A5.0 as AC5.12, "Tube Plug Placement."
		Surface contamination	Loss of contamination control	Spread of contamination	Increased potential for exposure to ionizing radiation Environmental impact	None	F3	F3	None	S1	S1	See Chapter A7.0 of HNF-3553, Annex A,[d] for radiological protection controls.

Table 20. Canister Storage Building Hazard Analysis: Operating Area. (12 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-P-01 OA-P-02 OA-P-03 OA-P-04	External events	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P).										
Operating area OA-Q-01 OA-Q-02 OA-Q-03 OA-Q-04	Vehicles in motion	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-Q).										
Operating area OA-R-01 OA-R-03 OA-R-04 OA-R-05 OA-R-06 OA-R-08 OA-R-09 OA-R-10	Natural phenomena	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R).										

[a] SNF-3328, 2000, *Canister Storage Building Design Basis Accident Analysis Documentation*, Rev. 2, Fluor Hanford, Incorporated, Richland, Washington.
[b] HNF-1527, 1999, *Estimates of Particulate Mass in Multi-Canister Overpacks*, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[c] HNF-SD-SNF-FHA-002, 2000, *Fire Hazard Analysis for the Canister Storage Building*, Rev. 3, Fluor Hanford, Incorporated, Richland, Washington.
[d] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report ," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.
[e] HNF-SD-SNF-TI-059, 1999, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
HEPA = high-efficiency particulate air (filter).
MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.
SNF = spent nuclear fuel.

F0 = Too improbable to warrant consideration for further accident analysis development.
F1 = Possible, but extremely unlikely.
F2 = Foreseeable, but unlikely.
F3 = Likely to occur during the lifetime of the facility.

S0 = Insufficient material and energy to adversely impact facility workers.
S1 = Sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.
S2 = Sufficient material and energy available to cause a high or moderate impact to the maximum onsite individual.
S3 = Sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-B-05	Thermal - welding arc	Localized overheating and burning damages MCO locking ring and/or canister cover assembly	Weld head dropped or misaligned Operator error during weld repair	Damage to the MCO locking ring or canister cover	Weld head burns approximately 1/8 inch into metal and then stops due to loss of arc	Sampling/weld area shielding prevents the weld head from dropping to the pressurized boundary of the MCO. (passive feature)	F1	F1	None	S0	S0	Operators continually observe weld on video monitor. Operators are trained and qualified to follow proper welding procedures.
Sampling/ weld area WS-B-07a	Thermal - radioactive decay heat (MCO)	Heat up of the MCO due to thermal buildup	Insufficient cooling at the sampling/weld area	MCO exceeds design temperature criteria	Violation of design criteria Personnel injury Possible OCRWM violation Degradation with possible structural damage to the concrete near the sampling/weld pit	None	F3	F3	None	S0	S0	An MCO can stay in the sampling/ weld area with no glycol cooling for 80 days without exceeding 270 °F.[a] Glycol cooling of shielding materials.
Sampling/ weld area WS-B-07b	Thermal - radioactive decay heat (MCO)	Heat up of the MCO in the MHM due to thermal buildup	MHM ventilation system is not functional for at least 6 days with an MCO in the MHM	MCO exceeds design temperature criteria	Violation of design criteria Possible OCRWM violation	None	F2	F2	None	S0	S0	

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-E-07	Rotational kinetic	Rotating turret	Equipment failure Human error	MCO shears when turret rotates with MCO only partially retracted into the MHM	Breach of MCO Loss of criticality contingency (See WS-K-12, -K-15)		F3	F3	MCO design (passive feature) Analysis shows that the MHM turret rotation motors and drives can not cause a rotational shear of an MCO	S2	S0	MHM resolver indicates MCO's relative position within the storage tube and/or MHM while it is being lowered or raised. The MHM is provided with a backup grapple disengagement capability. The MHM-tube plug interface provides active ventilation. Personnel are trained to MHM-specific procedures for safe operation. P6 interlock inhibits turret rotation while an MCO is loaded but not fully raised. (SNF-3328, Table 2-1, Lines 20 and 28[b])

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-F-02 WS-F-05	Linear kinetic - forklifts, dollies, carts, crane loads (portable welder, sample cart, portable test equipment)	Inadvertent movement	Human error Mechanical failure of gantry Seismic forces	Shear of sampling lines connected to MCO	MCO depressurization through failed lines	None	F2	F2		S2	S1	Safety procedures address operation of crane and other nearby equipment during sampling/weld operations. (i.e., test equipment and portable welder) Crane limit switches prevent crane collisions Crane has seismic restraints Sample cart restrained during sampling Cranes are designed such that one crane cannot reach the other station Bumpers (passive feature) MHM collision avoidance system
Sampling/ weld area WS-F-06	Linear kinetic - pressure vessel blowdown (missiles): gas bottle blowdown	Gas cylinders are damaged and become missiles	Earthquake, trailer impacts, forklift impacts	Bottle becomes missile, strikes structure and/or equipment	Personnel injury, structure and/or equipment damage	None	F3	F3	Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity)	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-F-07a	Linear kinetic	MCO sheared by translating MHM with MCO only partially deployed into the weld area pit	Equipment failure Human error	MCO shear	Breach of MCO Loss of criticality contingency (See WS-K-12, -K-15)		F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	The MHM has an auditory indication of its movement (i.e., alarms). The MHM is limited to relatively slow movement. MHM resolver indicates MCO's relative position within the storage tube and/or MHM while it is being lowered or raised. Personnel are trained in MHM-specific procedures regarding its safe operation. P2 interlock inhibits MHM bridge and trolley travel while an MCO is loaded but not fully raised [no tube plug within plug cask of MHM]. (SNF-3328, Table 2-1, Line 27[b])
Sampling/ weld area WS-F-07b	Linear kinetic	MCO shear while partially inserted into sampling/weld area pit during an earthquake	Seismic event	MCO shear	Breach of MCO Loss of criticality contingency (See WS-K-12, -K-15)		F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	See OU-R-01 Interlocks P3, P6, P8, P9, P21 and P80 (SNF-3328, Table 2-1, Line 18[b])
Sampling/ weld area WS-G-01	Mass, gravity, height - human effort	This hazard is bounded by WS-G-03b, "Mass, gravity, height - lifts and cranes."										

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-G-03a	Mass, gravity, height - lifts and cranes - structure and equipment	Seismic event causes MHM carrying an MCO to fall onto the operating deck	Seismic event	Seismic event causes MHM to tip over and fall onto operating deck	Damage to MHM and facility Breach of MCO Loss of criticality contingency (See WS-K-12, -K-15) Personal injury	None	F2	F2	MHM seismic restraints Analysis indicates the MHM does NOT tip over or collapse in a DBE.	S2	S0	See OU-R-01 Seismic detection and MHM power-disconnect (SNF-3328, Table 2-1, Line 19[b])
Sampling/ weld area WS-G-03b	Mass, gravity, height - lifts and cranes - structure and equipment	Seismic event causes building or equipment to fall onto MCO	Seismic event	Seismic event causes building or equipment to fall onto MCO	Breach of MCO Loss of criticality contingency (See WS-K-12, -K-15) Personal injury	None	F2	F2	The CSB facility is seismically qualified (passive feature) MHM protects MCO (passive feature)	S1	S1	See OU-R-01 (SNF-3328, Table 2-1, Line 13[b])
Sampling/ weld area WS-G-03c (WS-G-04a) (WS-G-06a) (WS-G-07a)	Mass, gravity, height - lifts and cranes - structure and equipment	Rigging, equipment, or welding hood falls onto MCO while in welding pit	Equipment failure Human error	Rigging or equipment falls onto MCO while in welding pit	Potential MCO breach Personal injury	None	F3	F3	MCO construction (passive feature)	S1	S1	Sampling/weld area gantry crane bumper prevents collisions with the sample hood and sample lines. Crane seismic restraints. Cranes are designed such that one crane cannot reach the other station MCO design Approved procedures control work.

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area (WS-G-04b) (WS-G-06b) (WS-G-07b)	Mass, gravity, height - lifts and cranes, slings (covers)	Equipment dropped on sample line Dropped equipment (e.g., hoods, sampling equipment, pit covers)	Human error Mechanical failure	Shear of sample lines Impacts with personnel	Gaseous release from MCO through failed sample line	None	F3	F3	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Sampling/weld area gantry crane bumper prevents collisions with the sample hood and sample lines. Crane seismic restraints. Cranes are designed such that one crane cannot reach the other station. No credit is taken for the MCO HEPA filter.
Sampling/ weld area WS-G-13a	Mass, gravity, height - vessels (MCO)	MCO drop	Equipment failure Human error	MCO drops onto impact absorber in the weld area tube	Breach of MCO Loss of criticality contingency (See WS-K-12, -K-15)		F2	F2	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design The MHM grapple is designed such that it cannot release while a load is being suspended from it. Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM. Impact absorber (SNF-3328, Table 2-1, Line 29/30[b])

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-G-13b	Mass, gravity, height - vessels (MCO)	MCO drop	Equipment failure Human error	MCO drops onto edge of sample or weld area pit	Breach of MCO Loss of criticality contingency (See WS-K-12, -K-15) Personal injury	MCO construction (passive feature)	F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Interface guide ring MHM interlocks (P57, P61, P62, P63, P65 and P66) and grapple design Upper temporary shield and MHM centering guide (SNF-3328, Table 2-1, Line 35[b])
Sampling/ weld area WS-H-04	Pressure, volume - test loops	Refer to WS-F-05, "Linear kinetic - crane loads."										
Sampling/ weld area WS-H-06a WS-H-07 WS-H-11	Pressure, volume - pressure vessels (MCO), gas receivers (accumulators), inert gas lines	High pressures	Regulator failure Reaching bounding MCO pressures because of heatup	Overpressurization of the MCO, sampling system, and/or inerting system	MCO reaches pressures in excess of design pressures and subsequently ruptures.	Helium supply system pressure relief device (rupture disk)	F1	F0	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Helium supply system pressure regulator. Pressure relief devices on the MCO sampling system and on the helium supply system.
Sampling/ weld area WS-H-06b	Pressure, volume - pressure vessels (MCO)	Inappropriate purge gas or procedure used for MCO purge following sampling operations	Purge gas mixture out of specification Purge gas contaminated with oil or moisture Human error -- fail to inert the purge line in accordance with procedure	Fuel reaction with contaminants	Hydrogen deflagration Thermal runaway		F2	F2	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Labeling and color of helium and argon gas bottles are distinctive and help prevent hooking up the wrong purge gas. (Note: Refer to SNF-3328[b] for documentation on thermal runaway reactions.) Verify helium minimum purity from sample on receipt at the CSB for any inert gas cylinders used to supply the inert gas system Inert the supply lines after they have been depressurized before using inert gas system

