ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 647501

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	~~D. E. Krahn~~/~~SNF-NS~~/R3-26 /~~372-3651~~ T. Powers / P. Patterson	[] Yes [X] No	2-12-99
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[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

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

~~N/A~~ Revision due to design Changes.

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

~~N/A~~ Design of CSB has changed since Revision 0 was issued.

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

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ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1): 647501

16. Design Verification Required: [] Yes [X] No

17. Cost Impact

	ENGINEERING		CONSTRUCTION	
Additional	[]	$ n/a	[]	$ n/a
Savings	[]	$	[]	$

18. Schedule Impact (days)

Improvement [] n/a

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
~~n/a~~ HNF-3553 Annex A, Rev. 0 - CSB FSAR		

21. Approvals

Signature		Date	Signature	Date
Design Authority G. D. Bazinet	G D Bazinet	2/11/99	Design Agent	
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			DEPARTMENT OF ENERGY	
			Signature or a Control Number that tracks the Approval Signature	
			ADDITIONAL	

Canister Storage Building Hazard Analysis Report

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U.S. Department of Energy Contract DE-AC06-96RL13200

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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.

* ARES Corporation

2/17/99
Release Approval Date

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(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr. Date	(6) Cog. Mgr. Date
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CANISTER STORAGE BUILDING
HAZARD ANALYSIS REPORT

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CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TERMS

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 meets the intent of HNF-PRO-704, *Hazard and Accident Analysis Process.* This hazard analysis implements the requirements of DOE Order 5480.23, *Nuclear Safety Analysis Reports.*

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). Also identified and analyzed were the potential hazards associated with storing an off-normal MCO in an overpack storage tube following undetermined accident recovery actions. 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 hazard analysis was based on the design and operations described in Chapters A2.0 and A4.0 of HNF-3553, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report." The analysis included review of a draft operation flow diagram and draft operating procedures. The following normal CSB operations were considered:

- Receiving the transporter containing the cask–MCO and moving it into the facility
- Moving the cask–MCO to the service area and removing the cask lid
- Transporting the MCO from the service area to the storage tube with the MCO handling machine (MHM)
- Transporting the MCO from the storage tube to the MCO sampling/weld station and returning it to the storage tube after sampling
- Conducting activities during MCO staging and interim storage.

The following off-normal MCO storage operations also were considered.

- 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.

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 section 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. The hazard evaluation process identified hazardous conditions, determined causes and preventive and mitigative features, and qualitatively estimated the frequency and consequences of occurrence. The hazard evaluation was performed by a team of cognizant CSB operations and design personnel, safety analysts familiar with the CSB, and technical experts in specialty areas. Attachment A lists the members of the hazard analysis team and describes the background and experience of each.

Results of the hazard evaluations were used to select candidate accidents for quantitative analysis. Results of the hazard and accident analyses were then used to identify safety structures, systems, and components, technical safety requirements, and other controls required to protect the public, workers, and environment. The hazard and accident analysis results also supported determination of the final facility hazard classification.

3.1 HAZARD IDENTIFICATION

The hazard analysis identified hazards associated with CSB design and operations. Hazards were defined as material (referred to as material at risk) that could have a potentially adverse effect on people, the CSB facility, or the environment, and as energy sources that could contribute to uncontrolled release of radioactive or hazardous material or to injury of personnel.

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:

1. Truck vestibule (TV)
2. Service area (SA)
3. Operating area, including overpack storage tubes and tube vent and purge cart (OA)
4. Sampling/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 8 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 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 (American Institute of Chemical Engineers) hazard evaluation techniques. The first step in the hazard evaluation, once the hazards had been identified, was to screen the potentially hazardous materials and energy sources 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 9 through 14 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.

Hazardous conditions not identified and sorted out as standard industrial hazards were further characterized and evaluated as the analysis process progressed. The material at risk associated with the hazardous conditions were identified and defined using the hazard identification checklists for each facility area (Table 2 through Table 8), reference documentation, and input from project design and operations personnel. A summary of the materials at risk, in terms of hazard type, form, quantity, and location, is included in this report as Table 15.

The next step was to evaluate each hazardous condition. The team met in facilitated sessions to perform this portion of the evaluation. Hazard analysis worksheets were designed to capture the required information for each hazard. The hazards were entered into the tables by their unique identifier for further 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 16 through 22, 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 truck 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 release energy to affect a receptor at the nearest point of uncontrolled public access.

S2 On the basis of material at risk and causes postulated, there is sufficient material and energy to affect an onsite receptor (collocated worker) 100 m from the source of the release.

S1 On the basis of material at risk and causes postulated, the release is confined to the facility and affects facility workers.

S0 On the basis of material at risk and causes postulated, there is insufficient material released to affect 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) 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, lead 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 23 and Table 24. The following sections describe each step, and identify where in Table 23 or Table 24 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 23, with their frequency and consequence rankings listed under the column entitled "Frequency/consequence codes.". There were no hazardous conditions assessed as S1 (facility worker consequences) involving radiological hazards requiring detailed accident analysis. 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 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 23, "Release energy" column)
- Release location (Table 23, "Designator" column)
- Release initiator (Table 23, "Hazardous condition and initiators" column).

Creation of Hazardous Material Release Bins. As the 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 23 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 24, 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 Table 25). In Table 24 the bin category hazardous conditions are listed in descending order with the highest ranking hazardous condition at the top. ore than one condition may have been required to provide the necessary bounding conditions for a bin. Table 24 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 24 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 26. 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 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

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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.

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: Truck 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*
- ■ ☐ 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: Service 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 - welding fumes

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, Without Tube Vent and Purge Cart.

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

Y N **A. Electrical**
- ■ □ 1. Battery banks (service 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 (service 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 Station.

Location: *Weld Station (WS)*

Y N **A. Electrical**
- ☐ ■ 1. Battery banks
- ■ ☐ 2. Cable runs (welding, power track)
- ☐ ■ 3. Generators
- ■ ☐ 4. Elec equip (welder, UT, mass spec)
- ☐ ■ 5. HVAC heaters
- ☐ ■ 6. High voltage (> 600 V)
- ■ ☐ 7. Motors (crane, weld pit)
- ■ ☐ 8. Pumps (chiller pumps)
- ■ ☐ 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 - blowers, chillers

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

Y N **C. Friction**
- ■ ☐ 1. Belts (fume exhaust)
- ■ ☐ 2. Bearings (auto welder, rotary drive))
- ■ ☐ 3. Fans (MHM, fume exhaust)
- ■ ☐ 4. Gears (auto welder)
- ■ ☐ 5. Motors (auto welder, weld pit)
- ■ ☐ 6. Power tools (grinder)
- ■ ☐ 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 containing chlorides

Y N **E. Kinetic - Rotational**
- ☐ ■ 1. Centrifuges
- ■ ☐ 2. Motors (auto welder, weld pit)
- ■ ☐ 3. Pumps (chiller, vacuum pump)
- ■ ☐ 4. Fans (fume exhaust, MHM)
- ☐ ■ 5. Laundry equipment
- ☐ ■ 6. Shop equipment
- ■ ☐ 7. Other - MHM turret, MCO

Y N **F. Kinetic - Linear**
- ☐ ■ 1. Cars, trucks, buses
- ■ ☐ 2. Forklifts, dollies, carts (dest/samd cart)
- ☐ ■ 3. Railroad
- ■ ☐ 4. Obstructions (handrails)
- ■ ☐ 5. Crane loads (hoist, gantry)
- ■ ☐ 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 (service cart)
- ☐ ■ 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 (accumulator tank)
- ☐ ■ 3. Autoclave
- ■ ☐ 4. Test loops
- ■ ☐ 5. Gas bottles (portable welder)
- ■ ☐ 6. Pressure vessels (MCO)
- ■ ☐ 7. Gas receivers (accumulators)
- ■ ☐ 8. Vacuum (leak testing)
- ☐ ■ 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

Y N **M. Hazardous Materials**
- ☐ ■ 1. Alkali metals
- ■ ☐ 2. Asphyxiants (helium)
- ☐ ■ 3. Biologicals
- ■ ☐ 4. Carcinogens (welding fumes)
- ☐ ■ 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 (440 volt switch gear)
- ■ □ 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 (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 (compressors)
- ■ □ 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. Decontamination solution
- □ ■ 5. High temperature waste
- □ ■ 6. Other

Y N E. Kinetic - Rotational
- □ ■ 1. Centrifuges
- ■ □ 2. Motors
- ■ □ 3. Pumps
- □ ■ 4. Cooling tower 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 (compressors)
- □ ■ 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. Stressed members
- ■ □ 8. Gas receivers (air)
- □ ■ 9. Negative pressure collapse
- □ ■ 10. Steam headers and lines
- ■ □ 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
- □ ■ 7. Gases, others
- □ ■ 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
- ■ □ 4. Lube oil
- □ ■ 5. Coolant oil
- □ ■ 6. Paint solvent
- ■ □ 7. Diesel fuel (generators)
- ■ □ 8. Buildings & contents (HVAC filter fire)
- □ ■ 9. Trailers and contents
- ■ □ 10. Grease
- ■ □ 11. Hydrogen
- □ ■ 12. Nitric acid
- ■ □ 13. Organics
- □ ■ 14. Gases - others
- □ ■ 15. Liquids - others
- ■ □ 16. Other (clothing)

Y N M. Hazardous Materials
- □ ■ 1. Alkali metals
- ■ □ 2. Asphyxiants (diesel exhaust)
- □ ■ 3. Biologicals
- ■ □ 4. Carcinogens
- □ ■ 5. Corrosives
- □ ■ 6. Oxidizers
- □ ■ 7. Toxics
- ■ □ 8. Heavy metals (lead from batteries)
- □ ■ 9. Other _____

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

Y N P. External Events
- ■ □ 1. Explosion
- ■ □ 2. Fire
- ■ □ 3. Other sites

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. Standard Industrial Hazards: Truck 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
Mass, gravity, height	Human effort (dropped items)	TV	G	1
	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	Gas bottles	TV	H	5

Table 9. Standard Industrial Hazards: Truck Vestibule. (2 sheets)

Hazard category	Hazard type	Checklist designator		
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

Table 10. Standard Industrial Hazards: Service 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
	Radioactive decay heat	SA	B	7
	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 10. Standard Industrial Hazards: Service 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	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	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 11. Standard Industrial Hazards: Operating Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Battery banks (service carts)	OA	A	1
	Cable runs (welding, festooning)	OA	A	2
	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 (service cart, seismic clamp)	OA	E	3
	Other — MHM hoist	OA	E	7
Kinetic - linear	Forklifts, dollies, carts (service carts)	OA	F	2
	Crane loads (service carts)	OA	F	5
	Pressure vessel blowdown (maintenance, gas bottles as missiles)	OA	F	6

Table 11. 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	Gas bottles	OA	H	5
	Gas receivers (MHM, service cart)	OA	H	7
	Other — inert gas lines, seismic clamp	OA	H	11
Hazardous materials	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.

