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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 (SAR) and documents the results.

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CANISTER STORAGE BUILDING
HAZARD ANALYSIS REPORT

HNF-SD-SNF-HIE-001
Revision 0

July 1997

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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 final CSB safety analysis report (SAR) and documents the results. The hazard analysis was performed in accordance with DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, and implements the requirements of DOE Order 5480.23, *Nuclear Safety Analysis Reports*.

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2.0 SCOPE OF THE HAZARD ANALYSIS

The scope of the CSB hazard analysis was limited to normal, intended, CSB operations, based on the design and operations described in Chapters 2.0 and 4.0 of HNF-SD-SNF-RPT-004, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction* (Garvin 1997). The analysis included review of a draft operation flow diagram and draft operating procedures. The CSB operations considered were those involved with bringing the transportation cask containing a multicanister overpack (MCO) into the facility on the transporter, 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), conducting activities during MCO staging and interim storage, and transporting the MCO from the storage tube to the Hot Conditioning System Annex and returning it to the storage tube after hot conditioning. The details of the hot conditioning process were not within the scope of the hazard analysis. They will be analyzed in the Hot Conditioning System hazard analysis.

One purpose of the hazard analysis effort was to identify information that remained to be developed before the hazard analysis could be completed in support of the final CSB SAR. A number of issues and open items were identified in the course of the hazard evaluation. While many have since been closed, several items remain open at this time. All remaining specific open action items and issues necessary to complete the hazard analysis are identified in the remarks column of the hazard analysis tables. In addition to the specific items and issues, the following generic issues important to the completion of the hazard and accident analysis were identified.

1. The means of detecting off-normal conditions during CSB operations and the plans for recovery actions need to be developed. These recovery actions also need to be examined for their potential to initiate additional hazardous conditions or accidents.

2. The hazard evaluation reflects a high degree of confidence that the CSB criteria for acceptance of an MCO into the facility (evidence of pressure test at the end of cold vacuum drying and adherence to the shipping window time limits identified in HNF-SD-SNF-SARP-017, *Preliminary Safety Analysis Report for Packaging (Onsite) Multiple Canister Overpack Cask* [RFS 1996]) will provide a safety margin sufficient to avoid a high pressure blowdown of the MCO before it is placed in the storage tube. The supporting analysis for this confidence has yet to be developed and documented.

3. Design of important components is not yet finalized. Of particular importance to the hazard evaluation and accident analysis are completion of MCO design, particularly the pressure relief systems, MHM and receiving crane design, and service cart design and intended use.

Both the specific open action items identified in the tables and the generic issues listed above will be closed out through future revisions to this document. All items will be closed before submittal of the final SAR for DOE approval.

The following key sources of information were used to evaluate the hazards:

- Chapters 2.0 and 4.0 of HNF-SD-SNF-RPT-004 (Garvin 1997) for facility design and operations information

- Chapter 3.0 of HNF-SD-SNF-RPT-004 (Garvin 1997) for the facility radioactive materials inventory and Appendix 3A for the results of the preliminary hazard analysis

- Chapter 6.0 of HNF-SD-SNF-RPT-004 (Garvin 1997) to evaluate the potential for hazards from nuclear criticality events

- Fluor Daniel, Inc., drawing SK-120916 (3 sheets), "Operational Sequence Top Level Block Diagram," "Operating Sequence MCO Service Station Block Diagram," "Operating Sequence MHM Operations MCO Service Operations Block Diagram" (see Attachment 1)

- Draft operating procedures, currently located on the Hanford local area network shared drive \\AP013\SNFP

- HNF-SD-SNF-FHA-002, *Preliminary Fire Hazard Analysis for the Canister Storage Building* (Sadanaga 1996); Ares Report 951107-001, *Canister Storage Building Fire Code Equivalency Evaluation* (Ares 1996a); Ares Report 951107-002, *White Paper Presenting Recommended Approach to Fire Protection of the Operating Area of the Canister Storage Building* (Ares 1996b); 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)

- HNF-SD-TP-SARP-017, *Preliminary Safety Analysis Report for Packaging (Onsite) Multiple Canister Overpack Cask* (RFS 1996), for coverage of accidents involving the transporter and transportation cask and for definition of assumptions inherent in defining the transportation window

- Two representatives from facility operations for details of proposed operating modes and procedures

- HNF-SD-SNF-SARR-005, *Multicanister Overpack Topical Report* (Lorenz 1997), for criteria and assumptions related to MCO design

- Representatives of the design authority for receiving crane and MHM for details of the current (incomplete) design of those components.

3.0 HAZARD ANALYSIS METHODOLOGY

This section presents the methodology used to perform the CSB hazard analysis. First 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 consequences and frequency of occurrence. 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 (SSCs); 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 included identification of the hazards associated with CSB design and operations. Hazards were defined as material, referred to as material at risk, that may 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 to personnel.

Hazard identification for the CSB was based on examination of the facility and operations descriptions provided in Chapters 2.0 and 4.0 of HNF-SD-SNF-RPT-004 (Garvin 1997), on a draft operation flow diagram and draft operating procedures, and on discussions with design representatives from Flour Daniel, Inc. The facility was divided into six areas:

- Truck vestibule
- Service area
- Operating area
- Vault
- Support building
- Outside.

A standardized checklist, Figure 3-1, was used to identify potentially hazardous materials and energy sources present in each of the six areas. Figures 3-2 through 3-7 show the hazard identification results for each area. The hazard identification checklists were developed by a subgroup of the hazard analysis team and reviewed and accepted by the entire team. The team included representatives of the CSB design authority and CSB operations personnel.

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. It 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 2 lists the members of the hazard analysis team and describes the background and experience of each. Information from a preliminary hazard analysis (Garvin 1997) that was performed at the conceptual design stage for the facility was used as a check for completeness.

The first step in the hazard evaluation was to screen the potentially hazardous materials and energy sources for those that present only standard industrial hazards. These are defined in DOE-STD-3009-94 as those hazards 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 3-1 through 3-6 provide the listing of standard industrial hazards by facility area. The industrial safety requirements for U.S. Department of Energy sites are covered by Title 29, *Code of Federal Regulations*, Part 1910, "Occupational Safety and Health Standards." The following parts of that document apply to the protection of workers from the hazards identified in the tables:

Subpart A	General
Subpart D	Walking - Working Surfaces
Subpart E	Means of Egress
Subpart F	Powered Platforms, Manlifts, and Vehicle-Mounted Work Platforms
Subpart G	Occupational Health and Environmental Control
Subpart H	Hazardous Materials
Subpart I	Personal Protective Equipment
Subpart J	General Environmental Controls
Subpart K	Medical and First Aid
Subpart L	Fire Protection
Subpart M	Compressed Gas and Compressed Air Equipment
Subpart N	Materials Handling, and Storage
Subpart O	Machinery and Machine Guarding
Subpart P	Hand and Portable Powered Tools and Other Hand-Held Equipment
Subpart Q	Welding, Cutting, and Brazing
Subpart S	Electrical
Subpart Z	Toxic and Hazardous Substances.

The hazard analysis team agreed by consensus to the results of the screening.

The remaining hazards were characterized to support the hazard evaluation process. Table 3-7 identifies the type, form, and quantity of the material at risk at the CSB facility. Tables 3-8 through 3-13 characterize the hazardous materials and energy sources that can contribute to the uncontrolled release of the material at risk identified in Table 3-7. The values in the tables are not intended to represent limits. They were used solely to indicate relative magnitude of the various hazards to aid in the evaluation and binning process. Some design and operations information is not yet available in the detail needed to completely characterize the hazards. The tables indicate "TBD" for those items that need to be identified before this hazard analysis can be finalized to support the final CSB SAR.

The characterized hazards were then entered into the hazard analysis tables by facility area. Using the tables as a guide, the team identified and recorded each hazardous condition and the potential accidents arising from the presence of the hazardous condition, potential causes and consequences of the hazardous condition, existing design features to prevent the condition or mitigate the consequences, planned administrative features to prevent the hazardous condition or mitigate the consequences, and estimates of the likelihood and consequences of the hazardous condition.

The hazard analysis tables, Tables 3-14 through 3-19, show the results of the hazard evaluation as compiled by the hazard analysis team. The hazard analysis tables contain descriptions of causes for hazardous conditions. Identification of causes was based on the hazard identification results, reviews of the systems designs and planned operations, existing safety documentation, and the experience of hazard analysis team members. Typical potential causes of the postulated hazardous conditions include equipment failures, operational errors, abnormal operating conditions, poor operating practices, and environmental conditions. The potential causes of a postulated hazardous condition were identified to support a qualitative frequency evaluation.

Each hazardous condition was assessed to determine a qualitative likelihood of occurrence and consequence. The assessment of likelihood and consequence for each hazardous condition was a collective, qualitative judgment made by the hazard analysis team. The assessment took into consideration the impact of designed passive features (e.g., structures, barriers) when estimating likelihoods and consequences but not active features or planned controls (e.g., valves, shipping restrictions).

The likelihood assessments were based on occurrences over the facility lifetime. 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.

The consequence assessments were based on potential effects of an MCO release on the health and safety of people and on the environment. 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).

The hazard analysis tables contain identified preventive or mitigative design features and proposed administrative controls that have the potential to reduce the estimated likelihood of a postulated hazardous condition or to reduce its consequences. Only passive design features were factored into the likelihood and consequence assessment. Proposed administrative controls were identified primarily by the draft operating procedures and the contribution of operations personnel on the hazard evaluation team.

3.3 CANDIDATE ACCIDENT SELECTION

The hazardous conditions identified by the hazard evaluation have been used to select candidate accidents for more detailed, quantitative analysis in the final CSB SAR. 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." This section describes the approach used to select candidate accidents. The results of the activity are contained in Attachment 3.

The concept of selecting candidate accidents from all hazardous conditions identified is based on the feasibility of characterizing risk from, and developing controls for, a representative set of hazardous conditions. A hazardous condition is generally considered to be representative of other hazardous conditions if it has similar release characteristics and involves similar initiators. Hazardous conditions that represent the most severe consequences and the highest risk (a combination of frequency and consequences) within each set of representative hazards are selected as candidate accidents for further analysis in the SAR.

In accordance with DOE-STD-3009-94 and consistent with the graded approach, the risks of a facility may be characterized and appropriate controls developed using the detailed analysis of a representative set of hazardous conditions. The representative hazardous conditions bound conditions with lesser but similar potential consequences, represent the highest risk, or , while not necessarily bounding, present some unique but important phenomenological challenge to system safety. The selection process comprises five steps:

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
5. Selection of unique hazardous conditions.

Initial Screening. All hazardous conditions whose unmitigated consequences are assessed as S3 (offsite consequences) or S2 (collocated worker consequences) are chosen for consideration for representative accident selection through a ranking of relative risk (see Table A3-1). Those assessed as S1 (facility worker consequences) do not warrant detailed accident analysis and are instead addressed qualitatively in the SAR using the hazard analysis results. Those assessed as having no consequences (S0) are dropped from consideration.

Assignment of Release Attributes. Each hazardous condition is described with certain release attributes related to uncontrolled release of the material at risk (see Table A3-2). This is done to ensure that at least one candidate accident is selected to represent each unique set of release conditions. The hazardous material release attributes used are as follows:

- Initial energy available to release the hazardous material (high, medium, or low)
- Initial release location
- The release initiator.

Creation of Hazardous Material Release Bins. Once the release attributes are assigned to each hazardous condition, they are collected to form release categories, or "bins." Collecting hazardous conditions into bins involves grouping all hazardous conditions with common initiators and ranking them by estimated consequence, available energy for release, and frequency.

Selection of Representative Bounding Hazardous Conditions for each Release Attribute Category. Within each release attribute bin, the most severe hazardous condition, considering consequences, and the highest risk accident, based on a likelihood and consequence ranking matrix as described in DOE-STD-3009-94 (see Attachment 3, Table A3-1), were selected. In some cases, they were the same hazardous condition.

Selection of Unique Hazardous Conditions. Hazardous conditions were selected to represent additional, unique causes within each release attribute bin. This was done to support development of controls for accidents with similar consequences but with different causes.

The final list of candidate accidents represents all S3 (offsite) and S2 (onsite) hazardous conditions identified by the hazard analysis. These hazardous conditions are grouped by candidate accident to facilitate incorporation of the information and conclusions from the accident analysis into the hazard analysis results when considering controls and hazard classification.

Individual release bins may need to be broken into several smaller bins in the future as a result of ongoing accident analysis activities. This is often driven by a determination that separate sets of controls are necessary for hazardous conditions in the same release bin to reduce the likelihood or consequence of the hazards involved. Any modifications to the binning categories will be incorporated into this document to support the final CSB SAR.

Figure 3-1. Hazardous Material/Energy Source Checklist: Example.

NODE: ____

Y N **A. Electrical**
☐☐ 1. Battery banks
☐☐ 2. Cable runs
☐☐ 3. Diesel 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. 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
☐☐ 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
☐☐ 9. Negative pressure collapse
☐☐ 10. Steam headers and lines
☐☐ 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
☐☐ 13. 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
☐☐ 8. Buildings & contents
☐☐ 9. Trailers and 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. 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

Figure 3-2. Hazardous Material/Energy Source Checklist: Truck Vestibule.

Location: ***Truck Vestibule***

Y N A. Electrical
- ■ □ 1. Battery banks
- ■ □ 2. Cable runs (crane cabling)
- □ ■ 3. Diesel generators
- □ ■ 4. Electrical equipment
- □ ■ 5. HVAC heaters
- □ ■ 6. High voltage
- ■ □ 7. Motors (crane)
- □ ■ 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 (no cutting 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 (no cutting 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 (service 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 (Crane maintenance)
- □ ■ 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 (cask tiedowns)
- □ ■ 8. Gas receivers
- □ ■ 9. Negative pressure collapse
- □ ■ 10. Steam headers and lines
- □ ■ 11. Other ________

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 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. 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
- □ ■ 8. Buildings & contents
- □ ■ 9. Trailers and contents
- ■ □ 10. Grease
- ■ □ 11. Hydrogen
- □ ■ 12. Nitric acid
- □ ■ 13. Organics
- □ ■ 14. Gases - others
- □ ■ 15. Liquids - others
- ■ □ 16. Other hydraulic fluid

Y N M. Hazardous Materials
- □ ■ 1. Alkali metals
- ■ □ 2. Asphyxiants
- □ ■ 3. Biologicals
- ■ □ 4. Carcinogens
- ■ □ 5. Corrosives
- □ ■ 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
- □ ■ 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

Figure 3-3. Hazardous Material/Energy Source Checklist: Service Area.