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-J-06a	Explosives or pyrophorics - hydrogen	A flammable hydrogen-air mixture, and an ignition source is present	Hydrogen formation in the MCO is due to corrosion of uranium by water	Deflagration or detonation within the MCO	MCO failure Uncontrolled release of hazardous material		F2	F2	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	The established bounding aluminum hydroxide value of 10.6 kg/MCO (99% confidence level) provides assurance that oxygen concentrations will be below the lower flammability limits during the 40-year interim storage period.[c] MCO is inerted. The drying process at the CVDF will ensure MCO pressures are relatively low during the receiving process.
Sampling/ weld area WS-J-06b	Explosives or pyrophorics - hydrogen	Hydrogen collects in MCO headspace	Leaky MCO during delay at weld area	Hydrogen forms flammable mixture and ignites	Hydrogen deflagration		F0	F0	None	S1 This event meets evaluation guidelines for a beyond extremely unlikely event.	S1	Weld hood exhaust is running while hood is in place Procedures will address delays
Sampling/ weld area WS-J-07 WS-L-14	Explosives or pyrophorics - acetylene gas	Flammable gas	Human error Mechanical failure	Flammable gas in the weld area ignites	Personnel injury	None	F2	F2	The combustible materials in the weld area are limited by the CSB Fire Hazard Analysis[d] and Implementation Plan and thus use of acetylene is prohibited.	S1	S1	

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-J-10a	Explosives or pyrophorics - plutonium and uranium metal, zirconium (uranium hydride)	Pyrophoric material exposed to air, and sufficient surface area and temperature are present	Shear of sampling lines MCO seal leak	Pyrophoric material ignites	Personnel injury Contamination release Damage to the MCO	Air inleakage is not sufficient for runaway reaction (SNF-3328)[b]	F0	F0	None	S3 This event meets evaluation guidelines for a beyond extremely unlikely event.	S3	Spontaneous ignition is precluded by the low fuel temperature expected during interim storage (~120 °C). A temperature over 300 °C is needed before spontaneous ignitions occurs.
Sampling/ weld area WS-J-10b	Explosives or pyrophorics -plutonium and uranium metal (uranium hydride)	Fuel water reaction	Insufficient drying at CVDF	Pyrophoric material ignites uranium	Personnel injury Contamination release Damage to the MCO	MCO acceptance specification limits free water to less than 200 g	F1	F0 Frequency analysis indicates that this unmitigated scenario frequency is less than 1E-6/yr.	None	S3	S3	Spontaneous ignition is precluded by the low fuel temperature expected during interim storage (~120 °C). A temperature over 300 °C is needed before spontaneous ignitions occurs.
Sampling/ weld area WS-K-12 WS-K-15	Nuclear criticality - cranes and lifts, MCO	This hazard is addressed in HNF-3553, Annex A, Chapter A6.0[e] — no new hazards have been identified.										
Sampling/ weld area WS-L-02 WS-L-04 WS-L-06 WS-L-10 WS-L-13 WS-L-16	Flammable materials - rags, lubricating oil, paints and solvents, grease, MHM neutron absorber, dye pen solvents, temporary greenhouse material, weld hood bonnet	The combustible materials in the weld area are limited by the CSB Fire Hazard Analysis[d] and Implementation Plan.										

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-L-11	Flammable materials - hydrogen	A flammable hydrogen-air mixture and an ignition source is present	Hydrogen release from MCO caused by mechanical seal failure or sampling line failure	Deflagration or detonation	Catastrophic failure of process lines, including process hood and HEPA filter Uncontrolled release of hazardous material	TSR: Verification of minimum air flow rate for hydrogen gas dilution (5 ft^3/min in the hood)	F3	F3	None Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	S2	S1	Ventilation flows may dilute hydrogen concentrations below the LFL. MCO valve operator Sampling hood exhaust system (hood, ducting, HVAC fan) Performance of pressure test of sampling connections, operator and hose assembly, including that the sample line and connection leaks less than 40 cm^3/s Independent verification of sampling connection assembly and performance of the pressure test of the sample assembly
Sampling/ weld area WS-M-07	Hazardous materials - toxic (plutonium and uranium)	Radiological limits are more restricting than toxicological limits for spent nuclear fuel.[f]										
Sampling/ weld area WS-N-01 WS-N-03	Ionizing radiation sources (MCO contents)	Ionizing radiation	Presence of fissile material in the MCO	Failure to install proper shielding during MCO insertion or removal from the sampling/weld area	Increased risk of exposure to facility workers	None	F3	F3	None	S1	S1	Personnel are trained to facility procedures that require shielding installation before raising or lowering an MCO into a sampling/ weld pit. Sampling/weld area has removable shielding (temporary, during insertion and removal).
		Surface contamination	Loss of contamination control	Spread of contamination	Increased potential for exposure to ionizing radiation Environmental impact	None	F3	F3	None	S1	S1	See Chapter A7.0 of HNF-3553, Annex A,[e] for radiological protection controls.

Table 21. Canister Storage Building Hazard Analysis: Sampling/Weld Area. (11 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Sampling/ weld area WS-P-01 WS-P-02 WS-P-03 WS-P-04	External events	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P).										
Sampling/ weld area WS-Q-01 WS-Q-02 WS-Q-03	Vehicles in motion	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-Q).										
Sampling/ weld area WS-R-01 WS-R-03 WS-R-04 WS-R-05 WS-R-06 WS-R-07 WS-R-08 WS-R-09 WS-R-10	Natural phenomena	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R).										

[a] CSB-HV-0014, 1999, *Long Term MCO Temperature W/O Cooling in Sample Station*, Fluor Daniel, Incorporated, Richland, Washington.
[b] SNF-3328, 2000, *Canister Storage Building Design Basis Accident Analysis Documentation*, Rev. 2, Fluor Hanford, Incorporated, Richland, Washington.
[c] HNF-1527, 1999, *Estimates of Particulate Mass in Multi-Canister Overpacks*, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[d] HNF-SD-SNF-FHA-002, 2000, *Fire Hazard Analysis for the Canister Storage Building*, Rev. 3, Fluor Hanford, Incorporated, Richland, Washington.
[e] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Safety Analysis Report," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.
[f] HNF-SD-SNF-TI-059, 1999, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
HEPA = high-efficiency particulate air (filter).
HVAC = heating, ventilation, and air conditioning.
LFL = lower flammability limit.
OCRWM = Office of Civilian Radioactive Waste Management.
MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.
TSR = technical safety requirement.

F0 = Too improbable to warrant consideration for further accident analysis development.
F1 = Possible, but extremely unlikely.
F2 = Foreseeable, but unlikely.
F3 = Likely to occur during the lifetime of the facility.

S0 = Insufficient material and energy to adversely impact facility workers.
S1 = Sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.
S2 = Sufficient material and energy available to cause a high or moderate impact to the maximum onsite individual.
S3 = Sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.

Table 22. Canister Storage Building Hazard Analysis: Vault. (2 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Vault (including intake structure and exhaust stack) VL-B-07 VL-B-10 VL-B-11	Thermal - radioactive decay heat and chemical reaction	High heat in vault, tubes, and MCO	Loss or degradation of natural convection caused by - Accumulation of dust, tumbleweeds, ash, insects, and other debris - Blockage of inlet stack (e.g., frost covering the inlet plenum) - Oxidation layer forming on storage tubes - Failure of the inlet or exhaust stack caused by tornado forces or earthquake forces - Range fire smoke and heat	Pressurization of MCOs Rise in fuel center line temperatures	Excessive temperatures for - MCOs - Concrete - Storage tubes or operating area Loss of structural integrity of vault walls and ceiling	Height and orientation of inlets and outlets reduce the likelihood of blockage. The stacks are designed to withstand significant forces without failing.	F1	F0 Frequency analysis indicates that this unmitigated scenario frequency is less than 1E-6/yr.	None	S3	S3	Differential temperature monitors are located on the outlet stack and provide indication of undesired trends. Screens on the inlet stacks reduce the likelihood of accumulation of debris in the vault. Routine check for potential blockage of inlet and outlet plenums.
Vault VL-K-15	Nuclear criticality - storage tubes	This hazard is addressed in HNF-3553, Annex A, Chapter A6.0.[a] — no new hazards have been identified.										
Vault VL-N-03	Ionizing radiation sources - radioactive sources	There is no access to this area, so this hazard, while present, is not a concern for worker safety.										

Table 22. Canister Storage Building Hazard Analysis: Vault. (2 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
VL-P-03	External events (water line break)	See OU-P-05 for analysis of water line break external to the facility.										
Vault VL-Q-01 VL-Q-02	Vehicles in motion - airplane, helicopter	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-Q).										
Vault VL-R-01 VL-R-04 VL-R-05 VL-R-07 VL-R-09 VL-R-10	Natural phenomena	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R).										

[a] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.

MCO = multi-canister overpack.

F1 = Possible, but extremely unlikely.

S3 = Sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.

Table 23. Canister Storage Building Hazard Analysis: Support Building.