Table 12. Standard Industrial Hazards: Sampling/Weld Station. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Cable runs (welding, power track)	WS	A	2
	Electrical equipment (welder, UT, mass spectrometer)	WS	A	4
	Motors (crane, weld pit)	WS	A	7
	Pumps (chiller pumps)	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 — blowers, chillers	WS	A	16
Thermal	Electrical equipment (welder, UT, mass spectrometer)	WS	B	2
	Welding, torch/arc (weld cap, maintenance)	WS	B	5
	Exposed components (shielding, exposed top of MCO)	WS	B	8
	Power tools (grinder)	WS	B	9
	Convective (chiller)	WS	B	10
	Cryogenic (glycol cooling)	WS	B	12
	Other — brakes (MHM, gantry, hoists)	WS	B	13
Friction	Belts (fume exhaust)	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)	WS	C	5
	Power tools (grinder)	WS	C	6
	Other — brakes on the MHM and crane	WS	C	7
Kinetic - rotational	Motors (auto welder, weld pit)	WS	E	2
	Pumps (chiller, vacuum pump)	WS	E	3
	Fans (fume exhaust, MHM)	WS	E	4
Kinetic - linear	Obstructions (handrails)	WS	F	4

Table 12. Standard Industrial Hazards: Sampling/Weld Station. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Mass, gravity, height	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	Gas bottles	WS	H	5
	Confined spaces (trench)	WS	H	10
	Other — inert gas lines, glycol in pit	WS	H	11
Hazardous materials	Carcinogens (welding fumes)	WS	M	4
	Heavy metals (welding fumes)	WS	M	8
Ionizing radiation sources	Radioactive sources (hand-held equipment)	WS	N	4

MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.
UT = ultrasonic test.

Table 13. 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 13. Standard Industrial Hazards: Support Building. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Kinetic - linear	Transporter truck	TV	F	1
	Crane loads	TV	F	5
	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
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 14. 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
	Diesel units, fire box, exhaust line	OU	B	6
	Exposed components	OU	B	8
	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

Table 14. 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
	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
	Grease	OU	L	10
	Gases, others (acetylene, propane)	OU	L	14
	Liquids, others (degreasers)	OU	L	15
Hazardous materials	Biologicals (snakes, spiders)	OU	M	3
	Corrosives (battery acid)	OU	M	5
	Heavy metals (battery lead)	OU	M	8

Table 15. 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
Truck 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	6.90 MTU at 4.11 E+04 Ci/MTU	Yes, particulate is transient	6.90 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	40 gal	NA	Liquid	Up to 40 gal	Yes	One tank	
Service 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	6.90 MTU at 4.11 E+04 Ci/MTU	Yes, particulate is transient	6.90 MTU 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 15. 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	13.8 MTU at 4.11 E+04 Ci/MTU	Yes, particulate is transient	13.8 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 station	MCO in sampling/ weld station	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	6.90 MTU at 4.11 E+04 Ci/MTU	Yes, particulate is transient	6.90 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	6.90 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	12 bottles	Helium gas	Gas	NA	Yes	12 bottles	

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 16. Canister Storage Building Hazard Analysis: Truck Vestibule. (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	
Truck 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	Analysis demonstrates that the cask-MCO will maintain confinement and criticality geometry control following a drop from a height of 40 in. or less onto the CSB trailer vestibule floor. Drop heights of greater than 40 in. are controlled and precluded by TSRs.	F3 The hazard analysis team considered a transportation accident to be an anticipated event. Hanford Site collisions happen at a rate of 8.85 E-7/ mile.[a] Assuming 100 trips to the CSB per year and 0.25 miles per trip results in 2.2 E-5 collisions per year.	F0	Analysis demonstrates that the cask-MCO will maintain confinement and criticality geometry control following a drop from a height of 40 in. or less onto the CSB trailer vestibule floor. Drop heights of greater than 40 in. are controlled and precluded by TSRs.	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	S1	The truck vestibule has wheel stops to alert the driver to his position. The approach into the truck 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. Packaging controls limit the conditions under which a transporter could arrive at the CSB (e.g., weather and road conditions, transporter-cask configurations).[b] Regular maintenance is performed on the transporter to ensure it is in good working order.

Table 16. Canister Storage Building Hazard Analysis: Truck Vestibule. (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	
Truck 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 or fuel rearrangement Damage to receiving crane, yoke, or other structures, systems, or components Loss of inner overhead door causing a loss of zone between the service area and the truck vestibule and/or allowing exhaust gases from the transporter cab to enter the service area Personnel injury	Analysis demonstrates that the cask-MCO will maintain confinement and criticality geometry control following a drop from a height of 40 in. or less onto the CSB trailer vestibule floor. Drop heights of greater than 40 in. are controlled and precluded by TSRs.	F3 The hazard analysis team considered a crane collision to be an anticipated event.	F0	Analysis demonstrates that the cask-MCO will maintain confinement and criticality geometry control following a drop from a height of 40 in. or less onto the CSB trailer vestibule floor. Drop heights of greater than 40 in. are controlled and precluded by TSRs.	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	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.
Truck vestibule TV-F-06	Linear kinetic - gas bottles as missiles	Collision or impact	Human error Mechanical failure	Bottle may move, but not enough to cause damage	Damage to the cask, MHM	Gas bottles contain flow-limiting orifice	F2	--	Site maintenance program prohibits maintenance on the bottles	S2	--	Frequency and consequence rankings retained for accident binning. All gas bottles except carbon dioxide fire extinguisher bottles have orifices that restrict the velocity of exiting gas so that the bottle can't do significant damage.[c]

Table 16. Canister Storage Building Hazard Analysis: Truck Vestibule. (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	
Truck 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	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	Analysis demonstrates that the cask-MCO will maintain confinement and criticality geometry control following a drop from a height of 40 in. or less onto the CSB trailer vestibule floor. Drop heights of greater than 40 in. are controlled and precluded by TSRs.	F3	F0	Analysis demonstrates that the cask-MCO will maintain confinement and criticality geometry control following a drop from a height of 40 in. or less onto the CSB trailer vestibule floor. Drop heights of greater than 40 in. are controlled and precluded by TSRs.	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	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.
Truck vestibule TV-G-13	Mass, gravity, height - vessels (transportation cask)	Raised cask on receiving crane	Hoist failure Yoke failure Human error	Cask falls from receiving crane to transporter or vestibule floor	Damage to cask Personnel injury Damage to transporter Damage to vestibule floor	Analysis demonstrates that the cask-MCO will maintain confinement and criticality geometry control following a drop from a height of 40 in. or less onto the CSB trailer vestibule floor. Drop heights of greater than 40 in. are controlled and precluded by TSRs.	F3	F0	Analysis demonstrates that the cask-MCO will maintain confinement and criticality geometry control following a drop from a height of 40 in. or less onto the CSB trailer vestibule floor. Drop heights of greater than 40 in. are controlled and precluded by TSRs.	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	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. Maintenance and operations manuals and details are to be provided by crane vendors. The hoist design includes - Interlocks to preclude lift and horizontal motion at same time - Dual brakes - No free-fall capacity.

Table 16. Canister Storage Building Hazard Analysis: Truck Vestibule. (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	
Truck 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 any one of multiple mechanical seals 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 is designed to withstand high pressure (~ 450 lb/in^2) without catastrophic failure (passive barrier).	F1	--	Likely leakage from the MCO is small because of the complex potential leak path (passive barrier).	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 truck vestibule. The drying process at the CVDF ensures MCO pressures are relatively low during the receiving process.
Truck 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 (~ 450 lb/in^2) without catastrophic failure (passive barrier).	F1	--	Likely leakage from MCO is small because of its complex potential leak path (passive barrier).	S1	--	The cask is designed with materials to prevent release from an MCO leak. HVAC provides air exchange. Cask has two head seals in series. Smoking not allowed within the facility.
Truck vestibule TV-J-07	Explosives or pyrophorics - acetylene gas	Flammable gas	Human error Mechanical failure	Flammable gas in the truck vestibule ignites	Personnel injury	None	F2	--	This hazard is within the envelope of the cask SARP[b] for external fires.	S1	--	

Table 16. Canister Storage Building Hazard Analysis: Truck Vestibule. (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	
Truck 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 full cask-MCO breach is necessary for this accident to occur.	F0	--	None	S3	--	
Truck vestibule TV-K-12 TV-K-15	Nuclear criticality - cranes and lifts, MCO	This hazard is addressed in HNF-SD-SNF-RPT-004, Chapter 6.0[d] - no new hazards have been identified.										
Truck vestibule TV-L-03 TV-L-04 TV-L-06 TV-L-07 TV-L-10 TV-L-14 TV-L-16	Flammable materials - gasoline, lubricating oil, paints and solvents, diesel fuel, grease, acetylene, hydraulic fluid	Fire hazards are to be evaluated in a fire hazards analysis.[e]										
Truck vestibule TV-L-11	Flammable materials - hydrogen	Refer to TV-J-06, "Explosives or pyrophorics - hydrogen."										
Truck vestibule TV-M-07	Hazardous materials - toxic (plutonium and uranium)	Toxic consequences are bounded by the radiological consequences.[f]										

Table 16. Canister Storage Building Hazard Analysis: Truck Vestibule. (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	
Truck vestibule TV-N-01	Ionizing radiation sources - fissile material (contents of MCO)	Ionizing radiation	Normal work	Personnel exposure to radiation	Exposure to ionizing radiation	None	F3	--	The transportation cask is designed to provide shielding to reduce personnel exposures (passive barrier).	S0	--	Site radiological control practices are in place (ALARA).
	Surface contamination on cask	Surface contamination	Loss of contamination control	Spread of contamination	Increased potential for exposure to ionizing radiation Environmental impact	None	F3	--	None	S1	--	Site practices for survey of contamination are followed.
Truck vestibule TV-N-03	Ionizing radiation sources - radioactive material	Refer to TV-N-01, "Ionizing radiation sources - fissile material."										
Truck vestibule TV-P-01	External events - explosion outside of the truck vestibule	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-01).										
Truck vestibule TV-P-02	External events - fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-02).										
Truck vestibule TV-P-03	External events - nearby facilities	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-03).										
Truck vestibule TV-P-04	External events - loss of power	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-04).										
Truck vestibule TV-Q-04	Vehicles in motion - cars, trucks, buses	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-Q-04).										