Location: ***MCO Service Area***

Y N A. <u>Electrical</u>
☐ ■ 1. Battery banks (<u>MHM backup power</u>)
■ ☐ 2. Cable runs
☐ ■ 3. Diesel generators
☐ ■ 4. Electrical equipment
☐ ■ 5. HVAC heaters
☐ ■ 6. High voltage
■ ☐ 7. Motors (<u>Hoist</u>)
☐ ■ 8. Pumps
■ ☐ 9. Power tools
■ ☐ 10. Switchgear
■ ☐ 11. Service outlets, fittings
☐ ■ 12. Transformers
☐ ■ 13. Transmission lines
☐ ■ 14. Underground wires
■ ☐ 15. Wiring
■ ☐ 16. Other <u>blowers</u>____

Y N B. <u>Thermal</u>
☐ ■ 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 <u>crane brakes & MHM</u>

Y N C. <u>Friction</u>
☐ ■ 1. Belts
■ ☐ 2. Bearings
■ ☐ 3. Fans
■ ☐ 4. Gears
■ ☐ 5. Motors
■ ☐ 6. Power tools
■ ☐ 7. Other <u>crane brakes & MHM</u>

Y N D. <u>Corrosives</u>
☐ ■ 1. Acids
☐ ■ 2. Caustics
☐ ■ 3. Natural chemicals
☐ ■ 4. Decontamination solution
☐ ■ 5. High temperature waste
☐ ■ 6. Other ________

Y N E. <u>Kinetic - Rotational</u>
☐ ■ 1. Centrifuges
■ ☐ 2. Motors
☐ ■ 3. Pumps
☐ ■ 4. Cooling tower fans
☐ ■ 5. Laundry equipment
☐ ■ 6. Shop equipment
■ ☐ 7. Other <u>MHM turret</u>___

Y N F. <u>Kinetic - Linear</u>
☐ ■ 1. Cars, trucks, buses
☐ ■ 2. Forklifts, dollies, carts
☐ ■ 3. Railroad
☐ ■ 4. Obstructions
■ ☐ 5. Crane loads (<u>includes MHM cask</u>)
■ ☐ 6. Pressure vessel blowdown
■ ☐ 7. Other <u>MHM movement</u>___

Y N G. <u>Mass, Gravity, Height</u>
■ ☐ 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. <u>Pressure - Volume</u>
☐ ■ 1. Boilers
☐ ■ 2. Surge tanks
☐ ■ 3. Autoclave
☐ ■ 4. Test loops
■ ☐ 5. Gas bottles (<u>on service carts & MHM</u>)
■ ☐ 6. Pressure vessels
☐ ■ 7. Stressed members
■ ☐ 8. Gas receivers (MHM inert system)
☐ ■ 9. Negative pressure collapse
☐ ■ 10. Steam headers and lines
■ ☐ 11. Other <u>pressurized inert gas line</u>

Y N J. <u>Exothermic Reactions</u>
☐ ■ 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. <u>Nuclear Criticality</u>
■ ☐ 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. <u>Flammable Materials</u>
☐ ■ 1. Packing materials
☐ ■ 2. Rags
☐ ■ 3. Gasoline
☐ ■ 4. Lube oil
☐ ■ 5. Coolant oil
☐ ■ 6. Paint solvent
☐ ■ 7. Diesel fuel
■ ☐ 8. Buildings & contents (tent enclosure)
☐ ■ 9. Trailers and contents
☐ ■ 10. Grease
■ ☐ 11. Hydrogen
☐ ■ 12. Nitric acid
■ ☐ 13. Organics (<u>tent material, MHM neutron absorber</u>)
☐ ■ 14. Gases - others
■ ☐ 15. Liquids - others (<u>hydraulic fluid on service carts</u>)
☐ ■ 16. Other ________

Y N M. <u>Hazardous Materials</u>
☐ ■ 1. Alkali metals
■ ☐ 2. Asphyxiants
☐ ■ 3. Biologicals
☐ ■ 4. Carcinogens
☐ ■ 5. Corrosives
☐ ■ 6. Oxidizers
■ ☐ 7. Toxics
☐ ■ 8. Heavy metals
☐ ■ 9. Other ________

Y N N. <u>Ionizing Radiation Sources</u>
■ ☐ 1. Fissile material
☐ ■ 2. Radiography equipment
■ ☐ 3. Radioactive material
☐ ■ 4. Radioactive sources
☐ ■ 5. Other ________

Y N P. <u>External Events</u>
■ ☐ 1. Explosion
■ ☐ 2. Fire
■ ☐ 3. Other sites

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

Y N R. <u>Natural Phenomena</u>
■ ☐ 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

Figure 3-4. Hazardous Material/Energy Source Checklist: Operating Area.

Location: ***CSB Operating Area***

Y	N	A. Electrical
■	☐	1. Battery banks (service carts and MHM)
■	☐	2. Cable runs
☐	■	3. Diesel generators
☐	■	4. Electrical equipment
☐	■	5. HVAC heaters
■	☐	6. High voltage
■	☐	7. Motors
■	☐	8. Pumps
☐	■	9. Power tools
■	☐	10. Switchgear (MHM)
■	☐	11. Service outlets, fittings
■	☐	12. Transformers (MHM)
☐	■	13. Transmission lines
☐	■	14. Underground wires
■	☐	15. Wiring
■	☐	16. Other lights, CAMs, detectors

Y	N	B. Thermal
☐	■	1. Bunsen burner/hot plates
☐	■	2. Electrical equipment
■	☐	3. Furnaces/boilers/heater (sample lines)
☐	■	4. Steam lines
☐	■	5. Welding torch/arc
☐	■	6. Diesel units/fire box/exhaust line
■	☐	7. Radioactive decay heat
■	☐	8. Exposed components (hot areas on cart)
☐	■	9. Power tools
■	☐	10. Convective
☐	■	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 and tube cart

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 MHM turret

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

Y	N	G. Mass, Gravity, Height
☐	■	1. Human effort
☐	■	2. Stairs
■	☐	3. Lifts and cranes
☐	■	4. Bucket and ladder
☐	■	5. Trucks
■	☐	6. Slings (to remove tube plug embed covers)
■	☐	7. Hoists
☐	■	8. Elevators
☐	■	9. Jacks
■	☐	10. Scaffold and ladders
■	☐	11. Pits and excavations
☐	■	12. Elevated doors
■	☐	13. Vessels
■	☐	14. Other dropped tube plugs, impact absorbers, etc.

Y	N	H. Pressure - Volume
☐	■	1. Boilers
☐	■	2. Surge tanks
☐	■	3. Autoclave
☐	■	4. Test loops
■	☐	5. Gas bottles
■	☐	6. Pressure vessels (MCO & tubes)
☐	■	7. Stressed members
■	☐	8. Gas receivers (MHM inert system)
☐	■	9. Negative pressure collapse
☐	■	10. Steam headers and lines
☐	■	11. Other ________

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 metal
☐	■	11. Sodium
☐	■	12. Other ________

Y	N	K. Nuclear Criticality
■	☐	1. Vaults
☐	■	2. Temporary storage areas
☐	■	3. Shipping and receiving area
■	☐	4. Filters (cart and tube plug)
☐	■	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
☐	■	8. Buildings & contents
☐	■	9. Trailers and contents
☐	■	10. Grease
■	☐	11. Hydrogen
☐	■	12. Nitric acid
■	☐	13. Organics (MHM neutron absorber, DOP)
☐	■	14. Gases - others
■	☐	15. Liquids - others (hydraulic fluid for tube cart plug cover hoist)
☐	■	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 (lead from batteries)
☐	■	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. 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

Figure 3-5. Hazardous Material/Energy Source Checklist: Vault.

Location: ***Vault (includes intake structure and exhaust stack)***

Y N A. **Electrical**
☐ ■ 1. Battery banks
☐ ■ 2. Cable runs
☐ ■ 3. Diesel 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. 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
☐ ■ 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 (intake structures)
☐ ■ 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
☐ ■ 9. Negative pressure collapse
☐ ■ 10. Steam headers and lines
☐ ■ 11. Other ________

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 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. 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
☐ ■ 8. Buildings & contents
☐ ■ 9. Trailers and 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 (Pu and U)
☐ ■ 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 (MCO radiation)

Y N P. **External Events**
☐ ■ 1. Explosion
☐ ■ 2. Fire
☐ ■ 3. Other sites (underground fire water pipes)

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

Figure 3-6. Hazardous Material/Energy Source Checklist: Support Building.

Location: ***Support Building***

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

Figure 3-7. Hazardous Material/Energy Source Checklist: Outside.

Location: ***Outside***

Y	N	A. Electrical
□	■	1. Battery banks
□	■	2. Cable runs
□	■	3. Diesel 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 (lighting)

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
■	□	12. Solar
□	■	13. Cryogenic
□	■	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. 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 (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
□	■	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 structures)
□	■	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 (He supply)
□	■	7. Stressed members
□	■	8. Gas receivers
□	■	9. Negative pressure collapse
□	■	10. Steam headers and lines
□	■	11. Other ________

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 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. 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 (dumpster)
□	■	2. Rags
■	□	3. Gasoline
■	□	4. Lube oil
■	□	5. Coolant oil (transformers)
□	■	6. Paint solvent
■	□	7. Diesel fuel
□	■	8. Buildings & contents
□	■	9. Trailers and 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 (diesel exhaust)
■	□	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
□	■	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

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Table 3-1. Standard Industrial Hazards: Truck Vestibule.

Hazard category	Hazard type	Checklist designator		
Electrical	Vehicle batteries	TV	A	1
	Crane cabling	TV	A	2
	Crane motor	TV	A	7
	Power tools	TV	A	9
	Service outlets, fittings	TV	A	11
	Wiring	TV	A	15
Thermal	Diesel units/exhaust lines on vehicles	TV	B	6
	Radioactive decay heat from fuel within MCO	TV	B	7
	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 (no cutting tools)	TV	C	6
Corrosives	Vehicle battery acid	TV	D	1
Kinetic - rotational	Crane motor	TV	E	2
Mass, gravity, height	Human effort (dropped items)	TV	G	1
	Lifts and cranes	TV	G	3
	Slings	TV	G	6
	Hoists	TV	G	7
	Scaffold and ladders (receiving crane maintenance)	TV	G	10
	Elevated doors	TV	G	12
Pressure - volume	Stressed members (cask tiedowns)	TV	H	7
Flammable materials	Lube oil	TV	L	4
	Diesel fuel	TV	L	7
	Grease	TV	L	10
	Other (hydraulic fluid)	TV	L	16
Hazardous materials	Asphyxiants	TV	M	2
	Carcinogens	TV	M	4
	Corrosives (battery acid)	TV	M	5
	Heavy metals (battery lead)	TV	M	8

MCO = multicanister overpack.

Table 3-2. Standard Industrial Hazards: Service Area.

Hazard category	Hazard type	Checklist designator		
Electrical	Cable runs (crane cabling)	SA	A	2
	Motors (hoist)	SA	A	7
	Power tools	SA	A	9
	Switchgear	SA	A	10
	Service outlets, fittings	SA	A	11
	Wiring	SA	A	15
	Other (blowers)	SA	A	16
Thermal	Power tools (no cutting tools)	SA	B	9
	Other (crane and MHM brakes)	SA	B	13
Friction	Bearings	SA	C	2
	Fans	SA	C	3
	Gears	SA	C	4
	Motors	SA	C	5
	Power tools (no cutting tools)	SA	C	6
	Other (crane and MHM brakes)	SA	C	7
Kinetic - rotational	Motors	SA	E	2
	Exposed parts on rotating MHM turret	SA	E	7
Kinetic - linear	MHM gas bottle blowdown (missile and whipping hazard)	SA	F	6
Mass, gravity, height	Hoists	SA	G	7
	Scaffolds and ladders	SA	G	10
	Pits and excavations	SA	G	11
	Elevated doors	SA	G	12
Pressure - volume	Other (pressurized inert gas line)	SA	H	11
Hazardous materials	Asphyxiants	SA	M	2

MHM = multicanister overpack handling machine.

Table 3-3. Standard Industrial Hazards: Operating Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Electrical	Battery banks (service carts)	OA	A	1
	Cable runs	OA	A	2
	High voltage	OA	A	6
	Motors	OA	A	7
	Pumps	OA	A	8
	Switchgear (MHM)	OA	A	10
	Service outlets, fittings	OA	A	11
	Transformers (MHM)	OA	A	12
	Wiring	OA	A	15
	Other (lighting, CAMs, detectors)	OA	A	16
Thermal	Furnaces/boilers/heater (cart sample line)	OA	B	3
	Exposed components (exposed area on cart)	OA	B	8
	Convective	OA	B	10
	Cryogenic	OA	B	12
	Other (operating deck)	OA	B	13
Friction	Bearings	OA	C	2
	Fans	OA	C	3
	Gears	OA	C	4
	Motors	OA	C	5
	Other (brakes on the MHM and tube cart)	OA	C	7
Kinetic - rotational	Motors	OA	E	2
	Pumps	OA	E	3
Kinetic - linear	Obstruction (removed floor embeds)	OA	F	4
	Crane loads	OA	F	5
	MHM and service cart gas bottle blowdown (missile and whipping hazards)	OA	F	6
Mass, gravity, height	Lifts and cranes	OA	G	3
	Slings (to remove tube plug cover)	OA	G	6
	Hoists	OA	G	7
	Scaffold and ladders	OA	G	10
	Pits and excavations	OA	G	11

Table 3-3. Standard Industrial Hazards: Operating Area. (2 sheets)

Hazard category	Hazard type	Checklist designator		
Pressure - volume	Gas bottles on service cart and MHM (missile and whipping hazard)	OA	H	5
	Gas receivers	OA	H	8
Hazardous materials	Asphyxiants	OA	M	2
	Heavy metals (battery lead)	OA	M	8

CAM = continuous air monitor.
MHM = multicanister overpack handling machine.

Table 3-4. Standard Industrial Hazards: Vault.

Hazard category	Hazard type	Checklist designator		
Thermal	Exposed components	VL	B	8
Mass, gravity, height	Pits and excavations	VL	G	11

Table 3-5. Standard Industrial Hazards: Support Building.

Hazard category	Hazard type	Checklist designator		
Electrical	Battery banks (uninterruptible power supply)	SB	A	1
	Cable runs	SB	A	2
	Diesel generators	SB	A	3
	Electrical equipment	SB	A	4
	Heating, ventilating, and air conditioning heaters	SB	A	5
	High voltage	SB	A	6
	Motors	SB	A	7
	Pumps	SB	A	8
	Switchgear	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
	Diesel units/fire box/exhaust line	SB	B	6
	Convective	SB	B	10
	Other (soldering in shop)	SB	B	13
Friction	Belts (compressors)	SB	C	1
	Bearings	SB	C	2
	Fans	SB	C	3
	Gears	SB	C	4
	Motors	SB	C	5
Corrosives	Acids (sealed batteries)	SB	D	1
Kinetic - rotational	Motors	SB	E	2
	Pumps	SB	E	3
Kinetic - linear	Forklifts, dollies, carts (service carts)	SB	F	2
	Obstructions	SB	F	4
	Pressure vessel blowdown (air compressors)	SB	F	6
Mass, gravity, height	Elevated doors	SB	G	12
Pressure - volume	Gas receivers (air)	SB	H	8
	Other (high pressure inert gas line)	SB	H	11
Hazardous materials	Asphyxiants (diesel exhaust)	SB	M	2
	Carcinogens	SB	M	4
	Heavy metals (battery lead)	SB	M	8
Ionizing radiation sources	Radioactive sources (instrument calibration sources)	SB	N	4

Table 3-6. Standard Industrial Hazards: Outside.

Hazard category	Hazard type	Checklist designator		
Electrical	Electrical equipment	OU	A	4
	High voltage	OU	A	6
	Motors	OU	A	7
	Pumps	OU	A	8
	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)	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	Bearings	OU	C	2
	Fans	OU	C	3
	Gears	OU	C	4
	Motors	OU	C	5
Corrosives	Vehicle batteries	OU	D	1
	Natural chemicals	OU	D	3
Kinetic - rotational	Motors	OU	E	2
	Pumps	OU	E	3
	Other (heating, ventilating, and air conditioning units)	OU	E	7
Mass, gravity, height	Stairs (stack)	OU	G	2
	Pits and excavations (air intake structures)	OU	G	11
Flammable materials	Packing materials (dumpster)	OU	L	1
	Gasoline	OU	L	3
	Lube oil	OU	L	4
	Coolant oil (transformers)	OU	L	5
Hazardous materials	Asphyxiants (diesel exhaust)	OU	M	2
	Biologicals (snakes, spiders)	OU	M	3
	Corrosives (battery acid)	OU	M	5
	Heavy metals (battery lead)	OU	M	8

Table 3-7. Canister Storage Building Material at Risk (Type, Form, and Quantity).