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Support building SB-J-07	Explosives or pyrophorics - acetylene gas	Flammable gas	Human error Mechanical failure	Flammable gas in the support building ignites	Personnel injury	None	F2	F2	The combustible materials in the support building are limited by the CSB Fire Hazard Analysis[a] and Implementation Plan and thus use of acetylene is prohibited.	S1	S1	
Support building SB-L-01 SB-L-02 SB-L-04 SB-L-07 SB-L-08 SB-L-10 SB-L-11 SB-L-13 SB-L-16	Flammable materials - packing materials, rags, lubricating oil, diesel fuel, buildings and contents, grease, hydrogen(batteries), organics, forklift propane, clothing	The combustible materials in the support building are limited by the CSB Fire Hazard Analysis[a] and Implementation Plan.										
Support building SB-P-01 SB-P-02 SB-P-03 SB-P-04	External events	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P).										
Support building SB-R-01 SB-R-03 SB-R-04 SB-R-05 SB-R-06 SB-R-08 SB-R-09 SB-R-10	Natural phenomena	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R).										

[a] HNF-SD-SNF-FHA-002, 2000, *Fire Hazard Analysis for the Canister Storage Building*, Rev. 3, Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building. F2 = Foreseeable, but unlikely. S1 = Sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.

Table 24. Canister Storage Building Hazard Analysis: Outside. (8 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
OU-K-05	Nuclear criticality	This hazard is addressed in HNF-3553, Annex A, Chapter A6.0.[a]										
Outside OU-P-01	External events - explosion	External explosion resulting in a shock wave introduces dust, heat, and/or projectiles into the trailer vestibule and load-in/load-out area	Explosion from nearby gas delivery truck, propane delivery truck, or gas station	Shock wave and debris from explosion impact personnel Personnel are exposed to heat from explosion The shock wave from the explosion impacts the building	Damage to or failure of structures, systems, or components (e.g., facility structure, inert gas tube trailer, transformers) Personnel injury	The facility structure is designed to withstand significant external phenomena (e.g., tornado missiles, straight winds).	F2	F2	None	S1	S1	The CSB is isolated from major roads, reducing the possibility of explosions outside the facility affecting the CSB. CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.
Outside OU-P-02	External events - fire	Based on the current design, there is no external energy source that would have greater consequences than a fire inside the facility. The fire hazards analysis is responsible for evaluating fire hazards.[b]										
Outside OU-P-03	External events - nearby facilities	Radioactive material, toxic material, and ionizing radiation introduced into the facility	Descriptions of potential accidents at nearby facilities and their resulting consequences are addressed in HNF-3553, Annex A, Chapter A1.0.[a]	Descriptions of potential accidents at nearby facilities and their resulting consequences are addressed in HNF-3553, Annex A, Chapter A1.0.[a]	Personnel exposure to radioactive and toxic material from the nearby facility Contamination of the CSB from nearby facility release, potentially making the building uninhabitable	None	F1	F1	The distance of the CSB from other facilities reduces the consequences of external events.	S1	S1	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.

Table 24. Canister Storage Building Hazard Analysis: Outside. (8 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-P-04	External events - loss of power	Loss of power causes operational disruption and/or delays	Natural phenomena (lightning, rain, earthquake), man-made external hazards (vehicle impacts, transformer damage), internal effects (severed power cords, electrical shorts)	Loss of powered control functions to CSB equipment such as MHM ventilation flow, TV&P carts, cranes, sampling/weld area cooling and welding equipment.	Possible contamination spread (associated with loss of MHM or service tent ventilation sweep). Delays in the sampling/weld area may lead to excessive MCO temperatures (loss of power can result in welding electrode becoming embedded in the weld pool, requiring manual grinding and recovery).	None	F3	F3	None	S1	S1	The MHM has an alternate, manual means of control and operation
Outside OU-P-05	External events - water line breaks	Washout of compacted soil. Undetected water line break or leak	Reduced structural integrity of the CSB facility	Subsequent damage to the CSB vault structure during an earthquake	Underground pipe designed according to the standards of the AWWA	None	F0	F0	None	S3	S3	
Outside OU-Q-01 OU-Q-02	Vehicles in motion - airplane, helicopter	Crashes	Loss of flight control	Impact to facility structure Impact with nearby power lines	Personnel injury Loss of offsite power Operational delays	The possibility of an aircraft crash affecting the CSB facility is considered beyond extremely unlikely based on the discussion in Chapter 1.0 of HNF-3553 Annex A.[a]	F0	F0	None	S1	S1	Existing air traffic pattern means no runway close enough to threaten CSB. Five-foot-thick operating floor. Seismic air vent system.

Table 24. Canister Storage Building Hazard Analysis: Outside. (8 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-Q-04	Vehicles in motion - truck, bus, car	Impact on the CSB facility	Human error or mechanical failure	A vehicle could potentially impact - The transporter in the trailer vestibule or the tractor outside - Trailer vestibule structures, systems, or components - Facility personnel	Damage to the transporter and/or tractor, the transportation cask, personnel, or facility systems, structures and components	None	F2	F2	Transporter effects are not specifically considered for determining consequence, as this is addressed by the SARP.[c]	S1	S1	The roads near the facility are designed to guide vehicles around the facility, rather than directly toward the facility, thus limiting their potential to impact the facility. The transporter and transportation cask are designed to survive vehicle impacts without releasing radioactive or toxic materials. Speed limits are posted in the vicinity of the CSB to keep vehicle speeds low. There will be no more than one transporter in the CSB boundary at one time, reducing the potential for consequences involving two or more transporters.

Table 24. Canister Storage Building Hazard Analysis: Outside. (8 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-01	Natural phenomena - earthquake (DBE)	Acceleration forces exerted on the facility	Earthquake	Structural damage or collapse Damage to facility structures, systems, or components (e.g., receiving crane, cable trays, MHM) Damage to the MCO while in the cask, service station pit, MHM, or storage tube (causes include building collapse, a fall off the transporter or receiving crane, impact from a falling receiving crane or MHM, or shear due to seismic forces while being raised or lowered into a storage tube or pit) Increased surface exposure of MCO contents, providing the potential for increased reactions	Loss of - Ventilation - Primary inert gas supply - Facility power (see OU-P-04) Release of radiation caused by breached MCO Personnel injury	None	F2	F2	Rail frogs are installed to meet structural criteria. CSB is built to appropriate seismic criteria. The MHM and receiving crane are built to appropriate seismic criteria (passive barrier). The MHM is equipped with seismic clamps. The facility components (including the structure and systems such as the receiving crane) are designed such that impacts to safety systems from the failure of non-safety systems will not impact the function of those safety systems.	S3	S1	The MHM has a power-tripping function. Personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition. The receiving crane trips on loss of power. Seismic detectors.
Outside OU-R-03	Natural phenomena - lightning	High electrical energy	Lightning strike	Strike on the facility	Loss of power (see OU-P-04) Damage to structures, systems, or components Personnel injury	None	F2	F2	None	S1	S1	The CSB facility is equipped with lightning protection that includes lightning rods, grounding, and ground fault detectors. The facility provides shelter for workers.

Table 24. Canister Storage Building Hazard Analysis: Outside. (8 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-04	Natural phenomena - rain	Water intrusion into the facility	Leaks through the roof Volume of rain exceeds the capacity of the facility grading and drainage system to carry off rainwater, water enters through the trailer vestibule and other doorways	Water in electrical systems such as cable trays, receiving crane, or MHM components Flooded floors (including service station pit, maintenance pit, or storage tubes) Water intrusion into equipment external to the facility (e.g., the transformer)	Personnel injury caused by slips Loss of equipment or personnel injury from electrical shorts Loss of power (see OU-P-04)	None	F1	F1	The site grading is designed to prevent rain intrusion into the facility.	S1	S1	The facility is designed to prevent water intrusion and to provide shelter for workers. The receiving crane is designed to minimize the potential for water intrusion into its electrical components. The electrical design within the facility minimizes potential consequences (electrical conduit inhibits fire spread caused by shorts). The storage tubes are normally covered. The facility design takes into consideration the need for nonskid surfaces.
					Modified criticality parameters within the storage tube and/or vault	This hazard is addressed in HNF-3553, Annex A, Chapter 6.0[a] — no new hazards were identified.						

Table 24. Canister Storage Building Hazard Analysis: Outside. (8 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-05	Natural phenomena - snow, freezing weather	Snow loading Extreme cold Modified criticality parameters in the vault	Snow storm, cold weather	Roof collapse (resulting in internal equipment damage) Damage to equipment outside the facility structure (e.g., inert gas tube trailer, transformer)	Personnel injury from collapsed roof or exposure to the cold Ice buildup Loss of power (see OU-P-04) Loss of primary inert gas supply	None	F2	F2	The building is designed to withstand anticipated snow loads.	S1	S1	The SARP prohibits MCO shipping during adverse weather conditions[c] (see Section 4.3.3, Part A) The facility is heated. The facility provides shelter for workers. Snow load combinations were evaluated in the design basis. Criticality hazards are addressed in HNF-3553, Annex A, Chapter A6.0[a] — no new hazards were identified.
Outside OU-R-06	Natural phenomena - straight wind (90 mi/h)	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Structures, systems, or components damaged by flying debris (e.g., inert gas tube trailer, transformer) Visibility reduced Accumulated debris	Personnel injury Restricted access to the facility Loss of power (see OU-P-04) Loss of primary inert gas supply	None	F2	F2	The facility structure and outer door are designed to withstand a design basis straight wind.	S1	S1	The facility provides shelter for workers. Tornado wind speeds were considered in the design of building structures. Area around CSB is regularly inspected (housekeeping inspections) and possible stray missiles (e.g., 2-by-4s) are removed.
Outside OU-R-07	Natural phenomena - dust devil	Flying debris Dust	Pressure gradient	Personnel struck by flying debris Visibility reduced Accumulated debris	Personnel injury	None	F3	F3	None	S1	S1	The facility provides shelter for workers.