Table 16. Canister Storage Building Hazard Analysis: Truck Vestibule. (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	
Truck vestibule TV-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-01).										
Truck vestibule TV-R-03	Natural phenomena - lightning	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-03).										
Truck vestibule TV-R-04	Natural phenomena - rain	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-04).										
Truck vestibule TV-R-05	Natural phenomena - snow, freezing weather	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-05).										
Truck vestibule TV-R-06	Natural phenomena - straight wind (90 mi/h)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-06).										
Truck vestibule TV-R-07	Natural phenomena - dust devil	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-07).										
Truck vestibule TV-R-08	Natural phenomena - tornado (40 mi/h translational, 160 mi/h rotational; pressure drop, 0.9 lb/in^2 at 0.3 $lb/in^2/s$)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-08).										
Truck vestibule TV-R-09	Natural phenomena - ashfall	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-09).										

Table 16. Canister Storage Building Hazard Analysis: Truck Vestibule. (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	
Truck vestibule TV-R-10	Natural phenomena - range fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-10).										

[a] WHC-SD-TP-RPT-007, 1993, *Standard Transportation Risk Assessment Methodology*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
[b] HNF-SD-TP-SARP-017, 1997, *Preliminary Safety Analysis Report for Packaging, Onsite, Multi-Canister Overpack Cask*, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[c] WHC-SD-SNF-ER-016, 1996, *Protection of Safety Class Systems Against Compressed Gas Cylinders at the 105KE and 105KW Basins*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
[d] HNF-SD-SNF-RPT-004, 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, Rev. 7, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[e] HNF-PRO-704, Rev. 0, *Hazard and Accident Analysis Process*, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[f] HNF-SD-SNF-TI-059, 1998, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 1, Fluor Daniel Hanford, Incorporated Richland, Washington.

ALARA = as low as reasonably achievable.
CAM = continuous air monitor.
CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
DBE = design basis earthquake.
HVAC = heating, ventilation, and air conditioning.
MCO = multi-canister overpack.
MHM = multi-canister overpack handling machine.
SARP = safety analysis report for packaging.[b]
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 released to affect facility workers.
S1 = Release confined to the facility and affects facility workers.
S2 = Sufficient material and release energy to affect an onsite receptor (collocated worker) 100 m from the source of the release.
S3 = Sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access (site boundary).
SC = Unprevented, this accident presents a challenge to a safety-class boundary.
-- = No ranking assigned because preventive or mitigative features were not identified (termination by passive features or low frequency or consequence)

Table 17. Canister Storage Building Hazard Analysis: Service 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	
MCO service area SA-E-07	Rotational kinetic - MHM turret	Rotating MHM turret creates a shearing force (a plane 5 ft above the floor) on a lowered MCO or on the supporting lifting cable and pneumatic lines of the MHM	Mechanical failure of the MHM Failure of the MHM's electrical interlocks Human error in activating turret rotation	Shearing forces puncture or rip the MCO, resulting in a breach Shearing forces on the lifting cable and pneumatic lines result in the MCO being stuck in the service station pit with no controls or ungrappling capability, or being dropped into the service station pit (refer to SA-G-03 for further details on drops)	Loss of primary containment (i.e., the MCO) resulting in contamination of the transport cask, service station pit, and/or MHM MHM drive damaged and locked up Lifting cable and/or pneumatic lines sheared off	MHM design includes interlocks, seismic-disconnect system and seismic restraints.	F3	F1	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	Personnel are trained to MHM-specific procedures for safe operation. 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 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.
MCO service area SA-F-05	Linear kinetic - receiving crane, MHM	MHM collides with cask–MCO as it is being lowered into MCO service station pit by the receiving crane	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 - Service area enclosure - 5-ton gantry crane	Damage to the transportation cask Collapse of receiving crane and damage to operating deck, storage tubes, and MCOs Damage to facility structures, systems, or components (such as the transport cask yoke) Damage to the service area enclosure Damage to the 5-ton gantry crane Personnel injury Fuel rearrangement inside MCO	The receiving crane is designed to ASME NOG–1[a] to preclude tipping or falling (passive barrier). Cask design (passive failure)	F2	F2	Cask design (passive failure)	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	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 service 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.

Table 17. Canister Storage Building Hazard Analysis: Service 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	
MCO service area SA-F-06	Linear kinetic - gas bottles as missiles	Collision or impact	Human error Mechanical failure	Bottle may move, but not enough to cause damage	Bottle impacts MHM or MCO	Gas cylinders contain flow limiting orifice	F0	--	Site maintenance program prohibits maintenance on the bottles	--	--	All gas bottles except carbon dioxide fire extinguisher bottles have orifices in the neck of the bottle that restrict the velocity of exiting gas so that the bottle can't do significant damage.[b]
MCO service area SA-F-07a	Linear kinetic - other (5-ton gantry and service area enclosure)	5-ton gantry or service area enclosure collision	Human error in mislocating equipment in the path of the gantry or service area enclosure Human inattentiveness Crane failure	Collision with - Equipment - Personnel - Transportation cask lid - Shield hatch assembly	Damage to the service area enclosure Damage to the gantry crane Personnel injury	None	F3	--	None	S1	--	The 5-ton gantry crane and service 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 service area enclosure is moved manually. The crane and service area enclosure have been designed to preclude tipping. Personnel are trained to operate the 5-ton gantry and service area enclosure according to facility-specific procedures, which include related activities such as ensuring equipment is not blocking gantry crane and service area enclosure movement.

Table 17. Canister Storage Building Hazard Analysis: Service 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	
MCO service area SA-F-07b	Linear kinetic - MHM lateral movement	MHM collision 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	Collision with - Receiving crane - Subsystems in the path of the MHM - Personnel - Service area enclosure - 5-ton gantry crane Shearing forces puncture or rip the MCO, resulting in a breach Shearing forces on the lifting cable and pneumatic lines result in the MCO being dropped into the service station pit, with no controls or ungrappling capability (refer to SA-G-03 for further details on drops)	Damage to facility structures, systems, or components (e.g., receiving crane, service area enclosure, 5-ton gantry crane) Personnel injury Loss of containment (i.e., the MCO) resulting in contamination of the transport cask, service station pit, and/or MHM MHM drive damaged and locked up Lifting cable and/or pneumatic lines sheared off	MHM design includes interlocks, seismic-disconnect system and seismic restraints.	F3	F1	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	Personnel are trained in procedures detailing the safe sequence of operations. These procedures prohibit interferences between the receiving crane and the MHM. Personnel are trained in MHM-specific procedures regarding its safe operation. 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 service 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. Interlocks (electrical and mechanical) prohibit any horizontal movement, linear or rotational, while an MCO is loaded but not fully raised. The MHM is provided with backup grapple disengagement capability. The MHM resolver indicates the MCO's relative position within the service station pit and/or MHM while it is being raised.

Table 17. Canister Storage Building Hazard Analysis: Service 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	
MCO service area SA-G-03a	Mass, gravity, height - lifts and cranes (may carry transportation cask, MCO, storage tube plug, cask lid, or impact absorber)	A drop of the transportation cask (with or without a loaded MCO) from the receiving crane A drop of the MCO from the MHM as it is being raised A drop of a cask lid at the service station pit, or a shield plug or impact absorber at the exchange pit MCO dropped back into cask or onto the cask rim by the MHM	Human error (either in rigging the yoke for the transportation cask or in forcing a release from the MHM) Mechanical failure of the receiving crane, MHM, or gantry	The transportation cask could impact either the facility floor or the bottom of the service station pit or maintenance pit MCO impact to either the bottom of the transportation cask in the service station pit, exchange pit, or the turntable in the MHM Cask lid impact with the MCO Impacts with personnel	A drop can result in damage to the cask, MHM turntable, or the MCO; significant damage to the MCO could result in a release of gas and contamination from the MCO Personnel injury	MHM interlocks prevent travel over the maintenance pit and FFTF pit when carrying an MCO. Interlocks are protected by TSRs. Analysis and testing show that the MCO design (structure and components), the lifting system design (crane and yoke), and the impact absorber installation combine to maintain MCO structural integrity (external and internal).	F1	F0	MHM interlocks prevent travel over the maintenance pit and FFTF pit when carrying an MCO. Interlocks are protected by TSRs. Analysis and testing show that the MCO design (structure and components), the lifting system design (crane and yoke), and the impact absorber installation combine to maintain MCO structural integrity (external and internal).	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	The MHM grapple is designed such that it cannot release while a load is being suspended from it. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, gantry, and MHM.