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; one loaded scrap basket and four loaded fuel baskets MCO estimated to contain 300 kg of particulate matter after cold vacuum drying and shipping to CSB (upper bound)	Mark IV spent fuel from N Reactor (upper bound)	Solid consisting of fuel and particulate corrosion products	6.90 MTU at 3.84 E+04 Ci/MTU (see Table 3-6)	Yes, particulate is transient	Upper bound mass is 6.90 tonne uranium 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; chunks of fuel possible if MCO is sheared	MCO estimated to contain 300 kg of particulate matter after cold vacuum drying and shipping to CSB (upper bound)	NA	Solid	0.3 MTU at 3.84 E+04 Ci/MTU	Yes, particulate is transient	0.3 MTU per MCO	
Operating area	MHM loading MCO into vault	SNF and particulate matter in MCO	Finely divided particulate matter; chunks of fuel possible if MCO is sheared	One loaded scrap basket and four loaded fuel baskets MCO estimated to contain 300 kg of particulate matter after cold vacuum dry and shipping to CSB and after hot conditioning (upper bound)	Mark IV spent fuel from N Reactor (upper bound)	Solid consisting of fuel and particulate corrosion products	6.90 MTU at 3.84 E+04 Ci/MTU (see Table 3-6)	Yes, particulate and fuel chunks are transient	6.90 tonne uranium including 0.3 tonne particulate per MCO	
	Contents of a loaded vault tube	SNF and particulate matter in two MCOs	NA	Two MCOs; each loaded with one scrap basket and four fuel baskets	Mark IV spent fuel from N Reactor (upper bound)	Solid consisting of fuel and particulate corrosion products	13.8 MTU at 3.84 E+04 Ci/MTU	Yes, particulate is transient	13.8 tonne uranium including 0.6 tonne particulate 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	[avg MTU per MCO (TBD) x 440 MCO] at avg Ci/MTU (TBD)	Yes, particulate is transient	TBD tonne uranium including 132 tonne maximum particulate	
Support building	Particulate on HVAC filters	Finely divided radioactive particulate from MCOs	Radioactive particulate matter	Unknown	NA	Solid	Unknown	Yes, particulate is transient	Unknown	
	Fuel for emergency generators	Diesel fuel in two day tanks	Diesel fuel	Two 50-gal diesel storage tanks	NA	Liquid	100 gal	Yes	100 gal	
Outside area	Fuel for emergency generators	Diesel fuel in two above- ground tanks	Diesel fuel	Two 500-gal diesel storage tanks	NA	Liquid	Up to 1,000 gal	Yes	Two tanks at 500 gal per tank	Overfill protection is provided
	Fuel delivery truck	Diesel fuel delivered to emergency generator tanks	Diesel fuel	One tanker truck	NA	Liquid	Delivers fuel to two 500-gal above-ground fuel tanks	Yes	TBD	Standard fuel hose and dispenser nozzle is used
	Inert gas storage	Helium used to inert MCOs, storage tubes, and MHM	Helium	Two identical 3,400 m3 storage tubes on trailer	NA	Gas	NA	Yes	Two identical 3,400 m^3 storage tanks on trailer	

CSB = Canister Storage Building.
HVAC = heating, ventilating, and air conditioning (filter).
MAR = material at risk.
MCO = multicanister overpack.
MHM = multicanister overpack handling machine.
MTU = metric ton of uranium.
NA = not applicable.
SNF = spent nuclear fuel.
TBD = to be determined.

Table 3-8. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Truck Vestibule. (sheet 1 of 4)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Linear kinetic - loaded transporter truck collides with personnel or equipment	TV-F-1	• Truck speed ≈ TBD • Truck mass ≈ 47 tonne	
Linear kinetic - receiving crane with yoke and loaded cask collides with object	TV-F-5	• Maximum gantry speed ≈ 12 m/min (40 ft/min) • Maximum trolley speed ≈ 12 m/min (40 ft/min) • Crane lifting capacity ≈ 54 tonne (60 ton) • Crane load: - Mass of loaded cask ≈ 27 tonne (30 ton) - Mass of cask lifting beam ≈ 340 kg	The gantry and trolley creep speeds are 1 ft/min per Design Basis Document, Rev. 1, Section 8.7.1
Mass, gravity, height - cask on transporter falls off	TV-G-5 and TV-G-13	• Mass of loaded cask ≈ 27 tonne • Distance to floor ≈ 1 m (3.3 ft)	
Mass, gravity, height - cask is dropped	TV-G-13	• Mass of loaded cask ≈ 27 tonne • Maximum lift height off floor ≈ TBD • Receiving crane lifting capacity ≈ 54 tonne (60 ton)	
Pressure, volume - MCO relieves pressure, releases gases into cask	TV-H-6	• Loaded cask free space volume ≈ 325 L • Cask design pressure ≈ 1.0 MPa gauge (150 lb/in^2 gauge) • MCO relief pressure: - Valve ≈ 830 kPa differential (120 lb/in^2 differential) - Rupture disk ≈ 1.0 MPa differential (150 lb/in^2 differential) • MCO design pressure ≈ 1.0 MPa gauge (150 lb/in^2 gauge) • Cask pressure ≈ 71 kPa gauge (10 lb/in^2 gauge) after release from valve • Initial helium pressure in cask ≈ 21 kPa gauge (3 lb/in^2 gauge) at 25 °C (77 °F) • Cask pressure ≈ 635 kPa gauge (92 lb/in^2 gauge) after release from rupture disk	Valve is primary pressure relief device; rupture disk is backup relief device. Valve reseat pressure is assumed to be 10% of set pressure or 108 lb/in^2 gauge.

Table 3-8. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Truck Vestibule. (sheet 2 of 4)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Explosives or pyrophorics, flammable material-hydrogen released from cask-MCO mixed with air plus ignition source (cask seal leaks)	TV-J-6	U-H_2O reaction: • Maximum estimated water in MCO after cold vacuum drying is 10% of particulate matter (≈ 15 kg) • Reaction temperature ≈ 75 °C (167 °F) with a U surface area of 120,000 cm^2 • H_2 generation rate ≈ 0.3 moles/h • Valve relief pressure ≈ 830 kPa differential (120 lb/in^2 differential) • Valve reseat pressure ≈ 740 kPa differential (108 lb/in^2 differential) • Number of valve releases ≈ 50	
Explosives or pyrophorics - uranium, plutonium, or zirconium metal (metals exposed to air because of breached MCO and cask seal)	TV-J-10	• Contents of one scrap basket in an MCO is most vulnerable, 1,300 kg* • Scrap could burn first then ignite rest of MCO fuel, ≈ 5,000 kg**	*A conservative estimate offered in WHC-SD-SNF-TI-023, Rev. 1, p. 12* **Based on 54 assemblies of 'E'-length MKIV fuel per basket x 4 baskets x 23.5 kg uranium per assembly
Nuclear criticality - cask	TV-K-5 TV-K-12	One MCO in cask with ≈ 6,800 kg of spent nuclear fuel	
Flammable material - hydrogen	TV-L-11	---	Refer to "Explosives or pyrophorics - hydrogen" for an evaluation of this hazard
Hazardous material: toxics - for example, plutonium, uranium, strontium, beryllium	TV-M-7	See release by pyrophorics	
Ionizing radiation - MCO contents	TV-N-1 TV-N-3	• Cask shielding ≈ 20 cm (7.7 in.) of steel • Operational limit for contact dose is < 100 mrem/h • Estimated dose rate at 2 m is < 10 mrem/h; 2 mrem/h in the tractor cab	
Ionization radiation - surface contamination through loss of contamination control	TV-N-3	Unknown	
External events - explosion outside the truck vestibule, (e.g., propane delivery truck)	TV-P-1	See "External events" under Service Area	

Table 3-8. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Truck Vestibule. (sheet 3 of 4)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
External events - fire, smoke, and heat limits accessability and visibility	TV-P-2	Heat and smoke quantity unknown	Depends on material that burns and wind direction
External events - nearby facility (e.g., radioactive material, toxics, or direct radiation into facility)	TV-P-3	Unknown	Depends on facility accident and wind direction at time of accident
Kinetic linear - vehicle in motion impacts truck vestibule	TV-Q-4	Selected loaded cement truck at ≈ 48 km/h (30 mi/h) with a mass of ≈ 32 tonne (70,000 lb)	Ongoing construction at CSB brings cement truck into area.
Natural phenomena - earthquake	TV-R-1	Forces exerted on facility from lateral and horizontal accelerations: 0.35 *g* horizontal, 0.23 *g* vertical (see Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - lightning strikes truck vestibule	TV-R-3	Electrical discharge of millions of volts	Lightning protection shall be provided for facility as required by NFPA 780[c]
Natural phenomena - rain intrusion	TV-R-4	Facility drainage designed for a 6-hour probable maximum precipitation of 23 cm (9.2 in.) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - snow, freezing weather	TV-R-5	Roof designed for snow loading of 98 kg/m^2 (20 lb/ft^2) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - straight wind causes flying debris, wind pressure, and dust	TV-R-6	Facility designed for a wind speed of 129 km/h (80 mi/h), which is the design basis for the Hanford Site (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - dust devil creates dust and flying debris	TV-R-7	Unknown	Cleanup of dust and debris would be needed
Natural phenomena - tornado	TV-R-8	Facility designed to withstand tornado wind speeds of 322 km/h (200 mi/h) total, 258 km/h (160 mi/h) rotational, and 64.4 km/h (40 mi/h) translational (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	

Table 3-8. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Truck Vestibule. (sheet 4 of 4)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Natural phenomena - volcanic ashfall	TV-R-9	Facility designed to withstand a ground ash load of 117 kg/m² (24 lb/ft²) (see Section 1.4.3.8.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - range fire	TV-R-10	Vegetation control in an 18-m (60-ft) clear space around CSB shall be provided (see Section 1.3.1.1 of HNF-SD-SNF-RPT-004[b])	

[a]Pajunen, A. L., and R. G. Cowan, 1996, *Bounding Particulate Contents of Multi-Canister Overpack*, WHC-SD-SNF-TI-023, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

[b]Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[c]NFPA, 1995, *Lightning Protection Systems*, NFPA 780, National Fire Protection Association, Quincy, Massachusetts.

CSB = Canister Storage Building.
MCO = multicanister overpack.
TBD = to be determined.

Table 3-9. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Service Area. (sheet 1 of 5)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Rotational kinetic - MHM turret shears MCO	SA-E-7	Shearing plane is ≈ 1.5 m (5 ft) above floor level; shear force is TBD	
Linear kinetic - receiving crane with loaded cask collides with object	SA-F-5	• Maximum gantry speed ≈ 12 m/min (40 ft/min) • Maximum trolley speed ≈ 12 m/min (40 ft/min) • Loaded receiving crane mass ≈ 150 tonne • Crane lifting capacity ≈ 54 tonne (60 ton) • Mass of loaded cask ≈ 27 tonne • Mass of lifting beam ≈ 340 kg	Gantry and trolley creep speed is 1 ft/min according to the Design Basis Document, Rev. 1, Section 8.7.1[a]
Linear kinetic - pressure vessel, MCO blowdown from 1.0 MPa gauge (150 lb/in^2 gauge) with gas impingement	SA-F-6	• MCO rupture disk diameter ≈ 2.5 cm (1.0 in.) • Maximum MCO blowdown rate ≈ 0.38 kg/sec (0.84 lbm/sec) • Impingement force ≈ 395 N	
Linear kinetic - MHM lateral movement results in collision with personnel or equipment	SA-F-7	• MHM gantry* bridge speed ≈ 12 m/min (40 ft/min) • Maximum MHM trolley* speed ≈ 12 m/min (40 ft/min) • MHM mass with plug and MCO ≈ 450 tonne**	*Gantry bridge and trolley creep speed is 30.5 cm/min (1 ft/min) according to the Design Basis Document, Rev. 1, Section 8.7.1[a] **See Section 4.3.4.4.1 of HNF-SD-SNF-RPT-004[b]
Mass, gravity, height - human effort allows tools or other objects to be dropped	SA-G-1	Unknown	
Mass, gravity, height - human error allows small parts off 5-ton gantry crane to fall off into service pit	SA-G-1	Load cell on MHM grapple stops lift at 1,000 lb to prevent load damage	
Mass, gravity, height - • Transport cask is dropped by receiving crane • MCO is dropped by MHM during load-out from service pit	SA-G-3 SA-G-13	• Cask lift height above floor ≈ TBD • Mass of cask ≈ 27 tonne • MCO lift height above bottom of service pit ≈ TBD • Mass of MCO ≈ 8.6 tonne	
Pressure, volume - damaged gas bottles (backup inert gas supply on MHM) result in uncontrolled release of gas	SA-H-5	• Gas bottle pressure ≈ 17 MPa gauge (2,500 lb/in^2 gauge) • Gas bottle nozzle diameter ≈ TBD • Mass flow rate of gas ≈ TBD at sonic velocity • Resultant force ≈ TBD	

Table 3-9. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Service Area. (sheet 2 of 5)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Pressure, volume - process delay results in release of gas from MCO into sealed cask*	SA-H-6	• Loaded cask free space volume ≈ 325 L • Cask design pressure ≈ 1.0 MPa gauge (150 lb/in^2 gauge) • MCO relief pressure: - Valve, 830 kPa differential (120 lb/in^2 differential) - Rupture disk, 1.0 MPa differential (150 lb/in^2 differential) • MCO design pressure ≈ 1.0 MPa gauge (150 lb/in^2 gauge) • Cask pressure ≈ 71 kPa gauge (10 lb/in^2 gauge) after release from valve • Cask pressure ≈ 635 kPa gauge (92 lb/in^2 gauge) after release from rupture disk	Valve is primary pressure relief device; rupture disk is backup relief device. Valve reseat pressure is assumed to be 10% of set pressure or 108 lb/in^2 gauge. *See *Calculations for Hydrogen Release and Combustion in the Service Tent Enclosure of the CSB*, HNF-SD-SNF-CN-020.[c]
Pressure, volume - uncontrolled release of inert gas supply for MHM inerting system	SA-H-8	• Festoon line pressure ≈ 120 lb/in^2 gauge • Festoon line size ≈ TBD • MCO service line pressure ≈ 550 kPa gauge (80 lb/in^2 gauge) • MCO service line size ≈ 5 cm (2 in.)	
Explosives or pyrophorics - in service pit, hydrogen release from MCO mixes with air then ignition source causes combustion*	SA-J-6	• MCO relief pressure: - Valve ≈ 830 kPa gauge (120 lb/in^2 gauge) - Valve reseat pressure ≈ 740 kPa gauge (110 lb/in^2 gauge) • H_2 release quantity from one valve release ≈ 14 gram-moles • Relief pressure of rupture disk ≈ 1.0 MPa differential (150 lb/in^2 differential) • Minimum flammability of H_2 in air ≈ 4% by volume • Maximum H_2 release quantity through rupture disk ≈ 210 gram-moles • After combustion, maximum gas temperature in service pit ≈ 1,800 °C (3,300 °F) and maximum pressure ≈ 1,380 Pa gauge (200 lb/in^2 gauge)**	*See *Calculations for Hydrogen Release and Combustion in the Service Pit of the CSB*, HNF-SD-SNF-CN-024.[d] **A pressure impulse of 1,380 kPa gauge (200 lb/in^2 gauge) acting on the underside of the shield hatch assembly on the service pit is great enough to lift it.
Explosives or pyrophorics - plutonium, uranium, and zirconium metal is exposed to air	SA-J-10	Minimum ignition temperature of plutonium, uranium, and zirconium: • Fuel ignition tests in lab showed minimum ignition temperatures ranging from 329 °C to 473 °C (624 °F to 883 °F). See PNNL "Ignition Testing of As-Cut Conditioned SNF Samples," 10/16/96.[e]	Reaction rate is temperature and surface area dependent; these metals are more inclined to ignite in the finely divided state than in the massive state; contents of scrap basket are most vulnerable.