Table 24. Canister Storage Building Hazard Analysis: Outside. (8 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-08	Natural phenomena - tornado (40 mi/h translational, 160 mi/h rotational; pressure drop, 0.9 lb/in^2 at 0.3 $lb/in^2/s$)	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Structures, systems, or components damaged by flying debris (e.g., inner or outer doors, transporter, receiving crane, MHM, service tent, TV&P carts, transformer, inert gas tube trailer, ventilation) Visibility reduced Accumulated debris	Personnel injury Restricted access to the facility Loss of power (see OU-P-04) Loss of primary inert gas supply	None	F1	F1	The facility superstructure is designed to withstand the forces of design basis tornado wind loads.	S1	S1	The facility provides shelter for workers. CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition. Missile strikes caused by tornado forces have an estimated frequency of 4×10^{-9} events/yr (refer to Chapter A1.0 of HNF-3553, Annex A[a]). Area around CSB is regularly inspected (housekeeping inspections) and possible stray missiles (e.g., 2-by-4s) are removed.
Outside OU-R-09	Natural phenomena - ashfall	Ash loading on roof	Volcanic eruption	Roof collapse Damage to structures, systems, or components (e.g., ventilation, transformer, and internal equipment affected by roof collapse) Ash intrusion	Personnel injury Equipment damage Loss of power (see OU-P-04)	None	F2	F2	The building is designed to withstand anticipated ash loadings.	S1	S1	Ashfall was combined with other structural loadings in the design basis.

Table 24. Canister Storage Building Hazard Analysis: Outside. (8 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-10	Natural phenomena - range fire	Windborne embers Smoke	Dry conditions and ignition	Reduced visibility Secondary fire from flying embers Damage to structures, systems, or components (e.g., inert gas tube trailer, transformer)	Loss of power (see OU-P-04) Personnel injury Loss of primary inert gas supply	None	F3	F3	None	S1	S1	The facility is designed with noncombustible materials (Type II-N). Personnel control and clear the vegetation in the vicinity of the CSB to reduce the impact of range fires. CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition. Fire systems, sprinklers, and Hanford Fire Department.

[a] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.
[b] HNF-SD-SNF-FHA-002, 2000, *Fire Hazard Analysis for the Canister Storage Building*, Rev. 3, Fluor Hanford, Incorporated, Richland, Washington.
[c] HNF-SD-TP-SARP-017, 1999, *Safety Analysis Report for Packaging (Onsite) Multi-Canister Overpack Cask*, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

AWWA = American Water Works Association.
CSB = Canister Storage Building.
DBE = design basis earthquake.
MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.
SARP = safety analysis report for packaging.[c]
TV&P = tube vent and purge

F0 = Too improbable to warrant consideration for further accident analysis development.
F1 = Possible, but extremely unlikely.
F2 = Foreseeable, but unlikely.
F3 = Likely to occur during the lifetime of the facility.

S0 = Insufficient material and energy to adversely impact facility workers.
S1 = Sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.
S2 = Sufficient material and energy available to cause a high or moderate impact to the maximum onsite individual.
S3 = Sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.

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Table 25. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (7 sheets)

Designator	Hazardous energy source	Hazardous condition and initiators	Bin	Release energy	Frequency/ consequence codes
TV-G-13	Mass, gravity, height - vessels (transportation cask)	Transportation cask falls from the receiving crane to the trailer vestibule floor.	Mechanical damage of MCO	Medium	F2/S2
SA-E-07	Rotational kinetic - MHM rotational movement	MHM movement while raising an MCO causes a shear force on • An MCO, causing a breach	Mechanical damage of MCO	Low	F3/S2
SA-F-05	Linear kinetic - MHM	MHM movement into overlap area strikes receiving crane lowering the cask-MCO into the receiving pit which causes a shear force on • An cask-MCO, causing a breach	Mechanical damage of MCO	Medium	F3/S2
SA-F-07b	Linear kinetic - receiving crane lateral movement	Receiving crane movement while lowering a cask-MCO into the receiving pit which causes a shear force on • An cask-MCO, causing a breach	Mechanical damage of MCO	Medium	F3/S2
SA-F-07c	Linear kinetic - MHM	MHM movement into overlap area strikes receiving crane lowering the cask-MCO into the receiving pit which causes a shear force on • An cask-MCO, causing a breach	Mechanical damage of MCO	Medium	F3/S2
SA-F-07d	Linear kinetic - MHM lateral movement	MHM movement while raising an MCO causes a shear force on • An MCO, causing a breach	Mechanical damage of MCO	Low	F2/S2

Table 25. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (7 sheets)

Designator	Hazardous energy source	Hazardous condition and initiators	Bin	Release energy	Frequency/ consequence codes
SA-F-07e	Linear kinetic - MHM lateral movement	MHM movement while raising an MCO during an earthquake causes a shear force on • An MCO, causing a breach	Mechanical damage of MCO	Low	F2/S2
SA-G-03a	Mass, gravity, height - lifts and cranes - structure and equipment	Rigging, yoke, or other lifting equipment drops from the receiving crane (caused by human error or mechanical failure) and results in a gaseous release from • An MCO that is breached	Mechanical damage of MCO	Medium	F2/S2
SA-G-03c	Mass, gravity, height - lifts and cranes - structure and equipment	A cask lid drop from the gantry crane (caused by human error or mechanical failure) results in a gaseous release from • An MCO that is breached	Mechanical damage of MCO	Medium	F2/S2
SA-G-03d	Mass, gravity, height - lifts and cranes - structure and equipment	Cask receiving pit plug drop from the MHM (caused by human error or mechanical failure) and results in a gaseous release from • An MCO that is breached	Mechanical damage of MCO	Low	F2/S2
SA-G-13a	Mass, gravity, height - vessels (transportation cask, MCO)	A drop from the receiving crane (caused by human error or mechanical failure) results in a gaseous release from • A cask–MCO that is breached, which drops from the receiving crane as it is moved to receiving pit	Mechanical damage of MCO	Medium	F2/S2

Table 25. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (7 sheets)

Designator	Hazardous energy source	Hazardous condition and initiators	Bin	Release energy	Frequency/ consequence codes
SA-G-13b	Mass, gravity, height - vessels (transportation cask, MCO)	A drop from the receiving crane (caused by human error or mechanical failure) results in a gaseous release from • A cask–MCO that is breached, which drops from the receiving crane into the service pit	Mechanical damage of MCO	Medium	F2/S2
SA-G-13c	Mass, gravity, height - vessels (transportation cask, MCO)	A drop from the receiving crane (caused by human error or mechanical failure) results in a gaseous release from • A cask–MCO that is breached, which drops from the receiving crane onto edge or into maintenance pit	Mechanical damage of MCO	Medium	F2/S2
SA-G-13d	Mass, gravity, height - vessels (MCO)	A drop from the MHM (caused by human error or mechanical failure) results in a gaseous release from • An MCO that is breached, which drops from the MHM onto edge of cask at the service pit (eccentric onto service pit)	Mechanical damage of MCO	Medium	F2/S2
SA-G-13e	Mass, gravity, height - vessels (MCO)	A drop from the MHM (caused by human error or mechanical failure) results in a gaseous release from • An MCO that is breached, which drops from the MHM back into the cask at the service pit	Mechanical damage of MCO	Medium	F2/S2
SA-G-13f	Mass, gravity, height - vessels (MCO)	A drop from the MHM (caused by human error or mechanical failure) results in a gaseous release from • An MCO that is breached, which drops from the MHM onto or into maintenance pit or tube plug exchange facility	Mechanical damage of MCO	Medium	F1/S2

Table 25. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (7 sheets)

Designator	Hazardous energy source	Hazardous condition and initiators	Bin	Release energy	Frequency/ consequence codes
SA-G-13g	Mass, gravity, height - vessels (MCO)	A drop from the MHM (caused by human error or mechanical failure) results in a gaseous release from • An MCO that is breached, which drops from the MHM onto or into the FFTF pit	Mechanical damage of MCO	Medium	F1/S2
SA-J-06a	Explosives or pyrophorics - hydrogen	Radiolysis of aluminum hydroxide results in hydrogen and oxygen, which upon ignition creates an explosion internal to the MCO resulting in an MCO failure and release of radioactive material.	Deflagrations	High	F2/S3
SA-J-10b	Explosives or pyrophorics - plutonium and uranium metal, zirconium	Fuel reacts with water forming hydrogen and oxygen. Pyrophoric material ignites uranium.	Reactions with fuel	High	F1/S3
OA-E-07	Rotational kinetic - MHM rotational movement	MHM movement while raising an MCO causes a shear force on • An MCO, causing a breach	Mechanical damage of MCO	Low	F3/S2
OA-F-07a	Linear kinetic - MHM lateral movement	Movement of the MHM before the MCO is fully lowered shears • The MCO itself, causing a breach and a gaseous release	Mechanical damage of MCO	Low	F2/S2
OA-F-07b	Linear kinetic - MHM lateral movement	Movement of the MHM due to an earthquake before the MCO is fully lowered shears • The MCO itself, causing a breach and a gaseous release	Mechanical damage of MCO	Low	F2/S2

Table 25. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (7 sheets)

Designator	Hazardous energy source	Hazardous condition and initiators	Bin	Release energy	Frequency/ consequence codes
OA-G-03a	Mass, gravity, height - lifts and cranes - structure and equipment	Seismic event causes the canister storage building or CSB equipment to fall onto an MCO resulting in • A gaseous release from an MCO that is breached	Mechanical damage of MCO	Medium	F2/S2
OA-G-13b	Mass, gravity, height - vessels (MCO)	A dropped MCO impacts the CSB operating deck OR vault 2 or 3 storage tube covers OR storage tube plug resulting in • A gaseous release from an MCO that is breached	Mechanical damage of MCO	Medium	F1/S2
OA-G-13c	Mass, gravity, height - vessels (MCO)	An MCO drops to the bottom of a storage tube resulting in • A gaseous release from an MCO that is breached	Mechanical damage of MCO	Medium	F2/S2
OA-G-13d	Mass, gravity, height - vessels (MCO)	An MCO drops onto the edge of a storage tube resulting in • A gaseous release from an MCO that is breached	Mechanical damage of MCO	Medium	F2/S2
OA-J-06a	Explosives or pyrophorics - hydrogen	Radiolysis of uranium hydrates, aluminum hydride and free water results in hydrogen and oxygen, and mixture ignites inside the MCO.	Deflagrations	High	F2/S2
OA-J-10b	Explosives or pyrophorics - plutonium and uranium metal, zirconium	Fuel reacts with water forming hydrogen and oxygen. Pyrophoric material ignites uranium.	Reactions with fuel	High	F1/S3
WS-E-07	Rotational kinetic - MHM rotational movement	MHM movement while raising an MCO causes a shear force on • An MCO, causing a breach	Mechanical damage of MCO	Low	F3/S2