Table 17. Canister Storage Building Hazard Analysis: Service 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	
MCO service area SA-G-03b	Mass, gravity, height - lifts and cranes (cask with MCO)	Drop of cask with MCO into maintenance pit or FFTF pit.	Human error Mechanical failure	Slap down impact of cask exceeding design limits	Criticality limits may be violated or confinement lost	MHM interlocks prevent travel over the MHM maintenance pit and FFTF pit when carrying an MCO. Interlocks are protected by TSRs. Analysis and testing show that the MCO design (structure and components), the lifting system design (crane and yoke), and the impact absorber installation combine to maintain MCO structural integrity (external and internal).	F1	F0	MHM interlocks prevent travel over the maintenance pit and FFTF pit when carrying an MCO. Interlocks are protected by TSRs. Analysis and testing show that the MCO design (structure and components), the lifting system design (crane and yoke), and the impact absorber installation combine to maintain MCO structural integrity (external and internal).	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	The MHM grapple is designed such that it cannot release while a load is being suspended from it. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, gantry, and MHM.

Table 17. Canister Storage Building Hazard Analysis: Service 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	
MCO service area SA-G-11	Mass, gravity, height - pits and excavations	Refer to SA-G-03a and SA-G-03b, "Mass, gravity, height - lifts and cranes."										
MCO service area SA-G-13	Mass, gravity, height - vessels (cask, MCO)	Refer to SA-G-03a and SA-G-03b, "Mass, gravity, height - lifts and cranes."										
MCO service area SA-H-04	Pressure, volume - test loops (cask pressure check)	Refer to SA-H-06, "Pressure, volume - pressure vessels (MCO and MCO-transportation cask system)."										

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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	
MCO service 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 service 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 service area - Radioactive particulate released to the service area - Personnel contamination from radioactive and/or hazardous material releases from the transportation cask.	None	F3 (Small gaseous release with no other consequence)	--	The MCO is designed to withstand high pressures (~ 450 lb/in^2 gauge) without catastrophic failure (passive barrier). Likely leakage is small because of design (complex potential leak path) (passive barrier).	S1	--	Personnel are trained to facility-specific procedures regarding transportation cask shipping, movement, and handling. The drying process at the CVDF will ensure MCO pressures are relatively low during the receiving process. A service 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 service area enclosure, if in place, provides HEPA-filtered confinement in the event of an MCO pressure release.

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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	
MCO service area SA-J-06a	Explosives or pyrophorics - hydrogen	A flammable hydrogen-air mixture and an ignition source is present	Radiolysis of aluminum hydroxide results in hydrogen and oxygen, which upon ignition creates an explosion	Deflagration or detonation may occur within the MCO	MCO failure Uncontrolled release of hazardous material	None	F2	--	The MCO is designed to withstand high internal pressures (~450 lb/in^2 gauge).	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	The drying process at the CVDF will ensure MCO pressures are relatively low during the receiving process.
MCO service area SA-J-06b	Explosives or pyrophorics - hydrogen	Hydrogen leak from MCO into the tent during venting	Radiolysis of aluminum hydroxide results in hydrogen formation in MCO	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	F2	--	Radionuclide inventory on the HEPA filter in the portable exhauster is limited	S2	S1	
MCO service 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	The structural design of the MCO is such that leaks have a very low probability of occurring (passive barrier).	F1	--	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	The MCO is designed to withstand high pressures (~450 lb/in^2 gauge) without catastrophic failure. Likely leakage across the MCO is small because of design (complex potential leak path).

Table 17. Canister Storage Building Hazard Analysis: Service 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	
MCO service 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	F0	--	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	The MCO is designed to withstand high pressures (~450 lb/in^2 gauge) without catastrophic failure.
MCO service area SA-K-12 SA-K-15	Nuclear criticality - cranes and lifts, MCO	This hazard is addressed in HNF-SD-SNF-RPT-004, Chapter 6[c] — no new hazards have been identified (refer also to SA-G-03b).										
MCO service area SA-L-01 SA-L-02 SA-L-04 SA-L-06 SA-L-10 SA-L-13 SA-L-14 SA-L-16	Flammable materials - packing materials (MCO), rags, lubricating oil, paints and solvents, grease, organics (MHM neutron absorber, tent enclosure), gases (acetylene), other (hydraulic fluid)	The fire hazards analysis is responsible for evaluating fire hazards.[d]										
MCO service area SA-L-11	Flammable materials - hydrogen	Refer to SA-J-06, "Explosives or pyrophorics - hydrogen."										
MCO service area SA-M-07	Hazardous materials - toxic (plutonium and uranium)	Toxic consequences are bounded by the radiological consequences.[c]										

Table 17. Canister Storage Building Hazard Analysis: Service 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	
MCO service area SA-N-01	Ionizing radiation sources - fissile material (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 service 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	--	The transportation cask is designed to provide shielding to reduce personnel exposures (passive barrier). The MCO is designed to withstand high pressures (~450 lb/in^2 gauge) without catastrophic failure (passive barrier). Likely leakage across the MCO is small because of complex potential leak path (passive barrier).	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 service area enclosure, if in place, provides HEPA-filtered secondary confinement in the event of an MCO pressure release.
	Surface contamination on cask	Surface contamination	Loss of contamination control	Spread of contamination	Increased potential for exposure to ionizing radiation Environmental impact	None	F3	--	None	S1	--	Site practices for survey of contamination are followed.
MCO service area SA-N-03	Ionizing radiation sources - radioactive material	Refer to SA-N-01, "Ionizing radiation sources - fissile material."										
MCO service area SA-P-01	External events - explosion outside of the truck vestibule	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-01).										

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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	
MCO service area SA-P-02	External events - fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-02).										
MCO service area SA-P-03	External events - nearby facilities	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-03).										
MCO service area SA-P-04	External events - loss of power	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-04).										
MCO service area SA-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-01).										
MCO service area SA-R-03	Natural phenomena - lightning	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-03).										
MCO service area SA-R-04	Natural phenomena - rain	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-04).										
MCO service area SA-R-05	Natural phenomena - snow, freezing weather	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-05).										
MCO service area SA-R-06	Natural phenomena - straight wind (90 mi/h)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-06).										

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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	
MCO service area SA-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)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-08).										
MCO service area SA-R-09	Natural phenomena - ashfall	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-09).										
MCO service area SA-R-10	Natural phenomena - range fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-10).										

[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] WHC-SD-SNF-ER-016, 1996, *Protection of Safety Class Systems Against Compressed Gas Cylinders at the 105KE and 105KW Basins*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
[c] HNF-SD-SNF-RPT-004, 1997, *Canister Storage Building Safety Analysis Report --- Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, Rev. 7, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[d] HNF-PRO-704, Rev. 0, *Hazard and Accident Analysis Process*, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[e] HNF-SD-SNF-TI-059, 1998, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
DBE = design basis earthquake.
FFTF = Fast Flux Test Facility.
HEPA = high-efficiency particulate air (filter).
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 released to affect facility workers.
S1 = Release confined to the facility and affects facility workers.
S2 = Sufficient material and release energy to affect an onsite receptor (collocated worker) 100 m from the source of the release.
S3 = Sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access (Site boundary).
SC = Unprevented, this accident presents a challenge to safety-class boundary.
-- = No ranking assigned because preventive or mitigative features were not identified (termination by passive features or low frequency or consequence)

Table 18. Canister Storage Building Hazard Analysis: Operating Area. (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	
CSB 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 barrier).	F1	--	None	S3	--	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.
CSB operating area OA-E-07	Rotational kinetic - MHM turret	Rotating MHM turret creates a shearing force (a plane 5 ft above the floor) on a lowered MCO or on its supporting lifting cable and pneumatic lines	Mechanical failure of the MHM Failure of the MHM's electrical interlocks Human error in activating turret rotation	Puncture or rip of the MCO resulting in a breach Shearing forces on the lifting cable and pneumatic lines resulting in the MCO being stuck in the storage tube with no controls or ungrappling capability, or being dropped into the storage tube (refer to OA-G-03 for further details on drops) Impact absorber being lowered into the storage tube is destroyed leaving pieces of the impact absorber in the storage tube	Loss of primary 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	MHM design includes interlocks, seismic-disconnect system and seismic restraints.	F3	F1	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	Interlocks (electrical and mechanical) are present that 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. 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. Project direction is to demonstrate the MCO design is sufficient to preclude damage from maximum MHM shear forces.

Table 18. Canister Storage Building Hazard Analysis: Operating Area. (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	
CSB 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., service 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	MHM design includes interlocks, seismic-disconnect system and seismic restraints.	F3	F1	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	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 service 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. 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. 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 18. Canister Storage Building Hazard Analysis: Operating Area. (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	
CSB 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	Analysis and testing show that the MCO design (structure and components) and impact absorber installation combine to protect MCO structural integrity (external and internal).	F2	F2	Analysis and testing show that the MCO design (structure and components) and impact absorber installation combine to protect MCO structural integrity (external and internal).	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	S0	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.
CSB 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	F2	--	None	S1	--	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 18. Canister Storage Building Hazard Analysis: Operating Area. (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	
CSB operating area OA-H-04	Volume, pressure - test loops (validation MCO monitoring)	This hazard will be evaluated as the design and process information for monitored MCOs is developed.										
CSB operating area OA-H-06a	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	None	F2	F0	The MCO is designed to withstand high pressures (~450 lb/in^2 gauge) without catastrophic failure (passive barrier). Likely leakage is small because of complex potential leak path) (passive barrier).	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.
CSB operating area OA-H-06b	Volume, pressure - pressure vessels (storage tube)	Pressure in storage tube	Sudden (i.e., rapid) depressurization of MCO through mechanical seals	Release to operating area	Personnel injury Contamination of storage tube and operating area Potential flammable atmosphere	The MCO is designed to withstand high pressure (~450 lb/in^2 gauge) without catastrophic failure (passive barrier). Likely leakage is small because of the complex potential leak path (passive barrier).	F0	--	None	S2	--	
CSB operating area OA-H-08	Volume, pressure - vacuum (sampling)	This hazard will be evaluated as the design and process information for monitored MCOs is developed.										