Table 3-9. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Service Area. (sheet 3 of 5)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Nuclear criticality	SA-K-1 SA-K-4 SA-K-5 SA-K-12	---	Addressed in Chapter 6.0 of HNF-SD-SNF-RPT-004;[b] no new hazards were identified.
Flammable materials - building and contents (in tent enclosure, hydrogen and tent material; on MHM, neutron absorber)	SA-L-8, SA-L-11, and SA-L-13	See HNF-SD-SNF-FHA-002[f]	These hazards are addressed by HNF-SD-SNF-FHA-002.[f]
Hazardous materials - toxic metals (e.g., plutonium, uranium, beryllium) entrained in pressurized gas release from MCO	SA-M-7	• Bounding range of particulate matter in MCO ≈ 150 to 300 kg (330 to 660 lb) • Unmitigated release fraction range from MCO blowdown, RF ≈ 10^{-4} to 10^{-3} • Range of particulate matter released: 15 to 300 g (0.03 to 0.66 lb); the respirable fraction of that release ≈ 0.1	
Ionizing radiation sources - fissile or radioactive material entrained in pressurized gas release from MCO	SA-N-1 SA-N-3	• Bounding range of particulate matter in MCO ≈ 150 to 300 kg (330 to 660 lb) • Unmitigated release fraction range from MCO blowdown, RF ≈ 10^{-4} to 10^{-3} • Range of particulate matter released: 15 to 300 g (0.03 to 0.66 lb) • Unit dose ≈ 4.35 x 10^{-5} rem/g*	*Calculated from data in Table 3-6 of HNF-SD-SNF-RPT-004.[b]
External events • Gasoline or propane delivery truck explodes nearby causing shock wave, projectiles, heat, and dust that effect service area • Storage tanks* at nearby facility explode due to fire	SA-P-1	• Delivery truck capacity ≈ TBD • Distance from CSB ≈ TBD • Blast overpressure at CSB ≈ TBD • Propane storage tank* capacity ≈ 7,300 L (1,900 gal) • Estimated distance from CSB ≈ 760 m (2,500 ft) • Blast overpressure at CSB ≈ TBD from boiling liquid expanding vapor explosion	*Two horizontal cylindrical storage tanks (1,000 gal and 940 gal) of propane are located outside approximately 0.5 mi from CSB at 2711-E Building.
External events - fire	SA-P-2	See HNF-SD-SNF-FHA-002[f]	
External events - nearby facility accident releases radioactive or toxic material into service area	SA-P-3	--	See Chapter 1.0 of HNF-SD-SNF-RPT-004.[b]

Table 3-9. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Service Area. (sheet 4 of 5)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Natural phenomena - earthquake forces damage SSCs	SA-R-1	Forces exerted on facility from lateral and horizontal accelerations: 0.35 *g* horizontal, 0.23 *g* vertical (see Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - lightning strikes CSB	SA-R-3	Electrical discharge of millions of volts	Lightning protection shall be provided for facility as required by NFPA 780.[g] Computer control systems are especially vulnerable to lightning strikes.
Natural phenomena - rain intrusion	SA-R-4	Facility drainage designed for 6-hour probable maximum precipitation of 23 cm (9.2 in.) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - snow, freezing weather	SA-R-5	Roof designed for snow loading of 98 kg/m^2 (20 lb/ft^2) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena -straight wind causes flying debris, wind pressure, and dust	SA-R-6	Facility designed for a wind speed of 129 km/h (80 mi/h), which is the design basis for the Hanford Site (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - dust devil creates dust and flying debris	SA-R-7	Unknown	Cooling air intake for vault is mounted on a 17.4-m- (57-ft-) high concrete tower.
Natural phenomena - tornado	SA-R-8	Facility designed to withstand tornado wind speeds of 322 km/h (200 mi/h) total, 258 km/h (160 mi/h) rotational, and 64.4 km/h (40 mi/h) translational (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - volcanic ashfall	SA-R-9	Facility designed to withstand ground ash load of 117 kg/m^2 (24 lb/ft^2) (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	

Table 3-9. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Service Area. (sheet 5 of 5)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Natural phenomena - range fire	SA-R-10	Vegetation control in an 18-m (60-ft) clear space around CSB shall be provided (see Section 1.3.1.1 of HNF-SD-SNF-RPT-004[b])	

[a]Bedell, P. J., 1996, *SNF Canister Storage Building* (Letter FRP-112 to M. K. Mahaffey, Westinghouse Hanford Company, October 25), Fluor Daniel, Incorporated, Richland, Washington.

[b]Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[c]Scott, D. L., 1997, *Calculations for Hydrogen Release and Combustion in the Service Tent Enclosure of the CSB*, HNF-SD-SNF-CN-020, Rev. 0, Draft, Fluor Daniel Northwest for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[d]Scott, D. L., 1997, *Calculations for Hydrogen Release and Combustion in the Service Pit of the CSB*, HNF-SD-SNF-CN-024, Rev. 0, Draft, Fluor Daniel Northwest for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[e]*Ignition Testing of As-Cut Conditioned SNF Samples*, Pacific Northwest National Laboratory, Richland, Washington.

[f]Sadanaga, C. T., 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DynCorp Tri-Cities Services, Incorporated, for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[g]NFPA, 1995, *Lightning Protection Systems*, NFPA 780, National Fire Protection Association, Quincy, Massachusetts.

CSB = Canister Storage Building.
MCO = multicanister overpack.
MHM = multicanister overpack handling machine.
SSC = structure, system, and component.
TBD = to be determined.

Table 3-10. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Operating Area. (sheet 1 of 6)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Thermal - radioactive decay heat and chemical reaction create hot gases and surfaces below storage tube plug	OA-B-7	• Maximum allowable MCO wall temperature ≈ 130 °C (270 °F) • Maximum allowable temperature in MCO ≈ 200 °C (400 °F) • Maximum allowable temperature at underside of concrete deck ≈ 65 °C (150 °F) • Maximum expected storage tube gas and wall temperature* ≈ 120 °C (250 °F)	*This expected storage tube gas and wall temperature is a calculated maximum MCO surface temperature based on a hot summer day air temperature of 46 °C (115 °F) and the hottest spot in a fully loaded vault (see Section 2.5.2 of HNF-SD-SNF-RPT-004[a]).
Corrosives - leaking acids from cart batteries	OA-D-1	• Number of batteries per service cart ≈ TBD • Type of acid used is TBD • Estimated volume of acid in each battery ≈ TBD • Total volume of battery acid ≈ TBD	
Rotational kinetic - MHM turret shears MCO	OA-E-7	• Shearing plane is ≈ 1.5 m (5 ft) above floor level • Shear force is ≈ TBD	
Linear kinetic - forklift, dolly, service cart and trailer collisions	OA-F-2	• Forklift speed ≈ TBD • Forklift mass ≈ TBD • Dolly speed ≈ TBD • Dolly mass ≈ TBD • Service cart speed ≈ TBD • Service cart mass ≈ TBD	
Linear kinetic - MHM movement (MHM impacts personnel or equipment)	OA-F-7	• Maximum MHM gantry bridge* speed ≈ 12 m/min (40 ft/min) • Maximum MHM trolley* speed ≈ 12 m/min (40 ft/min) • MHM mass with plug and MCO ≈ 450 tonne**	*Gantry bridge and trolley creep speed is 30.5 cm/min (1 ft/min) according to the Design Basis Document, Rev. 1, Section 8.7.1.[b] **See Section 4.3.4.4.1 of HNF-SD-SNF-RPT-004.[a]
Mass, gravity, height - MCO falls on • Turntable • Top and sides of storage tube • Bottom impact absorber • Intermediate impact absorber	OA-G-13	• MCO mass ≈ 8.6 tonne • MCO fall distance to - Turntable ≈ TBD - Storage tube opening ≈ 2 m (7 ft) - Bottom impact absorber ≈ 13 m (44 ft) - Intermediate impact absorber ≈ 9 m (30 ft)	The design basis is a 8.80 tonne MCO concentric drop ≈ 13 m (44 ft) into a storage tube (see Section 4.3.4.4.1 of HNF-SD-SNF-RPT-004[a]).

Table 3-10. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Operating Area. (sheet 2 of 6)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Mass, gravity, height - items dropped: • Tube plug • Intermediate impact absorber • Cover plate assembly • Rigging equipment	OA-G-14	• Tube plug mass ≈2.6 tonne • Tube plug drop height ≈ 2.9 m (9.5 ft) • Intermediate impact absorber mass ≈ TBD • Intermediate impact absorber drop height ≈ 9.5 m (31 ft) • Standard cover plate assembly* mass ≈ 670 kg (1,500 lb) overall • Center hatch of cover plate mass ≈ 193 kg (425 lb) • Cover plate assembly drop height ≈ 30 cm (1 ft) • Rigging equipment mass ≈ TBD • Rigging equipment drop height ≈ TBD	*See drawing of cover plate (H-2-120912) in HNF-SD-SNF-RPT-004.*
Volume, pressure - • Gas bottles (an uncontrolled release of inert gas from a failed regulator valve or gas bottle breach on either the MHM or service cart) • Gas bottles (inadvertent overpressurization of seal between the MHM nose piece and the floor during MCO removal from the transportation cask)	OA-H-5	Service cart: • Number of gas bottles ≈ TBD • Maximum pressure in gas bottle ≈ TBD MHM inerting system: • Number of gas bottles ≈ TBD • Maximum pressure in gas bottle ≈ TBD MHM nose piece: • Maximum allowable pressure ≈ TBD MHM chamber: • Maximum allowable pressure ≈ TBD	
Volume, pressure - pressure vessels (excessive gas generation in MCO overpressurizes MCO with MCO in storage tube)	OA-H-6a	• MCO relief pressure: - Valve ≈ 0.8 MPa gauge (120 lb/in^2 gauge) - Rupture disk ≈ 1.0 MPa differential (150 lb/in^2 differential) • MCO design pressure ≈ 1.0 MPa gauge (150 lb/in^2 gauge)	

Table 3-10. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Operating Area. (sheet 3 of 6)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Volume, pressure - pressure vessel (storage tube receives gas from MCO)	OA-H-6b	• Maximum number of MCOs per storage tube = 2 • Loaded storage tube free space volume - With one MCO present ≈ 3,100 L* - With two MCOs present ≈ 2,100 L* • Storage tube design pressure ≈ 5.2 MPa gauge (750 lb/in^2 gauge) at 21 °C (70 °F) • Leak rate of storage tube plug O-ring seals ≈ 10^{-4} standard cm^3/sec at 27 kPa gauge (4 lb/in^2 gauge) • Tube plug weighs 3,850 kg (8,500 lb) and will lift at 520 kPa gauge (76 lb/in^2 gauge) • Pressure relief valves in storage tube plugs: - HEPA filter on outlet = yes - Primary relief valve set pressure ≈ 62 kPa gauge (9 lb/in^2 gauge) - Secondary relief valve set pressure ≈ 76 kPa gauge (11 lb/in^2 gauge)	*Both impact absorbers are assumed to be in place with no credit taken for porosity.
Volume, pressure - gas receivers (high pressure inert gas fill line or manifold fails)	OA-H-8	• Inert gas line pressure ≈ TBD • Inert gas outside storage tank capacity ≈ 3,400 m^3	
Explosives or pyrophorics - flammable hydrogen mixture and ignition source	OA-J-6	Maximum possible hydrogen release is from MCO rupture disk release into storage tube followed by release through storage tube plug to the CSB operating deck; estimated maximum quantity of hydrogen released ≈ 100 gmoles along with ≈ 69 gmoles of helium	
Explosives or pyrophorics - plutonium, uranium, and zirconium metal is exposed to air because of breached MCO and air ingress	OA-J-10	Minimum ignition temperature of plutonium, uranium, and zirconium in air: Fuel ignition tests in lab showed minimum ignition temperatures ranging from 329 °C to 473 °C (624 °F to 883 °F). See PNNL "Ignition Testing of As-Cut Conditioned SNF Samples," 10/16/96.[c]	Reaction rate is temperature- and surface area-dependent; these metals are more inclined to ignite in the finely divided state than in the massive state; contents of scrap basket are most vulnerable.
Nuclear criticality - vaults	OA-K-1	---	Addressed in Chapter 6.0 of HNF-SD-SNF-RPT-004;[a] no new hazards were identified.

Table 3-10. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Operating Area. (sheet 4 of 6)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Nuclear criticality -filters (cart and tube plugs)	OA-K-4	---	Addressed in Chapter 6.0 of HNF-SD-SNF-RPT-004;[a] no new hazards were identified.
Nuclear criticality - crane lifts	OA-K-12	---	Addressed in Chapter 6.0 of HNF-SD-SNF-RPT-004;[a] no new hazards were identified.
Flammable materials - hydrogen	OA-L-11	---	Refer to "Explosives or pyrophorics-hydrogen" for an evaluation of this hazard.
Flammable materials - organics (MHM neutron absorber)	OA-L-13	---	See HNF-SD-SNF-FHA-002,[d] the white paper on occupational classification,[e] and the deviation and exemption request letters that cover this topic.[f,g]
Flammable materials - hydraulic fluid for tube service cart plug cover hoist leaks out and burns	OA-L-15	Volume of hydraulic fluid at risk ≈ TBD	Alternative, non-flammable fluids are being considered. The PFHA[d] addresses fires that fully involve the cart except internal low-level contaminant release.
Hazardous materials - corrosives from batteries leak out	OA-M-5	---	See "Corrosives -acid" (OA-D-1) for an evaluation of this hazard.
Hazardous materials - toxic materials in particulate matter, primarily plutonium and uranium, are carried out of MCO and storage tube by gases under pressure	OA-M-7	Estimated maximum particulate matter in MCO after hot conditioning is 300 kg (660 lb) Unmitigated airborne release fraction from MCO blowdown ≈ 0.001; the respirable fraction of that release is 0.1	Particulate matter in gases must find a leak path out of the storage tube.
Ionizing radiation sources • Fissile or radioactive material release by gases under pressure • Radiation shine from adjacent storage tubes	OA-N-1 and OA-N-3	The dose rate shielding goal for the MHM is 2.0×10^{-3} mSv/hr (0.2 mrem/hr)	

Table 3-10. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Operating Area. (sheet 5 of 6)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
External events - explosion (gasoline or propane delivery truck explodes nearby causing shock wave, projectiles, heat, and dust)	OA-P-1	See "External events" under Service Area	
External events - fire	OA-P-2	---	See HNF-SD-SNF-FHA-002.[d]
External events - nearby facility accident releases radioactive, toxic material into operating area	OA-P-3	---	See Chapter 1.0 of HNF-SD-SNF-RPT-004.[a]
Natural phenomena - earthquake forces damage SSCs	OA-R-1	Forces exerted on facility from lateral and horizontal accelerations: 0.35 *g* horizontal, 0.23 *g* vertical (see Table 1-23 of HNF-SD-SNF-RPT-004[a])	
Natural phenomena - lightning strikes CSB	OA-R-3	Electrical discharge of millions of volts	Lightning protection shall be provided for facility as required by NFPA 780.[h]
Natural phenomena - rain intrusion	OA-R-4	Facility drainage designed for a 6-hour probable maximum precipitation of 23 cm (9.2 in.) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[a])	
Natural phenomena - snow, freezing weather	OA-R-5	Roof designed for snow loading of 98 kg/m^2 (20 lb/ft^2) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[a])	
Natural phenomena - straight wind causes flying debris, wind pressure, and dust	OA-R-6	Facility designed for a wind speed of 129 km/h (80 mi/h), which is the design basis for the Hanford Site (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[a])	
Natural phenomena - tornado	OA-R-8	Facility designed to withstand tornado wind speeds of 322 km/h (200 mi/h) total, 258 km/h (160 mi/h) rotational, and 64.4 km/h (40 mi/h) translational (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[a])	
Natural phenomena - volcanic ashfall	OA-R-9	Facility designed to withstand a ground ash load of 117 kg/m^2 (24 lb/ft^2) (see Section 1.4.3.8.2 and Table 1-23 of HNF-SD-SNF-RPT-004[a])	

Table 3-10. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Operating Area. (sheet 6 of 6)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Natural phenomena - range fire	OA-R-10	Vegetation control in an 18-m (60-ft) clear space around CSB shall be provided (see Section 1.3.1.1 of HNF-SD-SNF-RPT-004[a])	

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

[b]Bedell, P. J., 1996, *SNF Canister Storage Building* (Letter FRP-112 to M. K. Mahaffey, Westinghouse Hanford Company, October 25), Fluor Daniel, Incorporated, Richland, Washington.

[c]*Ignition Testing of As-Cut Conditioned SNF Samples*, Pacific Northwest National Laboratory, Richland, Washington.

[d]Sadanaga, C. T., 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DynCorp Tri-Cities Services, Incorporated, for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[e]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.

[f]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.

[g]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.

[h]NFPA, 1995, *Lightning Protection Systems*, NFPA 780, National Fire Protection Association, Quincy, Massachusetts.

CSB = Canister Storage Building.
HEPA = high-efficiency particulate air (filter).
MCO = multicanister overpack.
MHM = multicanister overpack handling machine.
SSC = structure, system, and component.
TBD = to be determined.