Table 25. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (7 sheets)

Designator	Hazardous energy source	Hazardous condition and initiators	Bin	Release energy	Frequency/ consequence codes
WS-F-02 WS-F-05	Linear kinetic - forklifts, dollies, carts, crane loads	Movement of the crane supporting the sample hood or collision with that crane or the sample cart causes shearing of the sampling lines connected to the MCO.	Pressurized release	Medium	F2/S2
WS-F-07a	Linear kinetic - MHM lateral movement	Movement of the MHM before the MCO is fully lowered shears • The MCO itself, causing a breach and a gaseous release	Mechanical damage of MCO	Low	F2/S2
WS-F-07b	Linear kinetic - MHM lateral movement	Movement of the MHM due to an earthquake before the MCO is fully lowered shears • The MCO itself, causing a breach and a gaseous release	Mechanical damage of MCO	Low	F2/S2
WS-G-03a	Mass, gravity, height - lifts and cranes - structure and equipment	Seismic event causes the MHM carrying an MCO to fall onto the operating deck resulting in • A gaseous release from an MCO that is breached	Mechanical damage of MCO	Medium	F2/S2
WS-G-04b WS-G-06b WS-G-07b	Mass, gravity, height - lifts and cranes, slings (covers)	Equipment dropped, or colliding with, the sample line can result in the shear of the sample line.	Pressurized release	Medium	F3/S2
WS-G-13a	Mass, gravity, height - vessels (MCO)	An MCO dropped from the MHM impacts the impact absorber in the bottom of the sampling/weld area resulting in • A gaseous release from an MCO that is breached	Mechanical damage of MCO	Medium	F2/S2
WS-G-13b	Mass, gravity, height - vessels (MCO)	An MCO dropped from the MHM impacts the edge of the sampling/weld area pit resulting in • A gaseous release from an MCO that is breached	Mechanical damage of MCO	Medium	F2/S2

Table 25. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (7 sheets)

Designator	Hazardous energy source	Hazardous condition and initiators	Bin	Release energy	Frequency/ consequence codes
WS-H-06a WS-H-07 WS-H-11	Pressure, volume - pressure vessels (MCO), gas receivers (accumulators), inert gas lines	Regulator failures cause high pressures in the MCO during reinerting, or heat buildup causes high pressures in the MCO.	Pressurized release	High	F1/S2
WS-H-06b	Pressure, volume -MCO	Inappropriate purge gas used for processing operations results in MCO reactions.	Deflagrations	High	F2/S2
WS-J-06a	Explosives or pyrophorics - hydrogen	A flammable hydrogen mixture is created and a deflagration occurs within the MCO in the sampling/weld area.	Deflagrations	High	F2/S2
WS-J-10b	Explosives or pyrophorics - plutonium and uranium metal (uranium hydride)	Fuel reacts with water forming hydrogen and oxygen. Pyrophoric material ignites uranium.	Reactions with fuel	High	F1/S3
WS-L-11	Flammable materials - hydrogen	A flammable hydrogen-air mixture is released from the MCO because of seal failures or sampling line failures and an ignition source.	Deflagrations	High	F3/S2
VL-B-07, VL-B-10, VL-B-11	Thermal - radioactive decay heat	High heat in the vault tubes causes pressurization of the MCOs, or structural degradation of the vault.	Violation of design temperature criteria	Medium	F1/S3
OU-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	Acceleration forces exerted on the facility could cause structural integrity failure of the CSB	Reactions with fuel	Medium	F2/S3

CSB = Canister Storage Building.
DBE = Design Basis Earthquake.
FFTF = Fast Flux Test Facility.
MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.

F1 = Possible, but extremely unlikely.
F2 = Foreseeable, but unlikely.
F3 = Likely to occur during the lifetime of the facility.

S2 = Sufficient material and energy available to cause a high or moderate impact to the maximum onsite individual.
S3 = Sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.

Table 26. Binned Listing of Candidate Accidents. (2 sheets)

Candidate accident	Risk ranking[a]	Release or change energy[b]	Reference designator
Mechanical damage of MCO (HNF-3553, Annex A, Section A3.4.2.1)			
Possible mechanical damage of MCO due to a drop	5	Medium[c]	TV-G-13
	5	Medium[c]	SA-G-13a, -13b, -13c, -13d, -13e
	5	Medium[c]	OA-G -13c,-13d
	5	Medium[c]	WS-G-13a, 13b
	3	Medium[c]	SA-G-13f, -13g
	3	Medium[c]	OA-G-13b
Possible mechanical damage of MCO due to a shear	7	Low	SA-E-07
	7	Medium	SA-F-05
	7	Medium	SA-F-07b, -07c
	7	Low	OA-E-07
	7	Low	WS-E-07
	5	Low	SA-F-07d
	5	Low	SA-F-07e
	5	Low	OA-F-07a
	5	Low	OA-F-07b
	5	Low	WS-F-07a
	5	Low	WS-F-07b
Possible mechanical damage of MCO due to an impact other than drop or shear of cask-MCO or MCO	5	Medium	SA-G-03a, -03c
	5	Medium	OA-G-03a
	5	Medium	WS-G-03a
	5	Low	SA-G-03d
Gaseous release from the MCO (HNF-3553, Annex A, Section A3.4.2.2)			
Pressurized release from MCO	7	Medium	WS-G-04b, -06b, -07b
	5	Medium	WS-F-02, -05
	3	High	WS-H-06a, -07, -11
MCO internal hydrogen explosion (HNF-3553, Annex A, Section A3.4.2.3)			
Hydrogen deflagration	8	High	SA-J-06a
	5	High	OA-J-06a
	5	High	WS-H-06b
	5	High	WS-J-06a
MCO external hydrogen explosion (HNF-3553, Annex A, Section A3.4.2.4)			
External deflagration	7	High	WS-L-11
Thermal runaway fuel reactions inside the MCO (HNF-3553, Annex A, Section A3.4.2.5)			
Runaway reaction	Note d	Note d	WS-H-06b
Fuel reaction with water	8	Medium	OU-R-01
	6	High	SA-J-10b
	6	High	OA-J-10b
	6	High	WS-J-10b

Table 26. Binned Listing of Candidate Accidents. (2 sheets)

Candidate accident	Risk ranking[a]	Release or change energy[b]	Reference designator
Violations of design temperature criteria (HNF-3553, Annex A, Section A3.4.2.6)			
Violation of design temperature criteria[b]	6	Medium	VL-B-07, -10, -11

[a]The risk ranking is derived from methodology found in DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, which correlates the consequence–frequency pairs assigned by the hazard analysis (HNF-SD-SNF-HIE-001) to a single-scale risk ranking using a figure reproduced in Figure 3-1 of the SNF Project FSAR.

[b] Definition and use of energy release categories (high, medium, low) are based on guidance and examples in DOE-STD-3009-94.

[c]Energy was considered that could damage an MCO — falling onto the deck was viewed as higher energy than falling into the service or sample pit with impact absorbers present; falling into the tube with impact absorbers present was viewed as higher energy than falling into the service or the sample pit with an impact absorber present.

[d]Before detailed analysis was performed, the hazard evaluation identified WS-H-06b as a serious hazard to be evaluated. Subsequent detailed analysis has shown that thermal runaway reactions are not possible at the CSB given limitation of water and resulting temperature.

MCO = multi-canister overpack.

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Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-B-07	Thermal - radioactive decay heat and chemical reaction	Hot gases Hot surface (below tube cover assembly)	Decay heat and chemical reactions MCO may be damaged allowing spent nuclear fuel to react with air	Exceeding the design temperature of the MCO	Hot gases are released into the overpack storage tube by the MCO Equipment failure (e.g., storage tube seals, purge cart components) Personnel injury Leakage criteria of tube plug seals exceeded	Tube assemblies and seals designed for 150 °F service (300 °F maximum) temperature. Tube plugs required to be tested each time the plug is installed. Tube plug lockdown device holds plug in place for pressures up to 75 lb/in^2 gauge. Overpack storage tubes are inerted	FRxF2	FRxF1	None	SRxS0	SRxS0	Reaction rates are relatively slow at initial MCO temperatures Insufficient water is available in the MCO for a thermal runaway reaction
Operating area OA-D-01	Corrosives - acids (purge cart battery)	Corrosives	Battery acid in storage tubes	Acid causes corrosion of storage tubes and MCOs	Loss of storage tube integrity Loss of MCO integrity SNF exposure to vault atmosphere	Cart battery is located in isolated compartment.	F0	F0	None	SRxS2	SRxS2	Maintenance-free batteries are used on tube vent and purge cart Periodic battery inspections are performed. Written charging procedures are used. Reputable battery vendor is used.
Operating area OA-F-02	Kinetic/linear	Impacts or collisions with overpack shield plug assembly	Operator error	Loss of tube, port integrity	Potential explosive release of gas		FRxF2	FRxF2	None	SRxS2	SRxS2	

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-F-07	Linear kinetic - MHM lateral movement	MHM impact Moving MHM creates a shearing force (at floor level) on a lowered MCO or on the supporting lifting cable and pneumatic lines of the MHM	Human error in moving the MHM Human error in mislocating equipment where it is susceptible to MHM impacts Mechanical failure of the MHM Electrical interlock failure of the MHM	Impact with - Carts - Personnel - Misplaced equipment Puncture or rip of the MCO resulting in a breach Shearing forces on the lifting cable and pneumatic lines resulting in the MCO being dropped into the storage tube with no controls or ungrappling capability (refer to OA-G-03 for specific details on drops)	Personnel injury Damage to structures, systems, or components (e.g., TV&P carts, MHM) Loss of containment (i.e., the MCO) with contamination of the storage tube and/or MHM MHM drive damaged and locked up Lifting cable and/or pneumatic lines sheared off	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	FRxF2	FRxF2	None	SRxS1	SRxS1	The MHM is designed to ASME NOG-1[a] to preclude tipping. The frogs on the MHM's tracks have stops. Electrical interlocks relative to receiving crane and MHM positioning along their respective tracks preclude the presence of both the MHM and the receiving crane in the load-in/load-out area simultaneously. The MHM has an auditory indication of its movement (i.e., alarms). The MHM has a collision avoidance system that detects obstacles to its movement. The MHM is limited to relatively slow movement. MHM resolver indicates MCO's relative position within the storage tube and/or MHM while it is being lowered or raised. The MHM is provided with a backup grapple disengagement capability. Personnel are trained to procedures detailing the safe sequence of operations. These procedures prohibit interferences between the receiving crane and the MHM.