Table 18. Canister Storage Building Hazard Analysis: Operating Area. (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	
CSB operating area OA-J-06a	Explosives or pyrophorics - hydrogen (MCO)	A flammable hydrogen-air mixture, and an ignition source is present	Radiolysis of aluminum hydroxide results in hydrogen and oxygen, which upon ignition creates an explosion	Deflagration or detonation may occur within the MCO	MCO failure Uncontrolled release of hazardous material	The MCO is designed to withstand high pressure (~ 450 lb/in^2 gauge) without catastrophic failure (passive barrier). Acceptance specifications limit aluminum hydroxide to less than 48 kg.	F3	F0	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	The MCO is designed to withstand high internal pressures (~450 lb/in^2 gauge). The drying process at the CVDF will ensure MCO pressures are relatively low during the receiving process.
CSB operating area OA-J-06b	Explosives or pyrophorics - hydrogen (storage tube or MHM)	Flammable mixture and ignition source in MCO	Radiolysis of uranium nitrates, aluminum hydroxide, and free water results in hydrogen and oxygen	Explosive gas leaks through mechanical seal failure and ignites, creates an explosion	Uncontrolled release of contamination contained in gas Personnel injury	None	F2	--	None	S2	--	
CSB 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	MCO breaches caused by drops or shears are prevented administratively	F3	F0	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	

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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	
CSB 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	Pyrophoric material ignites uranium	Personnel injury Contamination release Damage to the MCO	The structural design of the MCO is such that leaks have a very low probability of occurring (passive barrier).	F2	F0	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	
CSB 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	F0	--	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	
CSB operating area OA-K-12 OA-K-15	Nuclear criticality - cranes and lifts, MCO	This hazard is addressed in HNF-SD-SNF-RPT-004, Chapter 6.0.[b] Refer to OA-G-03 and OA-G-13 for additional information related to criticality parameter violations.										
CSB operating area OA-L-04 OA-L-06 OA-L-10 OA-L-13 OA-L-14 OA-L-15	Flammable materials - lubricating oil, paints and solvents, grease, organics (MHM neutron absorber), gases (acetylene), liquids (hydraulic fluid)	The fire hazards analysis is responsible for evaluating fire hazards.[c]										

Table 18. Canister Storage Building Hazard Analysis: Operating Area. (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	
CSB operating area OA-L-11	Flammable materials - hydrogen	Refer to OA-J-06a and OA-J-06b, "Explosives or pyrophorics - hydrogen."										
CSB operating area OA-M-07	Hazardous materials - toxic (plutonium and uranium)	Toxic consequences are bounded by the radiological consequences.[d]										
CSB operating area OA-N-01a	Ionizing radiation sources - fissile material	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	--	MHM shielding, operating deck, and tube plug (passive barrier).	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.
CSB operating area OA-N-03	Ionizing radiation sources - radioactive material	Refer to TV-N-01, "Ionizing radiation sources - fissile material."										

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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	
CSB operating area OA-P-01	External events - explosion outside of the truck vestibule	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-01).										
CSB operating area OA-P-02	External events - fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-02).										
CSB operating area OA-P-03	External events - nearby facilities	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-03).										
CSB operating area OA-P-04	External events - loss of power	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-04).										
CSB operating area OA-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-01).										
CSB operating area OA-R-03	Natural phenomena - lightning	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-03).										
CSB operating area OA-R-04	Natural phenomena - rain	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-04).										
CSB operating area OA-R-05	Natural phenomena - snow, freezing weather	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-05).										
CSB operating area OA-R-06	Natural phenomena - straight wind (90 mi/h)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-06).										

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							Without prevention	With prevention		Without mitigation	With mitigation	
CSB operating area OA-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)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-08).										
CSB operating area OA-R-09	Natural phenomena - ashfall	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-09).										
CSB operating area OA-R-10	Natural phenomena - range fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-10).										

[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] HNF-SD-SNF-RPT-004, 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, Rev. 7, Fluor Daniel Hanford, Incorporated, Richland, Washington.

[c] HNF-PRO-704, Rev. 0, *Hazard and Accident Analysis Process*, Fluor Daniel Hanford, Incorporated, Richland, Washington.

[d] HNF-SD-SNF-TI-059, 1998, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

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MHM = multi-canister overpack handling machine.
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F0 = Too improbable to warrant consideration for further accident analysis development.
F1 = Possible, but extremely unlikely.
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F3 = Likely to occur during the lifetime of the facility.

S0 = Insufficient material released to affect facility workers.
S1 = Release confined to the facility and affects facility workers.
S2 = Sufficient material and release energy to affect an onsite receptor (collocated worker) 100 m from the source of the release.
S3 = Sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access (Site boundary).
SC = Unprevented, this accident presents a challenge to a safety-class boundary.
-- = No ranking assigned because preventive or mitigative features were not identified (termination by passive features or low frequency or consequence)

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-B-05	Thermal - welding arc	Localized overheating and burn through an MCO	Weld head dropped or misaligned Weld head drops a short distance and damages MCO seal Operator error during weld repair	Damage to the MCO Breached MCO (via hole)	Air ingress into the MCO Pressure release from the MCO Spread of contamination	Sampling/weld station shielding prevents the weld head from dropping to the pressurized boundary of the MCO.	F1	--	None	S2	--	Welder arrangement makes misalignments unlikely. The MCO and pit can be built to replicate the MCO-shielding arrangement. MHM grapple design reduces the likelihood of MCO release in an incorrect orientation. Shield mass provides a limited heat sink. The welder alignment is checked before welding. Multiple checks of the weld are made between passes. Operators are trained and qualified to follow proper procedures in the proper observation of welding activities.
Weld station WS-B-07	Thermal - radioactive decay heat (MCO)	Heat up of the MCO due to thermal buildup	Insufficient cooling at the sampling/weld station	MCO exceeds design temperature criteria	Violation of design criteria Personnel injury Possible OCRWM violation	An MCO can stay in the sampling/ weld station with no glycol cooling for 5 days without exceeding 270 °F.[a]	F3	--	Glycol cooling of shielding materials	S2	S1	Without exposure to oxygen, runaway reactions cannot drive MCO pressures high enough to exceed design pressure. Temperature is checked before contacting the MCO.

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-E-07	Rotational kinetic - other (MHM turret)	Rotating MHM turret creates a shearing force (a plane 5 ft above the floor) on a lowered MCO or on the supporting lifting cable and pneumatic lines of the MHM	Mechanical failure of the MHM Failure of the MHM's electrical interlocks Human error in activating turret rotation	Shearing forces puncture or rip the MCO resulting in a breach Shearing forces on the lifting cable and pneumatic lines result in the MCO being stuck in the sampling/weld station with no controls or ungrappling capability, or being dropped into the sampling/weld station (refer to WS-G-03 for further details on drops)	Loss of primary containment (i.e., the MCO) resulting in contamination of the sampling/weld station and/or MHM MHM drive damaged and locked up Lifting cable and/or pneumatic lines sheared off	MHM design includes interlocks, seismic-disconnect system and seismic restraints.	F3	F1	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	MHM resolver indicates MCO's relative position within the sampling/weld station and/or MHM while it is being raised. The MHM is provided with backup grapple disengagement capability. The MHM-sampling/weld station interface provides active ventilation. Personnel are trained to MHM-specific procedures regarding safe operation. Project direction is to demonstrate the MCO design is sufficient to preclude damage from maximum MHM shear forces.
Weld station WS-F-02 WS-F-05	Linear kinetic - forklifts, dollies, carts, crane loads	Inadvertent crane movement	Human error Mechanical failure of gantry Seismic forces	Shear of sampling lines connected to MCO	MCO depressurization through failed lines	None	F2	--	Seismic restraints Bumpers (passive feature) MHM collision avoidance system	S2	S1	
Weld station WS-F-06	Linear kinetic - pressure vessel blowdown (helium cylinders)	Missile impacts	Human error	None, bottle may move, but not enough to cause damage	Bottle impacts MHM or MCO	Gas cylinders contain flow-limiting orifice	F0	--	Site maintenance program prohibits maintenance on the bottles.	--	--	All gas bottles except carbon dioxide fire extinguisher bottles have orifices in the neck of the bottle that restrict the velocity of exiting gas so that the bottle can't do significant damage.[b]

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-F-07	Linear kinetic - MHM lateral movement	MHM collision Moving MHM creates a shearing force (at floor level) on a lowered MCO or 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	Collision with - Sampling or welding equipment in the path of the MHM - Personnel Shearing forces puncture or rip the MCO, resulting in a breach Shearing forces on the lifting cable and pneumatic lines result in the MCO being dropped into the sampling/weld station with no controls or ungrappling capability (refer to WS-G-03 for further details on drops)	Damage to facility structures, systems, or components Personnel injury Loss of containment (i.e., the MCO) resulting in contamination of the sampling/weld station and/or MHM MHM drive damaged and locked up Lifting cable and/or pneumatic lines sheared off	MHM design includes interlocks, seismic-disconnect system and seismic restraints.	F3	F1	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	The MHM has 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. The MHM resolver indicates the MCO's relative position within the sampling/weld station and/or MHM while it is being raised. The MHM is provided with a backup grapple disengagement capability. Personnel are trained in procedures detailing the safe sequence of operations. These procedures prohibit interferences between the receiving crane and the MHM. Personnel are trained in MHM-specific procedures for safe operation.
Weld station WS-G-01	Mass, gravity, height - human effort	This hazard is bounded by WS-G-03b, "Mass, gravity, height - lifts and cranes."										