Table 3-11. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Vault (Including Air Intake and Exhaust). (sheet 1 of 2)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Thermal - radioactive decay heat and chemical reaction heat (high temperature in vault tubes and MCOs caused by blockage of natural convection flow)	VL-B-7 VL-B-10 VL-R-7 VL-R-9 VL-R-10	• Maximum expected air natural convection flow rate ≈ 770 m^3/min (27,000 m^3/min)[a] • Minimum required flow rate ≈ TBD • Maximum allowable fuel centerline temperature ≈ 200 °C (400 °F) • Maximum allowable MCO wall temperature ≈ 130 °C (270 °F) • Maximum estimated MCO wall temperature ≈ 120 °C (250 °F) • Maximum allowable temperature of vault concrete ≈ 65 °C (150 °F) • Maximum expected temperature of vault concrete ≈ 56 °C (130 °F)	The natural convection flow rate depends on how many MCOs are loaded into storage tubes.
Volume, pressure - pressure vessel (rupture disk rupture on MCO pressurizes storage tube)	VL-H-6	• Number of MCOs per storage tube = 2 • Loaded storage tube free space volume - With one MCO present ≈ 3,100 L - With two MCOs present ≈ 2,100 L • Storage tube working pressure ≈ 5.2 MPa gauge (750 lb/in^2 gauge) at 21 °C (70 °F) • Maximum calculated service pressure ≈ 520 kPa gauge (76 lb/in^2 gauge) • Leak rate of storage tube plug O-ring seals ≈ 10^{-4} standard cm^3/sec at 27 kPa gauge (4 lb/in^2 gauge) • Tube plug weighs 3,850 kg (8,500 lb) and will lift at 520 kPa gauge (76 lb/in^2 gauge) • Relief valves in storage tube plugs: - HEPA filter on outlet = yes - Primary relief valve set pressure ≈ 62 kPa gauge (9 lb/in^2 gauge) - Secondary relief valve set pressure ≈ 76 kPa gauge (11 lb/in^2 gauge)	
Explosives or pyrophorics - hydrogen leaks into vault area (from breached storage tubes), mixes with air to form a flammable mixture, and spark ignites mixture	VL-J-6	Maximum possible hydrogen release is from MCO rupture disk release into storage tube followed by release from storage tube into vault; estimated maximum quantity of hydrogen released ≈ 100 gmole along with ≈ 69 gmole of helium	
Flammable materials - hydrogen	VL-L-11	---	Refer to "Explosives or pyrophorics-hydrogen" for an evaluation of this hazard.

Table 3-11. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Vault (Including Air Intake and Exhaust). (sheet 2 of 2)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Ionizing radiation sources - radioactive sources	VL-N-4	---	There is no access to this area, so this hazard, while present, is not a concern for worker safety.
Natural phenomena - earthquake forces damage SSCs	VL-R-1	Forces exerted on facility from lateral and horizontal accelerations: 0.35 *g* horizontal, 0.23 *g* vertical (see Table 1-23 of HNF-SD-SNF-RPT-004[a])	
Natural phenomena - rain intrusion	VL-R-4	Facility drainage designed for a 6-hour probable maximum precipitation of 23 cm (9.2 in.) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[a])	
Natural phenomena - snow, freezing weather	VL-R-5	Roof designed for snow loading of 98 kg/m^2 (20 lb/ft^2) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[a])	

[a]Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. , Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
HEPA = high-efficiency particulate air (filter).
MCO = multicanister overpack.
SSC = structure, system, and component.
TBD = to be determined.

Table 3-12. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Support Building. (sheet 1 of 2)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Flammable materials: • Building contents • Packing materials • Rags • Lubricating oil • Diesel fuel • Grease • Hydrogen • Organics • Clothing	 SB-L-01 SB-L-02 SB-L-04 SB-L-07 SB-L-08 SB-L-10 SB-L-11 SB-L-13 SB-L-16	Mass of materials (kg) TBD	
Ionization radiation sources - radioactive material in HVAC filters burns	SB-N-03	Mass of radioactive material in filters ≈ TBD	
External events - explosion of propane or gasoline delivery truck introduces shockwave, projectiles, heat and dust into support building	SB-P-01	• Propane volume ≈ TBD • Gasoline volume ≈ TBD • Distance from support building ≈ TBD • Shockwave overpressure ≈ TBD	
External events - fire introduces heat and smoke into building	SB-P-02	A fire inside the building has greatest consequences, which are covered by the preliminary fire hazards analysis[a]	
External events - accidents at nearby facilities that release radioactive material and direct radiation cause personnel injury and render the facility uninhabitable	SB-P-03	Descriptions of potential accidents at nearby facilities and their resulting consequences are addressed in Chapter 1.0 of HNF-SD-SNF-RPT-004[b]	
Natural phenomena - earthquake forces cause collapse of structure resulting in loss of primary power, ventilation, and inert gas supply; HVAC filter failure results in radiation release	SB-R-01	Forces exerted on facility due to lateral and horizontal accelerations of 0.35 *g* horizontal, 0.23 *g* vertical (see Table 1-23 of HNF-SD-SNF-RPT-004[b])	The support building is designed to withstand a design basis earthquake.
Natural phenomena - lightning strikes support building	SB-R-03	Electrical discharge of millions of volts	Lightning protection shall be provided for facility as required by NFPA 780;[c] control systems are especially vulnerable to lightning strikes.
Natural phenomena - rain intrusion	SB-R-04	Facility drainage designed for a 6-hr probable maximum precipitation of 23 cm (9.2 in.) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	

Table 3-12. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Support Building. (sheet 2 of 2)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Natural phenomena - snow, freezing weather	SB-R-05	Roof designed for snow loading of 98 kg/m^2 (20 lb/ft^2) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - straight wind causes flying debris, wind pressure, and dust	SB-R-06	Facility designed for a wind speed of 80 mi/h, which is the design basis for the Hanford Site (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - tornado	SB-R-08	Facility designed to withstand tornado wind speeds of 322 km/h (200 mi/h) total, 258 km/h (160 mi/h) rotational, and 64.4 km/h (40 mi/h) translational (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - volcanic ashfall	SB-R-09	Facility designed to withstand a ground ash load of 117 kg/m^2 (24 lb/ft^2) (see Section 1.4.3.8.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - range fire	SB-R-10	Vegetation control in an 18-m (60-ft) clear space around CSB shall be provided (see Section 1.3.1.1 of HNF-SD-SNF-RPT-004[b])	

[a]Sadanaga, C. T., 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DynCorp Tri-Cities Services, Incorporated, for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[b]Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[c]NFPA, 1995, *Lightning Protection Systems*, NFPA 780, National Fire Protection Association, Quincy, Massachusetts.

CSB = Canister Storage Building.
HVAC = heating, ventilating, and air conditioning.
TBD = to be determined.

Table 3-13. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Outside. (sheet 1 of 2)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Linear kinetic - trucks, forklifts, and crane loads collide with inert gas supply, diesel tanks, new MCOs, gas bottles, transformer	OU-F-01 OU-F-02 OU-F-05 OU-Q-04	• Truck: mass ≈ TBD; speed ≈ TBD • Forklift: mass ≈ TBD; speed ≈ TBD • Crane: load mass ≈ TBD; drop distance ≈ TBD • Number of diesel tanks = 2 • Volume of one diesel tank ≈ 1,900 L (500 gal) • Inert gas supply tube trailer capacity: - Volume ≈ 3,400 m^3 - Pressure ≈ TBD	
Volume pressure - inert gas tube trailer is impacted by linear kinetic equipment	OU-H-05 OU-H-06	Inert gas supply tube trailer capacity: - Volume ≈3,400 m^3 - Pressure ≈ TBD	
Flammable materials - diesel fuel carrier or tank is impacted by linear kinetic equipment	OU-L-07	• Diesel storage tank total volume ≈ 3,800 L (1,000 gal) • Delivery tank truck volume ≈ TBD	
External events - explosion of propane or gasoline delivery truck introduces shockwave, projectiles, heat, and dust into outside facility	OU-P-01	• Propane volume ≈ TBD • Gasoline volume ≈ TBD • Distance from outside facility ≈ TBD • Shockwave overpressure ≈ TBD	
External events - fire introduces heat and smoke outside facility	OU-P-02	A fire inside the building has greatest consequences, which are covered by the preliminary fire hazards analysis[a]	
External events - accidents at nearby facilities that release radioactive material and direct radiation cause personnel injury and render the facility uninhabitable	OU-P-03	Descriptions of potential accidents at nearby facilities and their resulting consequences are addressed in Chapter 1.0 of HNF-SD-SNF-RPT-004[b]	
Natural phenomena - earthquake forces cause collapse of structure resulting in loss of primary power, ventilation, and inert gas supply; HVAC filter failure results in radiation release	OU-R-01	Forces exerted on facility due to lateral and horizontal accelerations of 0.35 *g* horizontal, 0.23 *g* vertical (see Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - lightning strikes outside facility	OU-R-03	Electrical discharge of millions of volts	Lightning protection shall be provided for facility as required by NFPA 780;[c] control systems are especially vulnerable to lightning strikes.

Table 3-13. Canister Storage Building Operations Hazardous Energy Source Characterization — Location in Facility: Outside. (sheet 2 of 2)

Hazard energy source/material description	Designation per checklist	Capacity/quantity	Comments
Natural phenomena - rain intrusion	OU-R-04	Facility drainage designed for a 6-hr probable maximum precipitation of 23 cm (9.2 in) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - snow, freezing weather	OU-R-05	Roof designed for snow loading of 98 kg/m^2 (20 lb/ft^2) (see Section 1.4.1.1.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - straight wind causes flying debris, wind pressure, and dust	OU-R-06	Facility is designed for a wind speed of 80 mi/h, which is the design basis for the Hanford Site (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - dust devil creates dust and flying debris	OU-R-07	Unknown	Cleanup of debris would be needed.
Natural phenomena - tornado	OU-R-08	Facility designed to withstand tornado wind speeds of 322 km/h (200 mi/h) total, 258 km/h (160 mi/h) rotational, and 64.4 km/h (40 mi/h) translational (see Section 1.4.1.1.4 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - volcanic ashfall	OU-R-09	Facility designed to withstand a ground ash load of 117 kg/m^2 (24 lb/ft^2) (see Section 1.4.3.8.2 and Table 1-23 of HNF-SD-SNF-RPT-004[b])	
Natural phenomena - range fire	OU-R-10	Vegetation control in an 18-m (60-ft) clear space around CSB shall be provided (see Section 1.3.1.1 of HNF-SD-SNF-RPT-004[c])	

[a]Sadanaga, C. T., 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DynCorp Tri-Cities Services, Incorporated, for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[b]Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. , Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

[c]NFPA, 1995, *Lightning Protection Systems*, NFPA 780, National Fire Protection Association, Quincy, Massachusetts.

CSB = Canister Storage Building.
HVAC = heating, ventilating, and air conditioning.
MCO = multicanister overpack.
TBD = to be determined.

Table 3-14. Canister Storage Building Hazard Analysis: Truck Vestibule. (sheet 1 of 7)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Truck vestibule TV-F-01	1, 34	Linear kinetic - transporter trucks	Transporter collision	Human error Mechanical failure Mislocated equipment	Collision with - Facility structures, systems, or components - Personnel	Transporter impacts can cause - Damage to the transportation cask (but no breach) - Damage to facility structures, systems, or components (e.g., inner overhead door, receiving crane) - Damage to the transporter - Personnel injury - Damage to the MCO inside the transportation cask Any of these consequences could result in operational delays; delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The transportation cask and the MCO within are designed to survive all credible impacts within the CSB facility while on the transporter. In addition, the cask is securely tied down to the transporter while in transport. 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/road conditions, transporter-cask configurations).[a] Regular maintenance is performed on the transporter to ensure it is in good working order.	S1	F3	The consequence and frequency columns take credit for the transportation cask and truck design.
Truck vestibule TV-F-05	1, 34	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 transportation cask and/or transporter Damage to receiving crane, yoke, or other systems, structures, or components Loss of inner overhead door could cause a loss of zone between the service area and the truck vestibule and/or allow exhaust gases from the tranporter cab to enter the service area Personnel injury Any of these consequences could result in operational delays; delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The transportation cask is designed to survive all credible impacts from the receiving crane. The receiving crane design includes such features as restricted speed, load float, micropositioner, and auditory movement alarms. The inner overhead door provides indication (auditory and/or visual) of its position (i.e., whether fully open or not).	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.	S1	F3	The consequence column takes credit for the transportation cask design.
Truck vestibule TV-G-05	2,4	Mass, gravity, height - trucks (transporter)	Elevated cask sitting on transporter (≈2 ft off ground)	Seismic event Operator error Mechanical failure of transporter	Cask falls off transporter after the clamshell hold downs are removed but before the yoke is attached	Damage to the transportation cask Damage to facility structures, systems, or components (e.g., inner overhead door, receiving crane) Damage to the transporter Personnel injury Damage to the MCO inside the transportation cask	The transportation cask and the MCO within are designed to survive credible transportation accidents, including a fall or tipover from the transporter.	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.	S1	F2	Frequency column takes credit for short time between removing clamshell hold down and attaching yoke to cask. ACTION ITEM: The possibility of credible drops onto an unyielding surface in the truck vestibule that exceed the design basis is under consideration. The results must be verified against current assumptions in the hazard analysis. (Action Item #68)

Table 3-14. Canister Storage Building Hazard Analysis: Truck Vestibule. (sheet 2 of 7)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
Truck vestibule TV-G-13	5	Mass, gravity, height - vessels (transportation cask)	Raised cask on receiving crane falls (The maximum height on the hook is ≈5 to 6 ft off floor)	Hoist failure Yoke failure Human error	Cask falls from receiving crane to transporter or vestibule floor	Damage cask Personnel injury Damaged transporter Loss of time (schedule) Loss of time transport window Damaged vestibule floor	The hoist design includes - Interlocks to preclude lift and horizontal motion at same time - Dual brakes - No free fall capacity. Cask (with MCO) and truck vestibule floor are designed to withstand the forces of a 19-ft drop of the transportation cask onto the truck vestibule floor. MCO is designed for 30-ft flat drop.	Sequence of operations for crane operation (basis for procedures) Qualified crane operators Maintenance and operations manuals and details to be provided by crane vendors	S1	F2	Consequence and frequency columns take credit for cask design. ACTION ITEM: The possibility of credible drops onto an unyielding surface in the truck vestibule that exceed the design basis is under consideration. The results must be verified against current assumptions in the hazard analysis. (Action Item #66)
Truck vestibule TV-H-06	Between 1 and 5	Pressure, volume - pressure vessels (cask-MCO system)	Gases under high pressure (steam, hydrogen) reach release pressure	Delay in excess of transport window Inadequate conditioning (i.e., insufficient quantity of water removed) before receipt at CSB	MCO rupture disk ruptures (overpressure; bad rupture disk) Cask leak - Lid seal - Drain port ball valve failure - Drain port or vent port covers - Vent port failure Personnel contamination (cask handling personnel, transporter personnel)	Release of MCO gases and particulate into cask annulus (MCO still contained by cask) Release from cask (only a problem if MCO release or breach occurs): - If relief valve actuates, hydrogen and small amounts of fission gases could be released - If rupture disk ruptures, hydrogen and radioactive or toxic materials could be released - Radioactive contamination of cask	The cask is designed to not allow release from MCO breach - Cask design materials to preclude breach - Design pressure of 150 lb/in^2 for cask - Vestibule CAMs - Conditioning process	CSB acceptance criteria ensure that MCOs not meeting the minimum requirements for acceptance (e.g., shipping window, packaging conditions[a]) are not unloaded from the transporter Receipt survey (sequence of operations basis for procedures)	S2	F2	ACTION ITEM: The acceptance criteria for CSB receipt of MCOs that have been conditioned for shipment at the CVDF must be determined. (Action Item #12)
Truck vestibule TV-J-06	2-5	Explosives or pyrophorics - hydrogen	Flammable hydrogen mixture created and ignition source present	Hydrogen leaks from pressurized cask, mixing with air, ignition source present (hydrogen leak because of seal failure and/or vent/drain connections failing and/or vent/drain plates failing)	Deflagration or detonation-combustion	Burn victims Operational delays Damage to structures, systems, or components Low levels of contamination	Cask design Likely leakage is small because of design (complex potential leak path) HVAC design (when outer door closed) Cask head seals (two in series)	Shipping window provides assurance of low pressures CVDF procedure impacts seals and sealing surfaces before closing cask Smoking not allowed within the facility	S1	F1	ACTION ITEM: The acceptance criteria for CSB receipt of MCOs that have been conditioned for shipment at the CVDF must be determined. (Action Item #12)
Truck vestibule TV-J-10	Between 2 and 5	Explosives or pyrophorics - (uranium and/or plutonium metal zirconium)	Pyrophoric material is exposed to air and sufficient surface area and temperature are present	Breached MCO and cask	The exposed pyrophoric material reacts with the air	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 leading to the exposure of pyrophoric material to air.	CVDF personnel are trained in the proper procedures for inerting the MCO and transportation cask before shipment to the CSB.	S3	F1	A full cask-MCO beach is necessary to have a reaction that is not self-limited
Truck vestibule TV-K-05	2-4	Nuclear criticality - casks					CSB cannot be flooded by rain or water main break	General training of operators; operator will not disassemble an MCO		F0	Addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6 - no new hazards identified