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
OA-F-07 (cont'd)												MHM design includes seismic-disconnect system and seismic restraints. MHM design includes interlocks (electrical and mechanical) that prohibit any horizontal movement, linear or rotational, while an MCO is loaded but not fully raised.
Operating area OA-G-03 OA-G-13	Mass, gravity, height - lifts and cranes (including loads), vessels (MCO)	Kinetic energy	Human error Mechanical failure	Dropped MCO impacts - MHM turntable - Top and sides of standard storage tube - Bottom of standard tube if impact absorber not present (~50-ft drop) - Other MCO in the tube (double failure if impact absorber not installed)	Damage to the MCO Mark IA fuel basket centering tube moved off center		FRxF2	FRxF2		SRxS1	SRxS1	Impact absorbers are placed in intermediate positions. The MHM grapple is designed such that it cannot release while a load is being suspended from it. Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM.

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-G-14	Mass, gravity, height - lifts and cranes (including loads), vessels (MCO), other - tube plugs and impact absorbers	Kinetic energy	Human error Mechanical or equipment failure	Drop of standard tube plug, impact absorber, cover plate assembly, seal ring, or rigging equipment, or MCO	Damage to storage tube Damage to the MHM turntable Damage to grapple point (inability to remove damaged MCO) Damaged tube plug, embed, or impact absorber Damage to tube sealing surface or seal ring surface Impact absorber stuck in tube	None Design dimensions make it impossible for the tube plug to impact the MCO. Analysis shows that there is no breach of an MCO due to the drop of the intermediate impact absorber.	FRxF2	FRxF2	None	SRxS0	SRxS0	The MHM grapple is designed such that it cannot release while a load is being suspended from it. However, miscalibration of limit switches may be a common mode failure of the MHM grapple. Lifting devices used at the CSB are designed to handle the loads they will carry. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM.

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-H-06c	Volume, pressure - pressure vessels (overpack storage tube)	Hot gases under pressure reach release pressure	Failed MCO Excessive vault temperature Chemical reaction in MCO	Release caused by leaking tube seals Release caused by tube relief valve actuation Release caused by tube failure (into vault)	Excessive temperature in vault Flammable atmosphere on operating deck Contamination release to operating deck Flammable atmosphere in tube Contamination in tube Flammable atmosphere in vault Contamination release to vault		FRxF3	FRxF3	None	SRxS1	SRxS1	Building construction is Type II-N. Stack monitors detect tube failure. Tube vent and purge cart provide adequate purging to maintain nonflammable atmospheres. Area monitors detect releases to the operating deck. Periodic pressure monitoring, purging, and inerting will be performed by qualified operators using facility-specific procedures. A volumetric test of plug seals is conducted. Training and procedures on filter change-out operations are followed. The carbon steel tube material will maintain its integrity up to 700 °F Confinement provided by the storage tubes Inert gas environment maintained in the storage tube Tube plug lockdown device holds plug in place for pressures up to 75 lb/in^2 gauge

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-J-06d Vault VL-J-06	Explosives or pyrophorics - hydrogen (off normal MCO in an overpack storage tube)	Flammable hydrogen mixture and ignition source is present	Hydrogen release from tube to operating deck Hydrogen release from tube to vault Hydrogen release from MCO to tube with air present	Deflagration or detonation	Release of contamination to operating deck Operations delay Release to vaults Release to atmosphere Damage to tube Damage to MCO	Analysis indicates that this unmitigated scenario meets onsite evaluation guidelines.	FRxF3	FRxF3	None	SRxS1	SRxS1	Periodic pressure monitoring, purging, and inerting will be performed by qualified operators using facility-specific procedures. Accumulation of hydrogen is minimized (building HVAC). Oxygen getters remove oxygen. MCO penetrations are limited in size to reduce the rate of hydrogen release. Inert gas environment maintained in the storage tube. Inert helium atmosphere provided to preclude inleakage of air. Systems are in place to ensure adequate purging. Confinement provided by the storage tubes (passive). Tube plug lockdown device holds plug in place for pressures up to 75 lb/in^2 gauge. Lockdown device allows pressure to relieve before tube fails (passive). The carbon steel tube material will maintain its integrity up to 700 °F (passive).

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-J-10a	Explosives or pyrophorics -plutonium and uranium metal (uranium hydride)	Pyrophoric material exposed to air, and sufficient surface area and temperature are present	MCO seal leak allows air to enter the MCO	Pyrophoric material ignites uranium inside the MCO	Personnel injury Contamination release Damage to the MCO	Air inleakage is not sufficient for runaway reaction[b]	F0	F0	None	SRxS3 This event meets evaluation guidelines for a beyond extremely unlikely event.	SRxS3	Spontaneous ignition is precluded by the low fuel temperature expected during interim storage (~120 °C). A temperature over 300 °C is needed before spontaneous ignitions occurs.

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Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-N-01 OA-N-03	Ionizing radiation sources (MCO contents)	Ionizing radiation Release of fissile and/or radioactive materials entrained in pressurized gases within the MCO Exposure to direct radioactive streaming	Mechanical and (if present) weld seal failure Streaming from adjacent tube if tube plug is not in place	Gases with radioactive material escape from the MCO through failed mechanical seals Worker exposure caused by shine from adjacent tubes during storage or from MCO during transfer into or out of storage tube	An MCO release inside the MHM or storage tube could result in contamination of the MHM, storage tube, and operating area with fissile and/or radioactive materials (recovery actions are dealt with separately) A deflagration could result from the release of hydrogen Increased potential for direct exposure doses caused by missing tube plugs	None	FRxF2	FRxF2	MHM shielding (including shield skirt) , operating deck, and tube plug (passive barrier).	SRxS1	SRxS1	The MCO rupture disk is in a recessed location and blanked off with a cover plate. Personnel are trained to facility-specific procedures regarding MCO shipping, movement, handling, and site radiological control. Interlocks and sensors associated with the MHM are present to ensure the skirt is down before hoist operations are performed, and to ensure storage tube plugs are replaced before the MHM moves away from a storage tube position. The drying process at the CVDF ensures MCO pressures are relatively low until the MCO is installed in the storage tube. ASSUMPTION: The tube plugs will be installed in all tubes before MCO installation in any single tube. With all the storage tube plugs installed, radiation shine from adjacent tubes containing MCOs is not a concern. This idea is carried forward into Chapter A3.0 of the CSB FSAR[c] and as a control in Chapter A5.0 as AC5.12, "Tube Plug Placement."
		Surface contamination	Loss of contamination control	Spread of contamination	Increased potential for exposure to ionizing radiation Environmental impact	None	FRxF3	FRxF3	None	SRxS1	SRxS1	See Chapter A7.0 of HNF-3553, Annex A,[c] for radiological protection controls.

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Operating area OA-P-01 OA-P-02 OA-P-03 OA-P-04	External events	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P).										
Operating area OA-Q-01 OA-Q-02 OA-Q-03 OA-Q-04	Vehicles in motion	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-Q).										
Operating area OA-R-01 OA-R-03 OA-R-04 OA-R-05 OA-R-06 OA-R-08 OA-R-09 OA-R-10	Natural phenomena	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R).										

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	Acceleration forces exerted on the facility	Earthquake	Structural damage or collapse Damage to facility structures, systems, or components (e.g., receiving crane, cable trays, MHM) Damage to the MCO while in the cask, service station pit, MHM, or storage tube Increased surface exposure of MCO contents, potential for increased reactions	Loss of - Ventilation - Primary inert gas supply - Facility power Release of radiation caused by breached MCO Personnel injury Potential release of explosive gas	None	FRxF2	FRxF2	CSB is built to appropriate seismic criteria (passive barrier). The MHM and receiving crane are built to appropriate seismic criteria (passive barrier). The MHM is equipped with seismic clamps. The facility components (including the structure and systems such as the receiving crane) are designed 3/1.	SRxS1	SRxS1	The MHM has a power-tripping function. Personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.
Outside OU-R-03	Natural phenomena - lightning	High electrical energy	Lightning strike	Strike on the facility	Loss of power (see OU-P-04) Damage to structures, systems, or components Personnel injury	None	FRxF2	FRxF2	None	SRxS1	SRxS1	The CSB facility is equipped with lightning protection that includes lightning rods, grounding, and ground fault detectors. The facility provides shelter for workers. CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-04	Natural phenomena - rain	Water intrusion into the facility	Leaks through the roof Volume of rain exceeds the capacity of the facility grading and drainage system to carry off rainwater, water enters through the trailer vestibule and other doorways	Water in electrical systems such as cable trays, receiving crane, or MHM components Flooded floors (including service station pit, maintenance pit, or storage tubes) Water intrusion into equipment external to the facility (e.g., the transformer)	Personnel injury caused by slips Loss of equipment or personnel injury from electrical shorts Loss of power (see OU-P-04)	None	FRxF1	FRxF1	The site grading is designed to prevent rain intrusion into the facility.	SRxS1	SRxS1	The facility is designed to prevent water intrusion and to provide shelter for workers. The receiving crane is designed to minimize the potential for water intrusion into its electrical components. The electrical design within the facility minimizes potential consequences (electrical conduit inhibits fire spread caused by shorts). The storage tubes are normally covered. The facility design takes into consideration the need for nonskid surfaces.
					Modified criticality parameters within the storage tube and/or vault	This hazard is addressed in HNF-3553, Annex A, Chapter 6.0[c] — no new hazards were identified.						