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-G-03a	Mass, gravity, height - lifts and cranes (including loads)	A drop of the MCO from the MHM as it is being raised	Human error Mechanical failure	MCO impacts either the bottom of the sampling/weld station or the turntable in the MHM Impacts with personnel	Damage to the MHM turntable or the MCO Personnel injury	Analysis and testing show that the MCO design (structure and components) and impact absorber installation combine to protect MCO structural integrity (external and internal).	F2	F2	Analysis and testing show that the MCO design (structure and components) and impact absorber installation combine to protect MCO structural integrity (external and internal).	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	S0	The MHM grapple is designed such that it cannot release while a load is being suspended from it. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO_2 receiving crane, gantry, and MHM.
Weld station WS-G-03b	Mass, gravity, height - lifts and cranes	Equipment dropped on sample line Dropped equipment (e.g., hoods, sampling equipment, pit covers)	Human error Mechanical failure Sampling equipment is dropped on the MCO when the cover port is missing (removed to sample)	Shear of sample lines Impacts with personnel	MCO depressurization through failed sample lines	None	F2	--	None	S2	--	The sample hood is designed to confine any releases from the MCO during sampling. The sample hood has a HEPA filter on its exit to filter any releases to the sample hood before they are exhausted to the HVAC system. Sampling/weld station gantry crane bumper prevents collisions with the sample hood and sample lines. No credit is taken for the MCO HEPA filter.
Weld station WS-G-04	Mass, gravity, height - bucket and ladder (maintenance)	This hazard is bounded by WS-G-03b, "Mass, gravity, height - lifts and cranes."										
Weld station WS-G-06	Mass, gravity, height - slings (covers)	This hazard is bounded by WS-G-03b, "Mass, gravity, height - lifts and cranes."										

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-G-13	Mass, gravity, height - vessels (MCO)	Refer to WS-G-03a, "Mass, gravity, height - lifts and cranes."										
Weld station WS-H-04	Pressure, volume - test loops	Refer to WS-F-05, "Linear kinetic - crane loads."										
Weld station 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.	Relief valve on the sample line near the MCO is safety significant.	F2	--	None	S2	--	Pressure regulator is in place. Relief valve is tested. Glycol lines are low pressure. The pressure gauge will fail at a lower pressure than the MCO.
Weld station WS-H-06b	Pressure, volume - pressure vessels (MCO)	Inappropriate purge gas used for processing operations	Wrong gas hooked into helium supply (results from human error at vendor, filling the bottles incorrectly) Purge gas mixture off of specification for oxygen content Purge gas contaminated with oil or moisture	MCO reaction with inappropriate purge gas or contaminated helium	Hydrogen deflagration Runaway fuel reactions	Receipt inspection samples bottles as they arrive onsite from vendor.	F3	F2	None	S3	--	
Weld station WS-H-08	Pressure, volume - vacuum (leak testing)	This hazard will be developed in conjunction with the development of the leak testing process.										

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-J-06	Explosives or pyrophorics - hydrogen	A flammable hydrogen-air mixture, and an ignition source is present	Radiolysis of aluminum hydroxide results in hydrogen and oxygen, which upon recombination initiates an explosion	Deflagration or detonation within the MCO	MCO failure Uncontrolled release of hazardous material	The MCO is designed to withstand high pressure (~ 450 lb/in^2 gauge) without catastrophic failure (passive barrier). Acceptance specifications limit aluminum hydroxide to less than 48 kg.	F3	F1	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	
Weld station 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	The structural design of the MCO is such that leaks have a very low probability of occurring (passive barrier).	F2	F0	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	
CSB operating 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	F0	--	None	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	--	

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-K-12 WS-K-15	Nuclear criticality - cranes and lifts, MCO	This hazard is addressed in HNF-SD-SNF-RPT-004, Chapter 6.[c] — no new hazards have been identified.										
Weld station WS-L-02 WS-L-04 WS-L-06 WS-L-10 WS-L-13 WS-L-14 WS-L-16	Flammable materials - rags, lubricating oil, paints and solvents, grease, MHM neutron absorber, acetylene, dye pen solvents	The fire hazards analysis is responsible for evaluating fire hazards.[d]										
Weld station 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	None	F2	--	None	S2	--	Ventilation flows may dilute hydrogen concentrations below the LFL.
Weld station WS-M-07	Hazardous materials - toxic (plutonium and uranium)	Toxic consequences are bounded by the radiological consequences.[e]										

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-N-01	Ionizing radiation sources - fissile material	Ionizing radiation	Presence of fissile material in the MCO	Failure to install proper shielding during MCO insertion or removal from the sampling/weld station	Increased risk of exposure to facility workers	None	F3	--	Sampling/weld station has removable shielding (temporary, during insertion and removal). Operators must place the appropriate shielding around the sampling/weld station before inserting or removing MCO.	S2	S1	Pressurized releases of radioactive material are addressed under WS-H-06, "Pressure, volume - pressure vessels"
Weld station WS-N-03	Ionizing radiation sources - radioactive material	Refer to WS-N-01, "Ionizing radiation sources - fissile material."										
Weld station WS-P-01	External events - explosion outside of the truck vestibule	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-01).										
Weld station WS-P-02	External events - fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-02).										
Weld station WS-P-03	External events - nearby facilities	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-03).										
Weld station WS-P-04	External events - loss of power	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-04).										

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-01).										
Weld station WS-R-03	Natural phenomena - lightning	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-03).										
Weld station WS-R-04	Natural phenomena - rain	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-04).										
Weld station WS-R-05	Natural phenomena - snow, freezing weather	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-05).										
Weld station WS-R-06	Natural phenomena - straight wind (90 mi/h)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-06).										
Weld station WS-R-08	Natural phenomena - tornado (40 mi/h translational, 160 mi/h rotational; pressure drop, 0.9 lb/in^2 at 0.3 $lb/in^2/s$)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-08).										
Weld station WS-R-09	Natural phenomena - ashfall	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-09).										

Table 19. Canister Storage Building Hazard Analysis: Sampling/Weld Station. (10 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	
Weld station WS-R-10	Natural phenomena - range fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-10).										

[a] CSB-HN-0011, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[b] WHC-SD-SNF-ER-016, 1996, *Protection of Safety Class Systems Against Compressed Gas Cylinders at the 105KE and 105KW Basins*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
[c] HNF-SD-SNF-RPT-004, 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, Rev. 7, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[d] HNF-PRO-704, Rev. 0, *Hazard and Accident Analysis Process*, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[e] HNF-SD-SNF-TI-059, 1998, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 1, Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
DBE = design basis earthquake.
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 released to affect facility workers.
S1 = Release confined to the facility and affects facility workers.
S2 = Sufficient material and release energy to affect an onsite receptor (collocated worker) 100 m from the source of the release.
S3 = Sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access (Site boundary).
SC = Unprevented, this accident presents a challenge to a safety-class boundary.
-- = No ranking assigned because preventive or mitigative features were not identified (termination by passive features or low frequency or consequence).

Table 20. 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 deposited within the vault by dust devils or other winds - 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	--	None	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.

Table 20. 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 VL-K-15	Nuclear criticality - storage tubes	This hazard is addressed in HNF-SD-SNF-RPT-004, Chapter 6.0.[a] — no new hazards have been identified.										
Vault VL-N-04	Ionizing radiation sources - radioactive sources	There is no access to this area, so this hazard, while present, is not a concern for worker safety.										
Vault VL-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-01).										
Vault VL-R-04	Natural phenomena - rain	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-04).										
Vault VL-R-05	Natural phenomena - snow, freezing weather	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-05).										

[a] HNF-SD-SNF-RPT-004, 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, Rev. 7, Fluor Daniel Hanford, Incorporated, Richland, Washington.

DBE = design basis earthquake
MCO = multi-canister overpack.

F1 = Possible, but extremely unlikely.

S3 = Sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access (site boundary).
-- = No ranking assigned because preventive or mitigative features were not identified (termination by passive features or low frequency or consequence).

Table 21. Canister Storage Building Hazard Analysis: Support Building. (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	
Support building SB-L-01 SB-L-02 SB-L-03 SB-L-04 SB-L-06 SB-L-07 SB-L-08 SB-L-10 SB-L-11 SB-L-13 SB-L-14 SB-L-15 SB-L-16	Flammable materials - packing materials, rags, gasoline, lubricating oil, paints and solvents, diesel fuel, buildings and contents, grease, hydrogen(batteries), organics, forklift propane, acetylene, degreasers, clothing	The fire hazards analysis is responsible for evaluating fire hazards.[a]										
Support building SB-P-01	External events - explosion	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-01).										
Support building SB-P-02	External events - fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-02).										
Support building SB-P-03	External events - nearby facilities	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-03).										
Support building SB-P-04	External events - loss of power	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-P-04).										
Support building SB-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-01).										
Support building SB-R-03	Natural phenomena - lightning	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-03).										
Support building SB-R-04	Natural phenomena - rain	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-04).										

Table 21. Canister Storage Building Hazard Analysis: Support Building. (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	
Support building SB-R-05	Natural phenomena - snow, freezing weather	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-05).										
Support building SB-R-06	Natural phenomena - straight wind (90 mi/h)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-06).										
Support building SB-R-08	Natural phenomena - tornado (40 mi/h translational, 160 mi/h rotational; pressure drop, 0.9 lb/in^2 at 0.3 $lb/in^2/s$)	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-08).										
Support building SB-R-09	Natural phenomena - ashfall	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-09).										
Support building SB-R-10	Natural phenomena - range fire	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-R-10).										

[a] HNF-PRO-704, Rev. 0, *Hazard and Accident Analysis Process*, Fluor Daniel Hanford, Incorporated, Richland, Washington.

DBE = design basis earthquake.