Table 3-14. Canister Storage Building Hazard Analysis: Truck Vestibule. (sheet 3 of 7)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
Truck vestibule TV-K-12	2-4	Nuclear criticality - cranes and lifts					CSB cannot be flooded by rain or water main break	General training of operators; operators will not disassemble an MCO		F0	Addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6 - no new hazards identified
Truck vestibule TV-L-11	2-5	Flammable materials - hydrogen									Refer to TV-J-06, "Explosives or pyrophorics - hydrogen"
Truck vestibule TV-M-07	1-5	Hazardous materials - toxic (plutonium and uranium)	Release of plutonium and uranium, entrained in pressurized gases within the MCO	A process delay that causes the MCO to exceed its calculated transport window before placement in a storage tube Improper or insufficient conditioning performed on the MCO before its receipt at the CSB Failure of the MCO relief valve or rupture disk caused by manufacturing flaws or damage Improper closing of the MCO process ports at the CVDF	A breach of the transportation cask and pressure relief of the MCO exposing workers to toxic materials	An MCO release inside the cask, by itself, has no safety consequences beyond contamination of the transportation cask with toxic materials (recovery actions are dealt with separately); the transportation cask contains the release.	The MCO rupture disk is designed with protective features such as a recessed location and a protective steel plate to minimize the potential for damage. The relief valve is recessed to minimize the potential for damage. The relief valve contains a HEPA filter to minimize the potential for toxic particulate releases. The transportation cask provides secondary confinement in the event of an MCO release.	Personnel are trained to facility-specific procedures regarding MCO shipping, moving, and handling. The drying process at the CVDF provides a calculated transport window in which MCO overpressurization is precluded. This will ensure MCO pressures are relatively low during the receiving process. CVDF personnel are trained in the proper procedures for closing the MCO process ports.	S0	F3	
						A transportation cask release following an MCO release or breach could release toxic materials	The MCO rupture disk is designed with protective features such as a recessed location and a protective steel plate to minimize the potential for damage. The relief valve is recessed to minimize the potential for damage. The relief valve contains a HEPA filter to minimize the potential for toxic particulate releases.	Personnel are trained to facility-specific procedures regarding MCO shipping, moving, and handling. The drying process at the CVDF provides a calculated transport window in which MCO overpressurization is precluded. This will ensure MCO pressures are relatively low during the receiving process. CVDF personnel are trained in the proper procedures for closing the MCO process ports.	S1	F3	
Truck vestibule TV-N-01/03	2-4	Ionizing radiation sources - fissile and radioactive material (contents of MCO)	Contact exposure Release of fissile or radioactive material	Normal work Breached MCO or cask			The transportation cask is designed to contain the MCO and its contents, and to provide shielding to reduce personnel exposures.	Site radiological control practices (ALARA)	S0	F3	See causes column for contents of MCO
		(surface contamination on cask)	Surface contamination	Loss of contamination control	Personnel exposure to radiation Spread of contamination to the environment	Personnel injury from ionizing radiation Environmental impact		Site practices for survey of contamination	S1	F3	

Table 3-14. Canister Storage Building Hazard Analysis: Truck Vestibule. (sheet 4 of 7)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Truck vestibule TV-P-01	1-5	External events - explosion outside of the truck vestibule	Shock wave from external explosion introduces dust, heat, and/or projectiles into the truck vestibule	Explosion of nearby gas delivery truck, propane delivery truck, or gas station	The shock wave from the explosion impacts the building Flying debris hits personnel Workers are exposed to heat from the explosion	The blast effect on the truck vestibule could cause - Structural damage or failure - The transportation cask to drop from the receiving crane - Personnel injury from flying debris Operational delays could result from structural damage, personnel injury, or a transportation cask drop or from the need to evacuate the facility; delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube.	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). The transporter and transportation cask are designed to survive specific drops and punctures that should bound this hazard.[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.	S1	F2	For additional details on the hazards associated with a dropped cask, refer to TV-G-13, "Mass, gravity, height - vessels." ACTION ITEM: The possibility of credible drops onto an unyielding surface in the truck vestibule that exceed the design basis is under consideration. The results must be verified against current assumptions in the hazard analysis. (Action Item #66)
Truck vestibule TV-P-02	1-5	External events - fire	Heat and smoke introduced into the truck vestibule (low visibility)								Based upon the current design, there is no external energy source that would have greater consequences than a fire inside the facility. These hazards are addressed by the preliminary fire hazards analysis.[c] Refer to the white papers on occupational classification[d,e] and the deviation and exemption request letters[f,g] that cover this topic.
Truck vestibule TV-P-03	1-5	External events - nearby facilities	Radioactive material, toxic material, and direct 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.[b]	Descriptions of potential accidents at nearby facilities and their resulting consequences are addressed in Chapter 1.0 of HNF-SD-SNF-RPT-004.[b]	Personnel exposure to radioactive and toxic material from the nearby facility Contamination of the CSB from nearby facility releases potentially making the building uninhabitable Operational delays as a result of a need to evacuate the facility or take cover that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The distance of the CSB from other facilities and the shielding the structure provides reduce the consequences of external events on the CSB.	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S1	F1	
Truck vestibule TV-Q-04	1-5	Vehicles in motion - cars, trucks, buses	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 systems, structures, or components - Facility personnel	Damage to the transporter and/or tractor, the transportation cask, personnel, or facility systems, structures and components Operational delays as a result of damage that cause the MCO to exceed its available transport window and may result in MCO pressure relief before placement within the storage tube	The roads near the facility are designed to guide vehicles around the facility, rather than directly toward the facility, which limits 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.	S1	F2	Transporter effects are not specifically considered for determining consequence, as this is addressed by the SARP.[a] Aircraft impacts are not considered as they are deemed incredible in Chapter 1.0 of HNF-SD-SNF-RPT-004.[b]

Table 3-14. Canister Storage Building Hazard Analysis: Truck Vestibule. (sheet 5 of 7)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Truck vestibule TV-R-01	1-5	Natural phenomena - earthquake (both DBE and <DBE)	Forces exerted on the facility by lateral and horizontal accelerations	Earthquake	An earthquake could result in - Structural damage or collapse - Damage to facility systems, structures, or components - Damage to the transportation cask caused by its falling off the transporter, transporter rollover, or impact from a falling receiving crane	The potential consequences of an earthquake include - Personnel injury - Release of radiation from a breached transportation cask and MCO - Loss of facility power Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility (including the structure and systems such as the receiving crane) is designed with consideration of impacts to safety systems from the failure of non-safety systems. CSB is built to appropriate seismic criteria The transportation cask and the MCO within are designed to survive all credible impacts within the CSB facility while on the transporter. In addition, the cask is securely tied down to the transporter while in transport.	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S2	F2	ACTION ITEM: The possibility of credible drops onto an unyielding surface in the truck vestibule that exceed the design basis is under consideration. The results must be verified against current assumptions in the hazard analysis. (Action Item #66)
Truck vestibule TV-R-03	1-5	Natural phenomena - lightning	High electrical energy	Lightning strike	Strike on the truck vestibule	The potential consequences of a lightning strike on the truck vestibule include - Loss of power - Damage to systems, structures, or components - Personnel injury Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The CSB facility is equipped with lightning protection, which 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.	S1	F2	
Truck vestibule TV-R-04	1-5	Natural phenomena - rain	Water intrusion into the truck vestibule	Leaks around doors or through the roof Volume of rain exceeds the capacity of the facility grading and drainage system to carry off rainwater	Water in electrical systems such as receiving crane components Flooded floors	Personnel injury caused by slips Loss of power Loss of equipment or personnel injury from electrical shorts Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	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). The site grading is designed to prevent rain intrusion into the facility. The facility design takes into consideration the need for tactile (non-skid) surfaces.		S1	F3	

Table 3-14. Canister Storage Building Hazard Analysis: Truck Vestibule. (sheet 6 of 7)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
Truck vestibule TV-R-05	1-5	Natural phenomena - snow, freezing weather	Snow loading Extreme cold	Snow storm, cold weather	Roof collapse	Personnel injury from collapsed roof or exposure to the cold Ice buildup Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The building is designed to withstand anticipated snow loads. The truck vestibule is heated. The facility provides shelter for workers.	The SARP prohibits MCO shipping during adverse weather conditions.*	S1	F3	ACTION ITEM: The SARP definition of "adverse weather conditions," when established, will be included here. (Action Item #64)
Truck vestibule TV-R-06	1-5	Natural phenomena - straight wind	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Systems, structures, or components damaged by flying debris Visibility reduced Accumulated debris	Personnel injury Restricted access to the facility Operational delays from damaged equipment or the need to clear debris that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility structure and outer door are designed to withstand a 200 mi/h wind. The facility provides shelter for workers.		S1	F3	Winds in excess of the design basis were not considered.
Truck vestibule TV-R-07	1-5	Natural phenomena - dust devil	Flying debris Dust	Pressure gradient	Personnel struck by flying debris Visibility reduced Accumulated debris	Personnel injury Operational delays from injury or the need to clear debris that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility provides shelter for workers.		S1	F3	
Truck vestibule TV-R-08	1-5	Natural phenomena - tornado (40 mi/h translational, 160 mi/h rotational; missiles, 40 mi/h; wind loads, 200 mi/h)	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Systems, structures, or components damaged by flying debris (e.g., inner or outer doors, transporter, receiving crane) Visibility reduced Accumulated debris	Personnel injury Restricted access to the facility Operational delays from damaged equipment or the need to clear debris that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility superstructure is designed to withstand the forces of design basis tornado missiles and wind loads. 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.	S1	F1	
Truck vestibule TV-R-09	1-5	Natural phenomena - ash fall	Ash loading on roof	Volcanic eruption	Roof collapse Ash intrusion	Personnel injury Equipment damage Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The building is designed to withstand anticipated ash loadings.		S1	F2	
Truck vestibule TV-R-10	1-5	Natural phenomena - range fire	Windborne embers Smoke	Dry conditions and ignition	Loss of power Reduced visibility Secondary fire caused by flying embers	Personnel injury Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility is designed with non-combustible materials (Type II-N).	The facility controls or clears the vegetation in the vicinity of the CSB to reduce the impact of range fires.	S1	F3	

Table 3-14. Canister Storage Building Hazard Analysis: Truck Vestibule. (sheet 7 of 7)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
attendees	Fluor Daniel Northwest Duke Engineering and Services Hanford, Incorporated XWest Group Numatec Hanford Corporation Fluor Daniel, Incorporated Science Applications International Corporation										

[a] RFS, 1996, *Preliminary Safety Analysis Report for Packaging (Onsite) Multiple Canister Overpack Cask*, HNF-SD-TP-SARP-017, Rev. 0, Rust Federal Services Northwest for Fluor Daniel Hanford, Incorporated, Richland, Washington.
[b] Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.
[c] Sadanaga, C. T., 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DRAFT, DynCorp Tri-Cities Services, Incorporated, for Fluor Daniel Hanford, Incorporated, Richland, Washington.
[d] Ares, 1996, *Canister Storage Building Fire Code Equivalency Evaluation*, Report 951107-001, Rev. 0, Ares Corporation, Richland, Washington.
[e] 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.
[f] 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.
[g] 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 SystemRequirements* (Letter 9655233 to E. D. Sellers, U.S. Department of Energy, Richland Operations Office, November 14), 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.
HEPA = high-efficiency particulate air (filter).
HVAC = heating, ventilating, and air conditioning.
MCO = multicanister overpack.
SARP = safety analysis report for packaging.

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 1 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
MCO service area SA-E-07	Blocks 14-19	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 pit, with no controls or ungrappling capability	Damage to the MCO center cover hatch Loss of primary containment (i.e., the MCO) resulting in contamination of the transport cask, service pit, and/or MHM MHM drive damaged and locked up Lifting cable and/or pneumatic lines sheared off	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 pit and/or MHM while it is being raised. The MHM is provided with backup grapple disengagement capability. Secondary confinement provided by the MHM-service pit interface with active, HEPA-filtered ventilation.	Personnel are trained to MHM-specific procedures regarding its safe operation.	S2	F1	The design is not yet complete relative to MHM interlocks and permissive switches. ISSUE: Water may be added to the transportation cask void as the MCO is removed to cushion a drop. This is not part of the current baseline and is not considered in this evaluation. (Issue #8)
MCO service area SA-F-05	Blocks 5, 31	Linear kinetic - receiving crane	The receiving crane (with or without a load) experiences a collision	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 - The MHM (of particular concern when the MHM is in the process of extracting an MCO from the service pit) - Subsystems placed in the path of the receiving crane - Personnel - Service area enclosure - The 5-ton gantry crane	Damage to the transport cask Collapse of receiving crane and damage to operating deck, storage tubes, and MCOs Damage to facility systems, structures, or components (such as the transport cask yoke) Damage to the service area enclosure Damage to the 5-ton gantry crane Personnel injury Damaged equipment leads to operational delays that cause the MCO to exceed its available transport window, resulting in MCO pressure relief before placement within the storage tube	The receiving crane is designed to ASME NOG-I" to preclude tipping. The "frogs" on the receiving crane'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 receiving crane has auditory indication of its movement (i.e., alarms). The receiving crane is limited to relatively slow movement.	Personnel are trained to procedures detailing the safe sequence of operations. These procedures prohibit interferences between the receiving crane and the MHM.	S2	F2	To be considered "S-2", multiple failures must be assumed (e.g., damage to the MCO, the service area enclosure). However, such failures may be credible as a result of common mode failures.
MCO service area SA-F-06	Blocks 14, 15	Linear kinetic - pressure vessel (MCO) blowdown	Gases within the MCO reach component failure pressure	Faulty MCO rupture disk or relief valve (actuating at pressures below the design values - 150 lb/in² for the rupture disk and approximately 120 lb/in² for the relief valve) Damaged MCO rupture disk or relief valve MCO process ports improperly closed at the CVDF	Blowdown lifts objects, creating a missile hazard Excessive noise and sonic effects Release of contamination (particulate) and gases (including hydrogen) from within the MCO	Missiles damage the service area enclosure (e.g., lighting, ventilation, material) or other equipment Missiles, excessive noise, and releases injure personnel Contamination resulting in personnel doses Flammable atmosphere within the service area enclosure Operational delays that cause the MCO to exceed its available transport window may result in further MCO pressure relief	The MCO rupture disk is protected by design (it is recessed and is protected by a steel plate). The rupture disk plate inhibits missile generation (i.e., from pieces of disk being expelled). The MCO relief valve is recessed and contains a HEPA filter. The service area enclosure provides secondary confinement with active, HEPA-filtered ventilation.	CVDF personnel are trained in the proper procedures for closing the MCO process ports. A pressure test is performed on the transport cask before the lid is removed. This prevents releases associated with exposing an MCO that has already experienced pressure relief.	S1 for MCOs under nominal pressure S2 for MCOs under rupture disk and relief valve design pressures	F2 F1	Although this event could occur before or after the listed process blocks, additional confinement features are in place at these times. Therefore, blocks 14 and 15 represent the most conservative situation for review.