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-05	Natural phenomena - snow, freezing weather	Snow loading Extreme cold Modified criticality parameters in the vault	Snow storm, cold weather	Roof collapse (resulting in internal equipment damage) Damage to equipment outside the facility structure (e.g., inert gas tube trailer, transformer)	Personnel injury from collapsed roof or exposure to the cold Ice buildup Loss of power (see OU-P-04) Loss of primary inert gas supply	None	FRxF2	FRxF2	The building is designed to withstand anticipated snow loads.	SRxS1	SRxS1	The SARP prohibits MCO shipping during adverse weather conditions[4] (see Section 4.3.3, Part A) CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition. The facility is heated. The facility provides shelter for workers. Snow load combinations were evaluated in the design basis. Criticality hazards are addressed in HNF-3553, Annex A, Chapter A6.0[c] — no new hazards were identified.
Outside OU-R-06	Natural phenomena - straight wind (90 mi/h)	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Structures, systems, or components damaged by flying debris (e.g., inert gas tube trailer, transformer) Visibility reduced Accumulated debris	Personnel injury Restricted access to the facility Loss of power (see OU-P-04) Loss of primary inert gas supply	None	FRxF2	FRxF2	The facility structure and outer door are designed to withstand a design basis straight wind.	SRxS1	SRxS1	The facility provides shelter for workers. Tornado wind speeds were considered in the design of building structures. Area around CSB is regularly inspected (housekeeping inspections) and possible stray missiles (e.g., 2-by-4s) are removed.
Outside OU-R-07	Natural phenomena - dust devil	Flying debris Dust	Pressure gradient	Personnel struck by flying debris Visibility reduced Accumulated debris	Personnel injury	None	FRxF3	FRxF3	None	SRxS1	SRxS1	The facility provides shelter for workers.

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-08	Natural phenomena - tornado (40 mi/h translational, 160 mi/h rotational; pressure drop, 0.9 lb/in^2 at 0.3 lb/in^2/s)	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Structures, systems, or components damaged by flying debris (e.g., inner or outer doors, transporter, receiving crane, MHM, service tent, TV&P carts, transformer, inert gas tube trailer, ventilation) Visibility reduced Accumulated debris	Personnel injury Restricted access to the facility Loss of power (see OU-P-04) Loss of primary inert gas supply	None	FRxF1	FRxF1	The facility superstructure is designed to withstand the forces of design basis tornado wind loads.	SRxS1	SRxS1	The facility provides shelter for workers. CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition. Missile strikes caused by tornado forces have an estimated frequency of 4 x 10^{-9} events/yr (refer to Chapter A1.0 of HNF-3553, Annex A[c]). Area around CSB is regularly inspected (housekeeping inspections) and possible stray missiles (e.g., 2-by-4s) are removed.
Outside OU-R-09	Natural phenomena - ashfall	Ash loading on roof	Volcanic eruption	Roof collapse Damage to structures, systems, or components (e.g., ventilation, transformer, and internal equipment affected by roof collapse) Ash intrusion	Personnel injury Equipment damage Loss of power (see OU-P-04)	None	FRxF2	FRxF2	The building is designed to withstand anticipated ash loadings.	SRxS1	SRxS1	Ashfall was combined with other structural loadings in the design basis.

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (14 sheets)

Location/ checklist entry	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency code		Credited mitigation	Consequence code		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-10	Natural phenomena - range fire	Windborne embers Smoke	Dry conditions and ignition	Reduced visibility Secondary fire from flying embers Damage to structures, systems, or components (e.g., inert gas tube trailer, transformer)	Loss of power (see OU-P-04) Personnel injury Loss of primary inert gas supply	None	FRxF3	FRxF3	None	SRxS1	SRxS1	The facility is designed with noncombustible materials (Type II-N). Personnel control and clear the vegetation in the vicinity of the CSB to reduce the impact of range fires. CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition. Fire systems, sprinklers, and Hanford Fire Department.

[a] ASME NOG-1, 1995, *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)*, American Society of Mechanical Engineers, New York, New York.
[b] SNF-3328, 2000, *Canister Storage Building Design Basis Accident Analysis Documentation*, Rev. 2, Fluor Hanford, Incorporated, Richland, Washington.
[c] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.
[d] HNF-SD-TP-SARP-017, 1999, *Safety Analysis Report for Packaging (Onsite) Multi-Canister Overpack Cask*, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
DBE = design basis earthquake.
HVAC = heating, ventilation, and air conditioning.
MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.

F0 = Too improbable to warrant consideration for further accident analysis development.
F1 = Possible, but extremely unlikely.
F2 = Foreseeable, but unlikely.
F3 = Likely to occur during the lifetime of the facility.
FR = Frequency of recovery event, which describes the undetermined likelihood of the "off-normal hazardous condition" developing following termination and recovery of the initial event; therefore, the off-normal frequency ranking is a product of FR and the frequency of the initial event (e.g., F3, F2, F1).

S0 = Insufficient material released to affect facility workers.
S1 = Sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.
S2 = Sufficient material and energy available to cause a high or moderate impact to the maximum onsite individual.
S3 = Sufficient material and energy available to cause a high or moderate impact to the maximum offsite individual.
SR = Severity of the recovery event, which describes the undetermined magnitude of release due to the unanalyzed condition of the damaged MCO; therefore, the off-normal consequence ranking is a product of SR and the consequence of the initial event (e.g., S3, S2, or S1).

Table 28. Binned Listing of Candidate Accidents for Off-normal Multi-Canister Overpack Storage.

Candidate accident	Risk ranking [a]	Release or change energy	Reference designator
Gaseous releases and explosions from overpack storage tubes			
Gaseous release in the overpack storage tube	FRxF2/SRxS0 FRxF2/SRxS2	Medium low	OA-B-07 OA-F-02
Hydrogen explosions in the overpack storage tube	FRxF3/SRxS2 FRxF2/SRxS2 FRxF2/SRxS2 FRxF2/SRxS2	Medium *High* Medium Low	OA-J-06d OU-R-01 VL-J-06 OA-F-02
Gaseous release from the overpack storage tube to the operating area	FrxF3/SRxS2	Medium	OA-H-06c

[a]FR Frequency of recovery event, which describes the undetermined likelihood of the "off-normal hazardous condition" developing following termination and recovery of the initial event; therefore, the off-normal frequency ranking is a product of FR and the frequency of the initial event (e.g., F3, F2, F1).

SR Severity of the recovery event, which describes the undetermined magnitude of release due to the unanalyzed condition of the damaged MCO; therefore, the off-normal consequence ranking is a product of SR and the consequence of the initial event (e.g., S3, S2, or S1).

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ATTACHMENT A

CANISTER STORAGE BUILDING
HAZARD ANALYSIS
TEAM MEMBERS

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ATTACHMENT A

CANISTER STORAGE BUILDING HAZARD ANALYSIS TEAM MEMBERS

The following is a list of the hazard analysis team members that have participated in any of the various stages of development of the Canister Storage Building (CSB) hazard analysis over is two years of development. Those members with an asterisk after their name were involved in the finalization of the hazard analysis for the CSB Final Safety Analysis Report.

Walter Alaconis	Maurice J. Higuera	James Mathews
Theodore Z. Anderson	Richard Hulskamp	Jeff Parker
Ralph D. Crowe*	Larry D. Kessie	Paul Patterson
William A. Frier	Steve D. Kopelic	Robert E. Piippo
Richard L. Garrett*	Dwight E. Krahn*	Thomas B. Powers*
Manuel Guzman	Maryanne Kummerer	David L. Scott
Danny R. Henry	Barclay S. Lew	W. Todd Watson
Taber G. Hersum	Yih Justin Liu*	

The members of the CSB hazard analysis team brought to the study the following experience.

Walter Alaconis

B.S., General Science, The University of the State of New York, Albany. Nearly 27 years of diversified nuclear safety and operations experience in the military, commercial, and U.S. Department of Energy (DOE) environments. Obtained registration with the National Registry of Radiation Protection Technologists in 1982. Over 16 years at the Hanford Site supporting major facility modifications and new facility design projects. Co-author of the Process Facility Modification Project Preliminary Safety Analysis Report. Managed the development of the Hanford Site Quality Training and Resource Center Root Cause Analysis Training Program and the Accident/Event Trending Program. Managed the Nuclear Engineering/Safety Data Management Unit for 4 years. Technical advisor to the Liquid Effluent Services Program at the Hanford Site and the Environmental Restoration Programs at the Hanford Site and DOE-Headquarters. Facilities supported at the Hanford Site include the tank farms (east), PUREX, B Plant, Plutonium Finishing Plant, Treated Effluent Disposal Facility, and Effluent Treatment Facility.

Theodore Z. Anderson

B.S., Mechanical Engineering. More than 24 years experience in facility operations, maintenance and quality assurance, and construction project quality assurance. Twenty years experience in existing nuclear facilities (Analytical Laboratory, fuel processing facilities) and new nuclear construction projects (tank farms, pipelines, spent nuclear fuel handling). Present position

includes project construction quality assurance support to CSB multi-canister overpack handling machine and receiving crane procurements.

Ralph D. Crowe

M.S., Nuclear Engineering and Engineering Management. Over 20 years experience in the nuclear industry performing calculations using multidimensional, time-dependent, neutron kinetics and thermal hydraulic codes. Six years experience performing safety analysis within the DOE environment for a number of facilities, including high-level waste tanks, Plutonium Finishing Plant, and spent fuel storage.