Table 22. 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-01	External events - explosion	External explosion resulting in a shock wave introduces dust, heat, and/or projectiles into the truck vestibule and service 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	None	F2	--	None	S1	--	The CSB is isolated from major roads, reducing the possibility of explosions outside the facility affecting the CSB. The facility structure is designed to withstand significant external phenomena (e.g., tornado missiles, straight winds). 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. This hazard is addressed by the preliminary fire hazard analysis,[a] the white papers on occupational classification,[b,c] and the deviation and exemption request letters[d,e] that cover this topic.										
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 Chapter 1.0 of HNF-SD-SNF-RPT-004.[f]	Descriptions of potential accidents at nearby facilities and their resulting consequences are addressed in Chapter 1.0 of HNF-SD-SNF-RPT-004.[f]	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	--	The distance of the CSB from other facilities reduces the consequences of external events.	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 22. 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, service carts, cranes, sampling/weld station cooling and welding equipment.	Possible contamination spread (associated with loss of MHM or service tent ventilation sweep). Delays in the sampling/weld station 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	--	None	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	Damage to the CSB vault structure during an earthquake	Underground pipe designed according to the standards of the AWWA	None	F1	--	None	S3	--	
Outside OU-Q-01	Vehicles in motion - airplane	Airplane crash	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-SD-SNF-RPT-004.[f]	F0	--	None	--	--	

Table 22. 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-02	Vehicles in motion - helicopter	This hazard is evaluated for the facility as a whole under the heading of "Outside" (OU-Q-01)										
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 truck vestibule or the tractor outside - Truck 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	--	Transporter effects are not specifically considered for determining consequence, as this is addressed by the SARP.[8]	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 22. 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 (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 (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	--	Rail frogs are installed to meet structural criteria. 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 such that impacts to safety systems from the failure of non-safety systems will not impact the function of those safety systems.	SC Unprevented, this accident presents a challenge to a safety-class boundary. For rating purposes, an SC will be assigned a risk of 9.	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.

Table 22. 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-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	--	None	S1	--	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.
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 truck 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	--	The site grading is designed to prevent rain intrusion into the facility.	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-SD-SNF-RPT-004, Chapter 6.0 [f] — no new hazards were identified.						

Table 22. 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	--	The building is designed to withstand anticipated snow loads.	S1	--	The SARP prohibits MCO shipping during adverse weather conditions[6] (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-SD-SNF-RPT-004,[f] Chapter 6.0 --- 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	--	The facility structure and outer door are designed to withstand a design basis straight wind.	S1	--	The facility provides shelter for workers. Tornado wind speeds were considered in the design of building structures.

Table 22. 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-07	Natural phenomena - dust devil	Flying debris Dust	Pressure gradient	Personnel struck by flying debris Visibility reduced Accumulated debris	Personnel injury	None	F3	--	None	S1	--	The facility provides shelter for workers.
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, service 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	--	The facility superstructure is designed to withstand the forces of design basis tornado wind loads.	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 x 10^{-9} events/yr (refer to Chapter 1.0 of HNF-SD-SNF-RPT-004[4]).
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	--	The building is designed to withstand anticipated ash loadings.	S1	--	Ashfall was combined with other structural loadings in the design basis.

Table 22. 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	--	None	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.

[a] WHC-SD-SNF-FHA-002, 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, Rev. 1 Westinghouse Hanford Company Richland, Washington.

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

[c] Ares, 1996, *White Paper Presenting Recommended Approach to Fire Protection of the Operating Area of the Canister Storage Building*, Report 951107-002, Ares Corporation, Richland, Washington.

[d] Williams, N. H., 1996, *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.

[e] Williams, N. H., 1996, *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* (Letter 9655233 to E. D. Sellers, U.S. Department of Energy, Richland Operations Office, November 14), Fluor Daniel Hanford, Incorporated, Richland, Washington.

[f] HNF-SD-SNF-RPT-004, 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, Rev. 7, Fluor Daniel Hanford, Incorporated, Richland, Washington.

[g] HNF-SD-TP-SARP-017, 1997, *Preliminary Safety Analysis Report for Packaging. Onsite, Multi-Canister Overpack Cask*, Rev. 0, 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.[g]

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 released to affect facility workers.
S1 = Release confined to the facility and affects facility workers.
S2 = Sufficient material and release energy to affect an onsite receptor (collocated worker) 100 m from the source of the release.
S3 = Sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access (Site boundary).
SC = Unprevented, this accident presents a challenge to a safety-class boundary.
-- = No ranking assigned because preventive or mitigative features were not identified (termination by passive features or low frequency or consequences).

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Table 23. 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-F-01	Linear kinetic - transporter trucks	Transporter is moving into the CSB and collides with facility structures, systems, components, or personnel.	Possible rearrangement of MCO internals	Low	F3/SC
TV-F-06	Linear kinetic - gas bottles as missiles	Gas bottles, used for maintenance, fall, knocking the valve off and thus creating a missile as the high-pressure gas escapes, the gas bottle missile collides with the transporter, equipment, personnel, and the inner overhead door.	Possible rearrangement of MCO internals	Medium	F2/S2
TV-G-13	Mass, gravity, height - vessels (transportation cask)	Transportation cask falls from the receiving crane to the truck vestibule floor.	Possible rearrangement of MCO internals	Medium	F3/SC
SA-E-07	Rotational kinetic - MHM turret	Rotating MHM turret exerts a shearing force on			
		• An MCO, causing a breach	Reactions with fuel	Low	F3/SC
		• A lifting cable, causing MCO to impact the service station pit with no retrieval capability.	Possible rearrangement of MCO internals	Low	F3/SC
SA-F-05	Linear kinetic - receiving crane	Receiving crane collides with an obstruction while moving the transportation cask and causes the cask to fall to the deck.	Reactions with fuel	Medium	F2/SC
SA-F-07b	Linear kinetic - MHM lateral movement	MHM movement while raising an MCO causes a shear force on			
		• An MCO, causing a breach	Reactions with fuel	Low	F3/SC
		• A lifting cable, causing MCO to impact the service station pit with no retrieval capability.	Possible rearrangement of MCO internals	Low	F3/SC

Table 23. 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-03a	Mass, gravity, height - lifts and cranes (may carry transportation cask, MCO, storage tube plug, cask lid, or impact absorber)	A drop from the receiving crane or MHM (caused by human error or mechanical failure) results in a criticality contingency criterion violation or a pressurized release from			
		• The transportation cask, which drops from the receiving crane and impacts the facility floor or the bottom of the service station pit or maintenance pit	Possible rearrangement of MCO internals	Medium	F1/SC
		• The MCO, which drops from the MHM into the transportation cask in the service station pit or directly onto the turntable of the MHM	Pressurized release if the MCO is at a pressure greater than 450 lb/in^2 gauge	Medium	F1/SC
		• The MCO cask lid, which drops from the receiving crane and damages the MCO cover port over the rupture disk.		High	F1/SC
SA-G03b	Mass, gravity, height - lifts and cranes (cask with MCO)	A drop of the cask with MCO (caused by human error or mechanical failure) into the maintenance pit or FFTF pit results in a criticality contingency criterion violation or a pressurized release from			
		• The transportation cask, which drops from the receiving crane and impacts the facility floor or the bottom of the FFTF pit or maintenance pit	Possible rearrangement of MCO internals	Medium	F1/SC
		• The MCO, which drops, along with the cask, and is damaged	Pressurized release if the MCO is at a pressure greater than 450 lb/in^2 gauge	Medium	F1/SC

Table 23. 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-13	Mass, gravity, height - vessels (transportation cask, MCO)	A drop from the receiving crane or MHM (caused by human error or mechanical failure) results in a criticality contingency criteria violation from			
		• A cask-MCO, which drops from the receiving crane as it is lowered	Possible rearrangement of MCO internals	Medium	F1/SC
		• An MCO, which drops from the MHM as it is raised.	Possible rearrangement of MCO internals	Medium	F1/SC
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/SC
SA-J-10a	Explosives or pyrophorics - plutonium and uranium metal, zirconium	Pyrophoric material is exposed to air by MCO breach or failure to inert the MCO.	Reactions with fuel	High	F1/SC
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	F0/SC
OA-D-01	Corrosives - acids (cart battery)	A leaking service cart battery causes the failure of MCO integrity.	Pressurized release	Low	F1/S3
OA-E-07	Rotational kinetic - MHM turret	Rotation of the MHM turret before the MCO is fully lowered shears			
		• The MCO itself, causing a breach	Reactions with fuel	Low	F3/SC
		• The supporting cable, causing an MCO drop.	Possible rearrangement of MCO internals	Medium	F3/SC

Table 23. 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-F-07	Linear kinetic - MHM lateral movement	Movement of the MHM before the MCO is fully lowered shears			
		• The MCO itself, causing a breach	Reactions with fuel	Low	F3/SC
		• The supporting cable, causing an MCO drop.	Possible rearrangement of MCO internals	Medium	F3/SC
OA-G-03 OA-G-13	Mass, gravity, height - lifts and cranes (includes loads), vessels (MCO)	A dropped MCO impacts the MHM turntable, top or sides of standard storage tube, bottom of standard storage tube if impact absorber not present (~50 ft), or other MCO in the tube (double failure if impact absorber not installed) resulting in			
		• MCO damage	Possible rearrangement of MCO internals	Medium	F2/SC
		• Fuel basket center line moved off center.	Possible rearrangement of MCO internals	Medium	F2/SC
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	F3/SC
OA-J-06b	Explosives or pyrophorics - hydrogen (storage tube and MHM)	Radiolysis of uranium hydrates, aluminum hydride, and free water results in hydrogen and oxygen. Mixture leaks through seal failure and ignites			
		• In the MHM	Deflagrations	High	F2/S2
		• Within the storage tube.	Deflagrations	High	F2/S2
OA-J-06c	Explosives or pyrophorics - hydrogen	Flammable mixture and ignition source (other than radiolysis - air ingress from breached MCO) inside the MCO, ignites inside the MCO.	Deflagrations	High	F3/SC