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 2 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
MCO service area SA-F-07	Blocks 19-24	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 - The receiving crane - Subsystems placed in the path of the MHM - Personnel - Service area enclosure - The 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 stuck in the service pit, with no controls or ungrappling capability	Damage to facility systems, structures, or components (e.g., receiving crane, service area enclosure, 5-ton gantry crane) Personnel injury Damage to the MCO center cover hatch Loss of primary containment (i.e., the MCO) resulting in contamination of the transport cask, service pit, and/or MHM Loss of secondary confinement (i.e., the MHM) MHM drive damaged and locked up Lifting cable and/or pneumatic lines sheared off Damaged equipment may lead to operational delays that cause the MCO to exceed its available transport window and result in MCO pressure relief before placement within the storage tube	The MHM is designed to ASME NOG-I* 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 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 resolver indicates the MCO's relative position within the service pit and/or MHM while it is being raised. The MHM is provided with 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 regarding its safe operation.	S-2	F-2	To be considered "S-2", multiple failures must be assumed (e.g., damage to the MCO, the service area enclosure). However, such failures may be credible as a result of common mode failures. The design is not yet complete relative to MHM interlocks and permissive switches. ISSUE: Water may be added to the transportation cask void as the MCO is removed to cushion a drop. This is not part of the current baseline, and is not considered in this evaluation. (Issue #8) ISSUE: It is currently unclear to the hazards analysis team whether the frog stops are adequate to stop either the receiving crane or the MHM. (Issue #9) ACTION ITEM: The design calculations for frog stops relative to the receiving crane and MHM must be verified. (Action Item #28)
MCO service area SA-G-01	Blocks 9-18	Mass, gravity, height - human effort	Dropped equipment (e.g., slings, bolts, tools)	Human error resulting in tools or other items being dropped in the service area, and more importantly, in the service pit	Breach MCO primary confinement (by breaking a relief valve or puncturing a rupture disk) Tripping hazard Items dropped into the service pit between the MCO and transportation cask wall may cause sticking or galling of the MCO as it is lifted	Breach of the MCO may cause missile damage to the service area enclosure (e.g., lighting, ventilation, material) or other equipment because of possible MCO pressure vessel blowdown A resultant blowdown also has the potential for personnel injury caused by missiles, excessive noise, and contamination releases Gas releases (from a resultant blowdown) to the service area may result in a potential for a flammable atmosphere within the service area enclosure Tripping hazards may cause personnel to fall into the service pit Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within a storage tube	Bolted equipment within the facility uses "captured" bolts, which will stay with the equipment. The MCO ports are protected from damage by cover plates. A load cell on the MHM grapple assembly monitors the resistance force of the MCO as it is being removed. This will detect sticking or galling forces before they become excessive. The service pit is normally covered with either a pit cover or a shield hatch assembly.	The immediate area around the service pit is inspected and cleaned before lifting the cask lid. Personnel are trained in procedures that identify the proper operational steps to be performed within the service area enclosure.	S-2	F-3	

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 3 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
MCO service area SA-G-03a	Blocks 9-18	Mass, gravity, height - 5-ton gantry crane	Small parts from the gantry fall into the service area, and more importantly, into the service pit	Human error	Breach of MCO primary confinement (by breaking a relief valve or puncturing a rupture disk) Items dropped into the service pit between the MCO and transportation cask wall may cause sticking or galling of the MCO as it is lifted	A breach of the MCO may cause missile damage to the service area enclosure (e.g., lighting, ventilation, material) or other equipment because of possible MCO pressure vessel blowdown A resultant blowdown also has the potential for personnel injury from missiles, excessive noise, and contamination releases Gas releases (from a resultant blowdown) to the service area may result in a potential for a flammable atmosphere within the service area enclosure Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within a storage tube	The MCO ports are protected from damage by cover plates. A load cell on the MHM grapple assembly monitors the resistance force of the MCO as it is being removed. This will detect sticking or galling forces before they become excessive. The service pit is normally covered with either a pit cover or a shield hatch assembly.	Procedures detail maintenance of the 5-ton gantry crane.	S2	F3	
MCO service area SA-G-03b	Blocks 19-24	Mass, gravity, height - 5-ton gantry and service area enclosure linear movement	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 - The shield hatch assembly	Damage to the service area enclosure Damage to the gantry crane Personnel injury Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within a storage tube	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 a 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 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.	S1	F3	
MCO service area SA-G-13	Blocks 4, 5, 31	Mass, gravity, height - vessels (transportation cask, MCO)	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	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 or MHM	The transportation cask could impact either the facility floor or the bottom of the service pit MCO impact to either the bottom of the transportation cask in the service pit or the turntable in the MHM	A drop of the transportation cask results in damage to the cask or damage to the MCO inside; significant damage to the MCO (such as failure of the rupture disk or relief valve) results in a release of gas and contamination from the MCO A drop of the MCO results in damage to the MHM turntable or damage to the MCO; significant damage to the MCO (such as the failure of the rupture disk or relief valve) could result in a release of gas and contamination from the MCO	The transportation cask (and the associated MCO contained within) is designed to survive any credible drop within the facility, including a drop into the service pit[a] The MHM grapple is designed such that it cannot release while a load is being suspended from it.	The drying process at the CVDF provides a calculated transport window in which MCO overpressurization is precluded. This will ensure MCO pressures are relatively low during the receiving process. Personnel are trained to facility-specific procedures in the proper handling of the transportation cask, MCO, receiving crane, and MHM.	S2	F2	During any postulated event, secondary confinement is maintained around the spent fuel (the transportation cask for a cask drop and the MHM-service pit interface for an MCO drop). ACTION ITEM: An analysis of a cask/MCO drop into the service pit must be conducted, and may result in a requirement for an impact limiter in the service pit. (Action Item #31)

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 4 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
MCO service area SA-H-05	Blocks 4, 5, 31	Pressure, volume - gas bottles (backup inert gas supply on the MHM)	An uncontrolled release of high energy gases from the inert gas bottles on the MHM	Broken or damaged regulator valve, or a gas bottle breach	An overpressurization of the MHM while transporting an MCO The gas bottle (or its components) becomes a missile hazard The gas bottle hose causes a whipping hazard An overpressurization of the seals between the MHM nose piece and the floor during MCO removal from the transportation cask A loss of backup inert gas for the MHM	Higher than normal external pressures applied to an MCO Contamination releases through the floor seals while an MCO is being removed from the transportation cask (the cask interior is expected to contain small levels of contamination) Personnel injury from whipping and missile hazards Damage to facility structures, systems, or components from missile hazards Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within a storage tube	The bottle rack on the MHM is designed to seismic qualifications. The MHM is designed with a blow out panel to relieve excessive pressures. The transporter and transportation cask are designed to survive specific drops and punctures that should bound this hazard.*	Personnel are trained to facility-specific procedures in the proper installation and maintenance of gas bottles on the MHM.	S1	F2	The backup inert gas supply for the MHM provides a 12-hour supply of inert gas.
MCO service area SA-H-06	Blocks 4, 5, 31	Pressure, volume - pressure vessels (MCO and MCO-transportation cask system)	Uncontrolled release of gases under pressure within the MCO	A process delay that causes the MCO to exceed its calculated transport window before placement in a storage tube Improper or insufficient conditioning performed on the MCO before its receipt at the CSB Failure of the MCO relief valve because of manufacturing flaws or damage Failure of the MCO rupture disk because of manufacturing flaws or damage Improper closing of the MCO process ports at the CVDF	MCO rupture disk rupture because of excessive pressures within the MCO Failure of the rupture disk at lower pressures (caused by manufacturing flaws or damage) Transportation cask releases pressurized gases because of - A leak in the seal lid - Drain port ball valve failure - Vent port failure	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 release/breach, or the MCO release 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 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 - The service area enclosure (including lighting, fabric, and the ventilation system) or other facility systems, structures, or components damaged by missile effects - Personnel injury from excessive noise or missile effects - Operational delays could result from any of these consequences	The MCO rupture disk is designed with protective features such as a recessed location and a protective steel plate to minimize the potential for damage. The relief valve is recessed to minimize the potential for damage. The relief valve contains a HEPA filter to minimize the potential for radioactive particulate releases. The service area enclosure provides HEPA-filtered secondary confinement in the event of MCO pressure release.	Personnel are trained to facility-specific procedures regarding transportation cask shipping, movement, and handling. The drying process at the CVDF provides a calculated transport window in which MCO overpressurization is precluded. This will ensure MCO pressures are relatively low during the receiving process.	S2	F2	The hazards analysis team reached a general consensus that "pressure managed" MCOs do not provide as high of a level of operational safety as would be achieved if the MCO were continuously vented through HEPA filtration within the transportation cask. This would greatly reduce the potential for sudden high-pressure releases.

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 5 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
MCO service area SA-H-08	Blocks 4, 5, 31	Pressure, volume - gas receivers (MHM primary inerting system) (120 lb/in² festoon cable) (80 lb/in² MCO service line)	Uncontrolled release of high energy gases from the inert gas supply to the MHM	Broken or damaged regulator valve Broken or damaged relief valve Fitting failure Supply line failure caused by impact from an outside source	Overpressurization of the MHM while transporting an MCO Overpressurization of the seals between the MHM nose piece and the floor during MCO removal from the transportation cask Missile hazards Cryogenic burns Sonic effects Air introduced into the MHM interior (refer to SA-J-10) Festoon cable causes a whipping hazard Potential for asphyxiation exists if the inert gas is argon	Higher than normal external pressures applied to an MCO Contamination releases through the floor seals while an MCO is being removed from the transportation cask (the cask interior is expected to contain small levels of contamination) Personnel injury from whipping and missile hazards Damage to facility structures, systems, or components from missile hazards Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within a storage tube	The design of the supports for the festoon cable includes greater than normal strength and number of supports per linear foot. The MHM is designed with a blow out panel to relieve excessive pressures. The MHM and MCO have a robust design that allows them to withstand high levels of pressure or stress.	Personnel are trained to facility-specific procedures in the proper maintenance of the inert gas supply to the MHM.	S1	F2	The consequence and frequency does not address multiple failures except when operational delays cause the MCO to exceed its transportation window. In this case, the relief valve may be actuated. No damage was assumed to occur to the MCO. No automatic shutoff feature is designed into the inert gas supply system (and is not required by national codes).
MCO service area SA-J-06	Blocks 14-18	Explosives or pyrophorics - hydrogen	A flammable hydrogen-air mixture and an ignition source, causing combustion	Relief valve actuation or disk rupture	Deflagration or detonation may occur within the service pit and/or the service area enclosure; the pressure from this event may cause the center of the shield hatch assembly to lift slightly	Spread of contamination Personnel injury from burns Damage to nearby facility systems, structures, or components Operational delays	The transportation cask occupies the volume of the service pit, reducing the total volume of available air when the service pit is covered. The MCO pressure relief valve is HEPA filtered to minimize the potential for contamination spread. The service area enclosure, in conjunction with its active ventilation, will sweep the service area enclosure of hydrogen, minimizing the potential to form flammable mixtures. The shield hatch assembly will provide secondary confinement.	The drying process at the CVDF provides a calculated transport window in which MCO overpressurization is precluded. This will ensure MCO pressures are relatively low during the receiving process. No smoking is allowed within the facility.	S3	F1	
MCO service area SA-J-10	Blocks 4, 5, 31	Explosives or pyrophorics - plutonium and uranium metal, Zirconium	Pyrophoric material exposed to air and sufficient surface area and temperature are present	MCO breach Human error in failing to inert the MCO	Pyrophoric material ignites	Personnel injury Contamination release Damage to the MCO	The structural design of the MCO is such that breaches have a very low probability of occurring. Penetrations into the MCO are limited in size to reduce the rate of air flow into the MCO.	CVDF personnel will be trained according to CVDF-specific procedures regarding the inerting process for the MCO before shipment to the CSB.	S3	F1	F-1 was selected until the potential for air ingress (such as through a relief valve) is evaluated. It may then be changed to F-0.
MCO service area SA-K-01	Blocks 36-43, 53-62	Nuclear criticality - vaults					CSB cannot be flooded by rain or a water main break	General training of operators; operators will not disassemble an MCO		F0	This hazard is addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6.0; no new hazards were identified.
MCO service area SA-K-04	Blocks 36-43, 53-62	Nuclear criticality - filters (cart and tube plug)					CSB cannot be flooded by rain or a water main break	General training of operators; operators will not disassemble an MCO		F0	This hazard is addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6.0; no new hazards were identified.

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 6 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
MCO service area SA-K-05	2-4	Nuclear criticality - casks					CSB cannot be flooded by rain or a water main break	General training of operators; operators will not disassemble an MCO		F0	Addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6; no new hazards identified.
MCO service area SA-K-12	Blocks 36-43, 53-62	Nuclear criticality - cranes and lifts					CSB cannot be flooded by rain or a water main break	General training of operators; operators will not disassemble an MCO		F0	This hazard is addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6.0; no new hazards were identified.
MCO Service Area SA-L-08 SA-L-11 SA-L-13 SA-L-15		Flammable materials - buildings and contents (service area enclosure) Hydrogen Organics (enclosure material) MHM neutron absorber									These hazards are addressed by the preliminary fire hazards analysis.[c] Refer also to the white papers on occupational classification[d,e] and the deviation and exemption request letters[f,g] that cover this topic.
MCO service area SA-M-07	Blocks 14, 15	Hazardous materials - toxics (plutonium, uranium, beryllium, heavy metals)	Release of toxic materials entrained in pressurized gases within the MCO	A process delay that causes the MCO to exceed its calculated transport window before placement in a storage tube Improper or insufficient conditioning performed on the MCO before its receipt at the CSB Failure of the MCO relief valve because of manufacturing flaws or damage Failure of the MCO rupture disk because of manufacturing flaws or damage Improper closing of the MCO process ports at the CVDF	MCO rupture disk ruptures and releases toxic materials Excessive pressures within the MCO Failure of the rupture disk at lower pressures (because of manufacturing flaws or damage)	An MCO release inside the cask, by itself, has no safety consequences beyond contamination of the transportation cask with toxic 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, toxic materials could be released to the service area	The MCO rupture disk is designed with protective features such as a recessed location and a protective steel plate to minimize the potential for damage. The relief valve is recessed to minimize the potential for damage. The relief valve contains a HEPA filter to minimize the potential for toxic particulate releases. The service area enclosure provides HEPA-filtered secondary confinement in the event of MCO pressure release. The shield hatch assembly provides secondary confinement when the service area enclosure is moved away.	Personnel are trained to facility-specific procedures regarding MCO shipping, movement, and handling. The drying process at the CVDF provides a calculated transport window in which MCO overpressurization is precluded. This will ensure MCO pressures are relatively low during the receiving process. CVDF personnel are trained in the proper procedures for closing the MCO process ports. A pressure test is performed on the transport cask before the lid is removed. This prevents toxic releases associated with exposing an MCO that has already experienced pressure relief.	S2	F3	Although this event could occur before or after the listed process blocks, additional confinement features are in place at these times. Therefore, blocks 14 and 15 represent the most conservative situation for review.