William A. Frier

Over 21 years experience in nuclear industry. Managed safety-class project upgrades, K Basin seismic analyses, Basins Life Extension Program, and K Basins Roof Repair Program. Current design authority for K Basins structures and cranes and hoists.

Richard Garrett

Seventeen years experience as a manager and lead engineer in safety analysis, regulatory support, and operations support of DOE and commercial nuclear power facilities. This includes 8 years of experience in commercial Boiling Water Reactor and Pressurized Water Reactor facility startup and operations with 9 years of experience at DOE production reactors, spent fuel storage, and high level waste facilities.

Manuel Guzman

Fourteen years experience in the nuclear industry. Started in the bargaining unit as a Chief Reactor Fuel operator at the N Reactor, worked up through the management chain as a shift supervisor responsible for around-the-clock operations loading, packaging, and shipping 120 metric tons of irradiated spent nuclear fuel per month. Transferred to the K Basins in a supervisory role and also served as a shift manager. Presently assigned to the CSB as a plant engineer in the Facility Startup and Operations organization providing input to the CSB design.

Danny R. Henry

B.A. degree. Over 19 years of varied Hanford Site work experience as an individual contributor and manager, involving both operational support and oversight functions at reactor, nuclear, and nonnuclear facilities. Experience includes positions and training as a firefighter and emergency medical technician, certified control room reactor operator, nuclear process standards engineer, senior reactor outage planner, outage manager at an operating production reactor facility, a

Principal Nuclear Safety Department. Responsible for the development and implementation of both a company-wide Occupational Safety and Health Administration (OSHA) compliance inspection program and an OSHA-based baseline hazard assessment program for Westinghouse Hanford Company, as well as the coordination of the company programs and activities for gaining acceptance into the DOE/OSHA Voluntary Protection Program. Served as the company contact for the Westinghouse government-owned, contractor-operated subcommittee on industrial safety and as the primary point of contact for discipline-related interface meetings with the DOE counterpart. Designated contact for external audits, assessments, and reviews involving the safety programs. Served on special safety task forces, including the review and selection of contracted safety and health services.

Taber G. Hersum

M.S., Nuclear Engineering, registered professional engineer (California). Twenty-six years experience in nuclear safety, reactor physics, fuel loading and power ascension testing, operations, and technical and quality consulting for nuclear power plants, nuclear fuel, and nuclear waste in the United States, Europe, and Japan. Currently a member of the Fluor Daniel Hanford, Inc., Nuclear Safety organization providing oversight review of Project Hanford Management Contractor safety basis documents requiring DOE approval. Previously certified as a senior reactor operator and ANSI 45.2.6 Level III senior reactor operator test engineer.

Maurice J. Higuera

B.S., Mechanical Engineering; M.S., Program Engineering Management; B.S., Human Biology/Organic Chemistry. Twenty-plus years experience in U.S. Nuclear Regulatory Commission and DOE regulatory environment. Areas of expertise include nuclear project management and engineering; environmental, safety, and industrial health; licensing and regulatory compliance; system process, operations hazard, and operability studies; outage planning and scheduling; and startup and testing and commissioning. Currently lead independent safety engineer and lead safety analysis report chapter author, engineering and coordinating input to the safety analysis report for the CSB spent nuclear fuel storage mission.

Larry D. Kessie, AIA

B.S., Architectural Studies, B. of Architecture, Registered Architect. Fifteen years experience in architectural design, design management, cost account management, project management, and construction administration in both the private and government sectors. Positions have ranged from that of a project architect and design office architect to temporary facility and site infrastructure design authority. Currently serving as consulting architect/design authority for site infrastructure and temporary facilities for Project W-379, Spent Nuclear Fuel CSB.

Steve D. Kopelic

B.S., Mechanical Engineering. Twenty years experience related to commercial pressurized water reactor electric generation stations. Experience includes reactor core design and testing, primary and secondary cooling systems accident analysis, preparation and defense of plant licensing documentation, probabilistic risk assessment, and implementation of design modifications on operating plants. Currently performing safety analyses and preparing safety analysis reports for the Spent Nuclear Fuel Project.

Dwight E. Krahn

B.S., General Engineering, field of specialty in Operations Research. Eight years experience in engineering and safety analysis activities. Training includes safety analysis development, root cause analysis, and risk assessment. Most recent work has been in the area of technical safety requirements for the Waste Encapsulation and Storage Facility and the tank farms.

Maryanne Kummerer

M.S., Mechanical Engineering. Fifteen years experience in engineering analysis in the area of heat transfer, multiphase fluid flow, thermodynamics, and chemical phenomena. Nine years performing calculations in support of safety analysis for various Hanford Site facilities and providing accident analysis contributions to safety documentation, including safety assessments and safety analysis reports.

Barclay S. Lew

Twenty-five years of nuclear industry experience in safety analysis, engineering applications, and licensing and regulatory affairs for U.S. and international electric utilities, DOE, and international laboratory facilities and universities. Senior manager at Pacific Gas & Electric Company (PG&E) in regulatory and safety analysis of PG&E's pressurized water reactor and boiling water reactor facilities. As a consultant, performed risk-based prioritization studies for several DOE facilities to assist in the segregation and focus of issues important to public safety, site worker safety, environmental, and mission. Prepared and evaluated safety analyses and risk analyses related to final safety analysis report limiting conditions for operation requirements, hazard evaluation, and operational conditions, including fire detection and protection, and risk/detection/reliability studies. Responsible for the development and implementation of light water reactor nuclear analytical methods and analysis for applications to encore physics, criticality analysis, fuel management, thermal-hydraulics, fuel element performance, transient safety, and accident analysis for pressurized water reactors for several U.S. utilities. Recently published numerical simulation of multiphase heat transfer and fluid flow and has numerous past publications in safety analysis and regulatory applications.

James Mathews

Over 25 years of experience in the chemical and nuclear industry. Sixteen years experience at the Hanford Site working in the Operations, Fuel Handling and Waste and Radiological Control organizations. Provided management direction and oversight of daily and special operations. Played an integral role during the K East fuel segregation program and the PUREX fuel shipping programs and later transitioned to managing decontamination and waste control activities after the shutdown of N Reactor. The past 2 years he has been the manager of Project Operations for the Spent Nuclear Fuel Project with responsibility for reviewing all designs and safety documentation to ensure that new facilities and components can be operated and maintained safely and efficiently. Certified as a nuclear material custodian, hazardous material/waste shipper, hazardous waste coordinator, and an unreviewed safety question evaluator for the Spent Nuclear Fuel Project.

Paul Patterson

Senior Reactor Operator, Hanford N Reactor. Seventeen years experience in nuclear power plant and facility operations, training, safety and procedure development. As a Senior Reactor Operator responsibilities included maintaining reactor safety during all modes of operation from the reactor control room. A certified DOE technical trainer and oral board examiner. Instructed reactor operator and senior reactor operator candidates and facility management in reactor process operations, heat transfer and fluid flow, reactor physics fundamentals, and accident analysis and safety basis. As a consultant, facilitator, and writer supporting various Hanford Site and Idaho National Engineering Laboratory projects over the past 10 years, led safety document and requirements processes and hazard analyses sessions; participated in operational readiness reviews; designed and developed training and qualification programs; presented specialized training programs; facilitated specialized group processes; and supported process and facility operating procedure development during final stages of engineering and facility start-up.

Robert E. Piippo

B.S., Industrial Technology. Eighteen years experience in program management, planning, operations, and engineering within the nuclear and aerospace industry. Positions have included program manager/chief engineer, nuclear safety assurance principal engineer, lead aerospace systems engineer, advanced engineering manager for N Reactor fuels manufacturing, manager for fuels manufacturing, and lead aerospace manufacturing engineer. Performed nuclear safety oversight as a member of the operational readiness review boards for the startup and operation of the UO_3 calcination processing facility, N Reactor irradiated fuel element encapsulation, and grouting of low-level liquid waste. Participated in nuclear safety appraisals for PUREX, B Plant/Waste Encapsulation and Storage Facility, and fuels manufacturing. Currently performing nuclear safety on the Spent Nuclear Fuel Program.

Thomas B. Powers

B.S., Chemical Engineering. Over 23 years of experience, including 15 years of experience in systems safety analysis and risk assessment for both nuclear and nonnuclear facilities and operations and 8 years of experience in environmental analysis, engineering design, and testing of nuclear and nonnuclear systems. Worked on N Reactor and Fast Flux Test Facility Level I probabilistic risk assessments and performed numerous safety analyses using preliminary hazard analyses, failure modes and effects analyses, fault trees, and event tree methods.

David L. Scott

M.S., Chemical Engineering. Twenty-six years of professional experience in safety analysis, process engineering, project engineering and development work related to the nuclear and petrochemical industries. Over 5 years of experience at the Hanford Site working in safety analysis and risk assessment. Work in other areas includes fluid flow analysis, pump and piping system design, uranium processing, N Reactor modification engineering, N Reactor nuclear fuel manufacturing, and organic chemical production.

W. Todd Watson

M.S., Physics (Experimental Nuclear Physics), University of Illinois at Urbana-Champaign. Six years experience in the development of nuclear measurement systems, instrumentation, and computer data acquisition and analysis systems. Experience performing computer modeling of radiation transport, including nuclear criticality analyses, dose rate predictions, and nuclear characterization instrumentation response modeling. One year of experience performing criticality safety evaluations for the Hanford Plutonium Finishing Plant and evaluating the adequacy of criticality accident alarm systems for the Rocky Flats Environmental Technology Site. One year of experience performing safety analysis in support of Hanford Site tank farms and the Spent Nuclear Fuel Program.

Others who participated in the hazards analysis meetings and provided information to assist the process included

- Jeff Parker, Ares Corporation, facilitator for the sessions
- Richard Hulskamp, multi-canister overpack and receiving crane design information.

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