Table 23. 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-J-10a	Explosive or pyrophorics - plutonium and uranium metal	Pyrophoric material is exposed to the air because of an MCO breach that occurs with air present within the storage tube.	Reactions with fuel	High	F2/SC
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	F0/SC
WS-B-07	Thermal - radioactive decay heat (MCO)	MCO heats up in the sampling/weld station because of thermal buildup causing the MCO to exceed design temperature criteria.	Violation of design temperature criteria	Low	F3/S2
WS-E-07	Rotational kinetic - MHM turret	Rotation of the MHM turret before the MCO is fully lowered shears			
		• The MCO itself, causing a breach	Reactions with fuel	Medium	F3/SC
		• The supporting cable, causing an MCO drop.	Possible rearrangement of MCO internals	Low	F3/SC
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-06	Linear kinetic - pressure vessel blowdown (maintenance gas cylinders)	Impact of gas cylinder as a missile shears sampling lines connected to MCO in the sampling/weld station.	Pressurized release	Medium	F0/--
WS-F-07	Linear kinetic - MHM lateral movement	Movement of the MHM before the MCO is fully lowered shears			
		• The MCO itself, causing a breach	Reactions with fuel	Medium	F3/SC
		• The supporting cable, causing an MCO drop.	Possible rearrangement of MCO internals	Low	F3/SC
WS-G-01	Mass, gravity, height - human effort	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

Table 23. 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-G-03a WS-G-13	Mass, gravity, height - lifts and cranes (including loads)	An MCO dropped from the MHM impacts the turntable or the bottom of the sampling/weld station resulting in			
		• MCO damage	Possible rearrangement of MCO internals	Medium	F2/SC
		• Fuel basket center line moved off center.	Possible rearrangement of MCO internals	Medium	F2/SC
WS-G-03b	Mass, gravity, height - lifts and cranes	Equipment dropped on the sample line can result in the shear of the sample line.	Pressurized release	Medium	F2/S2
WS-G-04	Mass, gravity, height - bucket ladder (maintenance)	Collision of the bucket ladder with the crane or the sample cart or dropping of equipment from the bucket ladder on sample line causes shearing of the sampling lines connected to the MCO.	Pressurized release	Medium	F2/S2
WS-G-06	Mass, gravity, height - slings (covers)	Dropping of equipment (covers) from the slings onto the sample line causes shearing of the sampling lines connected to the MCO.	Pressurized release	Medium	F2/S2
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	F2/S2
WS-H-06b	Pressure, volume -MCO	Inappropriate purge gas used for processing operations results in MCO reactions.	Deflagrations	High	F3/S3
			Reactions with fuel	High	F3/S3
WS-J-06	Explosives or pyrophorics - hydrogen	A flammable hydrogen mixture is created and a deflagration occurs within the MCO in the sampling/weld station.	Deflagrations	High	F3/SC
WS-J-10a	Explosive or pyrophorics - plutonium and uranium metal	Pyrophoric material is exposed to the air because of an MCO breach that occurs at the sampling/weld station with air present.	Reactions with fuel	High	F2/SC
WS-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	F0/SC

Table 23. 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-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	F2/S2
WS-N-01	Ionizing radiation sources - fissile material	Direct streaming of ionizing radiation is caused by absence of proper shielding during MCO insertion and removal from the sampling/weld station.	Radiation exposure	NA	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-P-05	External events - water line breaks	Washout of compacted soil from an undetected water line break or leak reduces the structural integrity of the CSB facility especially during an earthquake.	Reactions with fuel	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/SC

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 release energy to affect an onsite receptor (collocated worker) 100 m from the source of the release.
S3 = Sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access (Site boundary.)
SC = Unprevented, this event could degrade the reliability of an established safety-class component. DOE Order 6430.1A stipulates that single component failures cannot defeat a safety-class component. Events marked safety class are automatically assigned a risk rank of 9, regardless of their frequency, so that they are analyzed further.
-- = No ranking assigned because preventive or mitigative features were not identified because of termination by passive features or low frequency or consequence.

Table 24. Binned Listing of Candidate Accidents. (2 sheets)

Candidate accident	Risk ranking	Release or change energy	Reference designator
Rearrangement of MCO internals (Section A3.4.2.1)			
Possible rearrangement of MCO internals due to a drop or shear[a]	9	Medium[b]	OA-E-07
	9	Medium[b]	OA-F-07
	9	Medium[b]	OA-G-03, -13
	9	Low[b]	SA-E-07
	9	Low[b]	SA-F-07b
	9	Low[b]	WS-E-07
	9	Low[b]	WS-F-07
	9	Medium[b]	WS-G-03a, -13
	9	Medium[b]	SA-G-03a, -03b, -13
	9	Medium[b]	TV-G-13
	9	Medium[b]	OU-R-01
	6	Medium[b]	OU-P-05
Possible rearrangement of MCO internals due to collision	8	Medium	SA-F-05
Possible rearrangement of MCO internals due to impact from gas cylinder	5	Medium	TV-F-06 SA-F-06 WS-F-06
Gaseous release from the MCO (Section A3.4.2.2)			
Pressurized release from MCO[a]	9	Medium	SA-G-03a
	6	Low	OA-D-01
	5	High	WS-H-06a, -07, -11
	5	Medium	WS-F-02, -05
	5	Medium	WS-F-06
	5	Medium	WS-G-01
	5	Medium	WS-G-03b
	5	Medium	WS-G-04
	5	Medium	WS-G-06
Pressurized release from cask–MCO	9	Low	TV-G-13
MCO internal hydrogen explosion (Section A3.4.2.3)			
Hydrogen deflagration[a]	9	High	WS-H-06b
	9	High	WS-J-06
	9	High	OA-J-06a, -06c
	9	High	SA-J-06a
MCO external hydrogen explosion (Section A3.4.2.4)			
External deflagration[a]	5	High	WS-L-11
	9	High	WS-J-06b

Table 24. Binned Listing of Candidate Accidents. (2 sheets)

Candidate accident	Risk ranking	Release or change energy	Reference designator
Thermal runaway fuel reactions inside the MCO (Section A3.4.2.5)			
Runaway reaction[a]	9	High	WS-H-06b
Fuel reaction with air	9	High	SA-J-10a
	9	High	OA-J-10a
	9	High	WS-J-10a
Fuel reaction with water	9	High	SA-J-10b
	9	High	OA-J-10b
	9	High	WS-J-10b
Fuel exposed to air	9	Medium	WS-E-07
	9	Medium	WS-F-07
	9	Low	SA-E-07
	9	Low	SA-F-07b
	9	Low	OA-E-07
	9	Low	OA-F-07
	9	Low	SA-F-05
Violations of design temperature criteria (Section A3.4.2.6)			
Violation of design temperature criteria[a]	7	Low	WS-B-07
	6	Medium	VL-B-07

[a] Chosen as a representative and bounding accident for further accident analysis development.

[b]Energy was considered that could rearrange the internals of the 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.

MCO = multi-canister overpack.

Table 25. Three-by-Three Likelihood and Consequence Ranking Matrix.

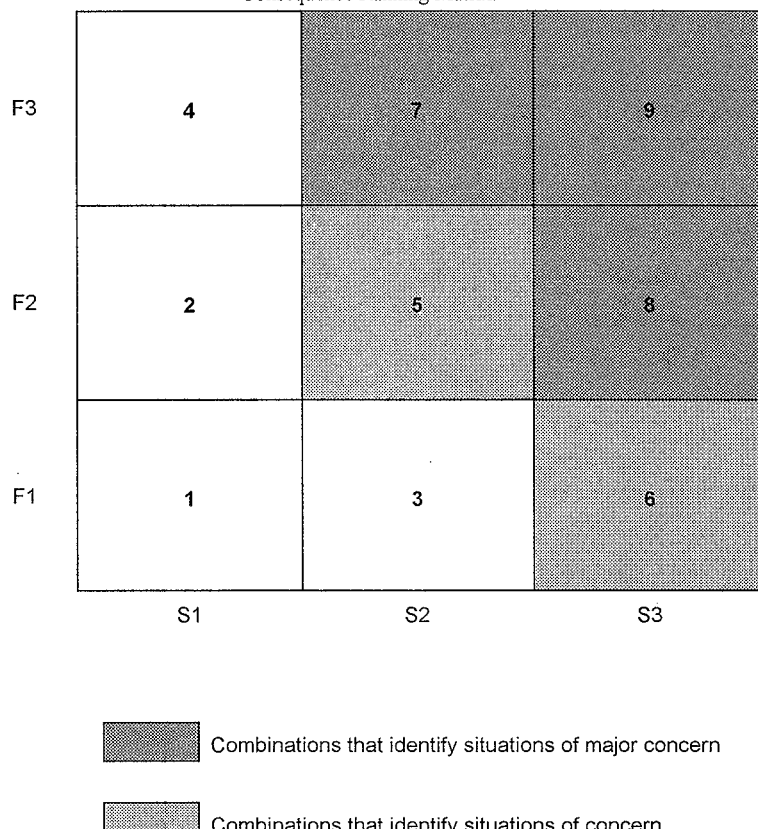

Table 26. Hazardous Material/Energy Source Checklist: Off-Normal Multi-Canister Overpack Storage in Overpack Tube.

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 - objects in area

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 - connect lines & tube

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 - Connect lines & tube

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 - SNF-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
- □ ■ 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

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Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (4 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	
CSB 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	--	None	SRxF2	--	Reaction rates are relatively slow at initial MCO temperatures Insufficient water is available in the MCO for a thermal runaway reaction

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (4 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	
CSB 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	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	FRxF3	--	None	SRxF2	--	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.

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (4 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	
CSB operating area OA-J-06d	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	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).	FRxF3	--	None	SRxF2	--	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.
CSB 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	--	None	SRxF2	--	
CSB vault area VL-J-06	Hydrogen	Explosive potential	MCO failure leads to hydrogen in tube, tube failure releases hydrogen into vault	Hydrogen explosion in vault	Onsite dose release	Installation test of tube integrity	FRxF2	--	None	SRxF2	--	

Table 27. Canister Storage Building Hazard Analysis: Off-normal Multi-Canister Overpack Storage in Overpack Storage Tube. (4 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	--	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.	FRxS2	FRxS1	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.

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).

S1 = Release confined to the facility and affects facility workers.
S2 = Sufficient material and release energy to affect an onsite receptor (collocated worker) 100 m from the source of the release.
S3 = Sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access (Site boundary).
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).
-- = No ranking assigned because preventive or mitigative features were not identified (termination by passive features or low frequency or consequences).

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/SRxS2 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 key members of the Canister Storage Building (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.

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.

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.