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 7 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
MCO service area SA-N-01 SA-N-03	Blocks 14, 15	Ionizing radiation sources - fissile and radioactive material	Contact exposure Release of fissile and/or radioactive materials entrained in pressurized gases within the MCO	A process delay that causes the MCO to exceed its calculated transport window before placement in a storage tube Improper or insufficient conditioning performed on the MCO before its receipt at the CSB Failure of the MCO relief valve because of manufacturing flaws or damage Failure of the MCO rupture disk because of manufacturing flaws or damage Improper closing of the MCO process ports at the CVDF	MCO rupture disk ruptures and releases fissile or radioactive materials Excessive pressures within the MCO Failure of the rupture disk at lower pressures (due to manufacturing flaws or damage)	An MCO release inside the cask, by itself, has no safety consequences beyond contamination of the transportation cask with fissile/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 spread during MHM or tube plug servicing at the maintenance pit	The MCO rupture disk is designed with protective features such as a recessed location and a protective steel plate to minimize the potential for damage. The relief valve is recessed to minimize the potential for damage. The relief valve contains a HEPA filter to minimize the potential for radioactive particulate releases. The service area enclosure provides HEPA-filtered secondary confinement in the event of MCO pressure release. The shield hatch assembly provides secondary confinement when the service area enclosure is moved away.	Personnel are trained to facility-specific procedures regarding MCO shipping, movement, handling, and site radiological control. The drying process at the CVDF provides a calculated transport window in which MCO overpressurization is precluded. This will ensure MCO pressures are relatively low during the receiving process. CVDF personnel are trained in the proper procedures for closing the MCO process ports. A pressure test is performed on the transport cask before the lid is removed. This prevents fissile and radioactive releases associated with exposing an MCO that has already experienced pressure relief.	S2	F3	Although this event could occur before or after the listed process blocks, additional confinement features are in place at these times. Therefore, blocks 14 and 15 represent the most conservative situation for review.
MCO service area SA-N-04	Blocks 36-43, 53-62	Ionizing radiation sources - radiation source	Exposure to direct radioactive shine	Direct shine associated with MCO during transfer	Shine from MCO during transport if MHM shield skirt is not in place	Worker exposure caused by shine from MCO during transfer	MHM, shielding		S1	F1	
MCO service area SA-P-01	Blocks 5-31	External events - explosion	External explosion resulting in a shock wave introduces dust, heat, and/or projectiles into the service area	Explosion of nearby gas delivery truck, propane delivery truck, or gas station	The shock wave from the explosion impacts the building Flying debris hits personnel Workers exposed to heat from the explosion	Structural damage or failure Transportation cask drop from the receiving crane Personnel injury from flying debris Operational delays could result from structural damage, personnel injury, or a transportation cask drop or from the need to evacuate the facility; delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The CSB is isolated from major roads, reducing the possibility of explosions outside the facility from affecting the CSB. The facility structure is designed to withstand significant external phenomena (e.g., tornado missiles, straight winds). The transporter and transportation cask are designed to survive external events without hazardous or radioactive material release.[b]	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S2	F2	For additional details on the hazards associated with a dropped cask, refer to TV-G-13, "Mass, gravity, height - vessels."
MCO service area SA-P-02	Blocks 5-31	External events - fire	External fire introduces heat and smoke into the service area (low visibility)								Based upon the current design, there is no external energy source that would have greater consequences than a fire inside the facility. These hazards are addressed by the preliminary fire hazards analysis.[c] Refer also to the white papers on occupational classification[d,e] and the deviation and exemption request letters[f,g] that cover this topic.

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 8 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
MCO service area SA-P-03	Blocks 5-31	External events - nearby facilities	Radioactive material, toxic material, and direct 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.[h]	Descriptions of potential accidents at nearby facilities and their resulting consequences are addressed in Chapter 1.0 of HNF-SD-SNF-RPT-004.[h]	Personnel exposure to radioactive and toxic material from the nearby facility Contamination of the CSB from nearby facility releases potentially making the building uninhabitable Operational delays could occur as a result of a need to evacuate the facility or take cover; delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The distance of the CSB from other facilities and the shielding the structure provides reduces the consequences of external events on the CSB.	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition	S2	F1	
MCO service area SA-R-01	Blocks 5-31	Natural phenomena - earthquake (equal to or less than the DBE)	Forces exerted on the facility from lateral and horizontal accelerations	Earthquake	Structural damage or collapse Damage to facility systems, structures, or components (e.g., receiving crane, cable trays, MHM) Damage to the transportation cask or MCO (while in cask, service pit, or MHM) Relief valve actuation on the MCO	Personnel injury Release of radiation from a breached MCO Loss of facility power Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility (including both the facility structure and systems such as the receiving crane and MHM) is designed with consideration of impacts to safety systems from the failure of non-safety systems. The CSB is built to appropriate seismic criteria.	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S2	F2	
MCO service area SA-R-03	Blocks 5-31	Natural phenomena - lightning	High electrical energy	Lightning strike	Strike on the facility	Loss of power Damage to systems, structures, or components Personnel injury Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	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.	S2	F2	
MCO service area SA-R-04	Blocks 5-31	Natural phenomena - rain	Water intrusion into the service area	Leaks through the roof Volume of rain exceeds the capacity of the facility grading and drainage system to carry off rainwater	Water in electrical systems such as cable trays or receiving crane components Flooded floors (including service pit)	Personnel injury caused by slips. Loss of power Loss of equipment or personnel injury from electrical shorts Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	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). The site grading is designed to prevent rain intrusion into the facility. The facility design takes into consideration the need for tactile (non-skid) surfaces.		S1	F1	

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 9 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
MCO service area SA-R-05	Blocks 5-31	Natural phenomena - snow, freezing weather	Snow loading Extreme cold	Snow storm, cold weather	Roof collapse	Personnel injury from collapsed roof or cold exposure Ice buildup Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The building is designed to withstand anticipated snow loads. The service area is heated. The facility provides shelter for workers.	The MCO shipping is prohibited during adverse weather conditions.[b]	S2	F3	ACTION ITEM: The Safety Analysis Report for Packaging[b] definition of "adverse weather conditions, when established, will be included here. (Action Item #64)
MCO service area SA-R-06	Blocks 5-31	Natural phenomena - straight wind	Wind pressure Flying debris Dust	Pressure gradient	Personnel may be struck by flying debris. Systems, structures, or components damaged by flying debris Visibility reduced Debris accumulates	Personnel injury Restricted access to the facility Operational delays could arise from damaged equipment or the need to clear debris; delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility structure is designed to withstand a 200 mi/h wind. The facility provides shelter for workers.		S1	F3	Winds in excess of the design basis were not considered. The consequences of this phenomenon are less than they were in the truck vestibule. This area is less susceptible to straight winds.
MCO service area SA-R-08	Blocks 5-31	Natural phenomena - tornado (40 mi/h translational, 160 mi/h rotational; missiles, 40 mi/h; wind loads, 200 mi/h)	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Systems, structures, or components damaged by flying debris (e.g., receiving crane, MHM service area enclosure) A tornado missile strikes MCO in the service pit while the cask lid is removed and the shield hatch assembly is not yet installed Visibility reduced Debris accumulates	Personnel injury Restricted access to the facility Operational delays could arise from damaged equipment or the need to clear debris; delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility superstructure is designed to withstand the forces of design basis tornado missiles and wind loads. The facility provides shelter for workers. A probability analysis for the vulnerability of all safety-class systems to tornado missiles shows that it is incredible for a tornado missile to strike the safety class systems within the CSB.'	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S3	F0	
MCO service area SA-R-09	Blocks 5-31	Natural phenomena - ashfall	Ash loading on roof	Volcanic eruption	Roof collapse Ash intrusion	Personnel injury Equipment damage Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The building is designed to withstand anticipated ash loadings.		S1	F2	
MCO service area SA-R-10	Blocks 5-31	Natural phenomena - range fire	Windborne embers Smoke	Dry conditions and ignition	Loss of power Reduced Visibility Secondary fire from flying embers	Personnel injury Operational delays that cause the MCO to exceed its available transport window may result in MCO pressure relief before placement within the storage tube	The facility is designed with non-combustible materials (Type II-N).	The facility controls and clears the vegetation in the vicinity of the CSB to reduce the impact of range fires.	S2	F3	The service area is less vulnerable than the truck vestibule with regards to a range fire, except in the area of loss of power.

Table 3-15. Canister Storage Building Hazard Analysis: Service Area. (sheet 10 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
attendees	Fluor Daniel Northwest Duke Engineering and Services Hanford, Incorporated XWest Group Numatec Hanford Corporation Fluor Daniel, Incorporated Science Applications International Corporation										

[a] ASME, 1995, *Rules for Construction of Overhead and Gantry Cranes (Top-Running Bridge, Multiple Girder)*, ASME NOG-1-1995, American Society of Mechanical Engineers, New York, New York.
[b] RFS, 1996, *Preliminary Safety Analysis Report for Packaging (Onsite) Multiple Canister Overpack Cask*, HNF-SD-TP-SARP-017, Rev. 0, Rust Federal Services Northwest for Fluor Daniel Hanford, Incorporated, Richland, Washington.
[c] Sadanaga, C. T., 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DRAFT, DynCorp Tri-Cities Services, Incorporated, for Fluor Daniel Hanford, Incorporated, Richland, Washington.
[d] Ares, 1996, *Canister Storage Building Fire Code Equivalency Evaluation*, Report 951107-001, Rev. 0, Ares Corporation, Richland, Washington.
[e] 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.
[f] 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.
[g] 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.
[h] Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.
[i] Tallman, A. M., 1996, *Canister Storage Building Natural Phenomena Hazards*, WHC-SD-SNF-DB-009, Rev. 4, Westinghouse Hanford Company, Richland, Washington.

CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
DBE = design basis earthquake.
HEPA = high-efficiency particulate air (filter).
MCO = multicanister overpack.
MHM = multicanister overpack handling machine.

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 1 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
CSB operating area OA-B-07	Blocks 36-62	Thermal - radioactive decay heat and chemical reaction	Hot gases Hot surface (below standard plug cover assembly)	Decay heat and chemical reactions	Exceeding the design temperature of the MCO	Operational delays that cause an MCO to exceed its available transport window result in MCO pressure relief before initial placement within a storage tube Equipment failure (e.g., storage tube seals, service cart components) Personnel injury Inleakage criteria on MHM exceeded Leakage criteria of tube plug seals exceeded	MHM and storage tube are designed to withstand MCOs with temperatures of 270 °F (seals, cooling and venting system). Tube plug design; seals with a test feature. The service cart sampling line includes equipment that measures the temperature of storage tube gases, providing an alarm if excessive temperatures are detected.	Procedures define the types of personal protective equipment that must be worn to protect against high temperatures on exposed surfaces. Each time the tube plug is installed, it is tested to verify seal integrity.	S2	F1	
CSB operating area OA-D-01	Blocks 35, 42-45, 52-54, 61-62	Corrosives - acids (cart battery, rechargeable)	Leaking battery	Cracked battery case Overfill Overcharge Faulty battery	Acid leak on plug seals Acid on the floor Acid on personnel Acid on cart and cart equipment and electrical systems	Leaking seal Corroded floor Personnel injury Failure of cart and/or cart equipment and systems Electrical shorts		Periodic maintenance includes battery inspection. "Never-fill" batteries used (TBD). Written charging procedures used. Reputable battery vendor used.	S2	F1	ISSUE: The service cart design is not finalized. When it is, the hazards analysis needs to evaluate further potential hazards. (Issue #16)
CSB operating area OA-E-07	Blocks 37-39, 47-49, 56-58	Rotational kinetic - MHM turret	Rotating MHM turret creates a shearing force (a plane 5 ft above the floor) on a lowered MCO or 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 result in the MCO being stuck in the storage tube with no controls or ungrappling capability An impact absorber being lowered into the storage tube is destroyed leaving pieces of the impact absorber in the storage tube	Damage to the MCO center cover hatch 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 Operational delay to clean out pieces of an impact absorber	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 backup grapple disengagement capability. Secondary confinement provided by the MHM-tube plug interface is present at all times, with active, HEPA-filtrated, ventilation.	Personnel are trained to MHM-specific procedures regarding its safe operation.	S2	F1	ISSUE: The design of MHM interlocks and permissive switches is not yet complete. (Issue #6) It is assumed that secondary confinement is maintained.

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 2 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
CSB operating area OA-F-02	Blocks 35, 42-45, 52-54, 61-62	Linear kinetic - forklifts, dollies, carts (service cart and trailer)	Moving equipment	Personnel error Equipment failure	Impact with personnel Impact with other carts Impact with the crane and/or MHM Impact with the plug cover assembly Severed electrical cord supplying services on cart Damage to electrical cord, pulling it out Spill of hazardous material (oils, battery acid)	Damage to equipment Personnel injury Operational delays Delay to specific operations (drawing a vacuum or pressurizing a storage tube) Spills getting to tube plug seals Broken purge and/or vent lines while connected to MCO	The cart speed has governors The service cart has brakes	Personnel are trained in the safe use of the service carts, forklifts, and other moving equipment.	S1	F3	
CSB operating area OA-F-07	Blocks 36, 41, 46, 51, 55, 60	Linear kinetic - MHM lateral movement	MHM impact 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	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 result in the MCO being stuck in the storage tube with no controls or ungrappling capability	Personnel injury Damage to systems, structures, or components (e.g., service carts, MHM) Damage to the MCO center cover hatch 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 Operational delays that cause the MCO to exceed its available transport window result in MCO pressure relief before placement within the storage tube	Design of MHM is expected to cool the MCO for a long time The MHM is designed to ASME NOG-I* 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 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 tubet and/or MHM while it is being lowered or raised. The MHM is provided with 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. Personnel are trained to MHM-specific procedures regarding its safe operation.	S2	F2	The design of MHM interlocks and permissive switches is not yet complete. ISSUE: It is currently unclear to the hazards analysis team whether the frog stops are adequate to stop either the receiving crane or the MHM. (Issue #9) ACTION ITEM: The design calculations for frog stops relative to the receiving crane and MHM must be verified. (Action Item #28)

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 3 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
CSB operating area OA-G-13	Blocks 36-38	Mass, gravity, height - vessels (MCO)	MCO falling	Human error Mechanical failure (Would take multiple failures with mechanical and human error)	MCO impacts - MHM turntable - Top and sides of storage tube - Bottom impact absorber - Other MCO in the tube (double failure if impact absorber not installed) MCO rupture disk ruptures Relief valve discharges Relief valve damaged	Damage to storage tube Damage to the MHM turntable Damage to the MCO (significant damage to the MCO, such as the failure of the rupture disk or relief valve, could result in a release of gas and contamination from the MCO) Damage to relief valve filter Damage to grapple point (inability to remove damaged MCO) Damage to MCO relief valves, valve ports, rupture disk Rubblized contents Mark IA fuel basket centering tube moved off center	Impact absorbers, both bottom and intermediate The MCO is designed to survive a 2-ft drop onto an unyielding surface and a drop from any credible height within the CSB onto an impact absorber. 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, and MHM. The drying process at the CVDF provides a calculated transport window during which an MCO overpressurization is precluded. This will ensure MCO pressures are relatively low during the receiving process. For MCO retrieval, a preretrieval evacuation of the storage tube to depressurize the MCO is performed. The storage tube pressure history also provides an indication of the susceptibility of the MCO to releases.	S2	F2	
CSB operating area OA-G-14	Blocks 35-42, 53-61	Mass, gravity, height - dropped - Tube plug - Impact absorber - Cover plate assembly - Seal ring - Rigging equipment	Kinetic energy	Human error Equipment failure	Personnel injury Dropped plug Dropped impact absorber Dropped cover Dropped rigging gear, tools, lifting and handling equipment	Plug seal damage Tube sealing surface damage Damaged embeds Scratched tube Damage to impact absorber Impact absorber stuck in tube Damage to top of tube plug Damage to seal ring surface (possible deformation)	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 receiving crane and MHM.	S1	F2	

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 4 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
CSB operating area OA-H-06a	Blocks 38-43	Volume, pressure - pressure vessels (MCO)	Gases under high pressure reach release pressure	Excessive gas generation in MCO Inadequate conditioning at CVDF Faulty relief valve Faulty rupture disk Damaged relief valve Damaged rupture disk Improperly closed ports at the CVDF	MCO rupture disk ruptures MCO relief valve discharges Deflagration MCO exists in: - MHM until inserted in tube - In tube and MHM when removed to go to HCS - In MHM coming back from HCS - In tube after hot conditioning (At no time is MCO outside of a secondary confinement) Sufficient pressure in tube to lift tube plug after plug hold downs are undone and before MHM is in place	Contaminated personnel (during plug blowout potential scenario) Personnel injury Spread of contamination Contamination of storage tube sonic damage to ears Operations delay Potential flammable atmosphere (during plug blowout scenario)	Relief valve design (has HEPA) Secondary confinement (MHM and tube) provided Inert environments established in the MCO and storage tube, with periodic reinerting of the storage tube	Drawing a vacuum in the storage tube before removing plug.	S2	F3	
CSB operating area OA-H-06b	Blocks 38-43, 53-62	Volume, pressure - pressure vessels (storage tube)	Hot gases under pressure reach release pressure	MCO relief valve relieves Rupture disk ruptures Failed MCO Excessive vault temperature Chemical reaction in MCO Human error leading to closing off both tube relief paths during filter change out	Release caused by leaking tube seals Release caused by tube relief valve actuation Release caused by tube failure (into vault)	Excessive vault heat Tube contamination Flammable atmosphere on operating deck Contamination release to operating deck Flammable atmosphere in tube Flammable atmosphere in vault Contamination release to vault	The carbon steel tube material will maintain its integrity up to 700 °F. Building construction is type IIN. Stack monitors detect tube failure. Service carts 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.	S2	F2	
CSB operating area OA-J-06	Blocks 36-43, 53-62	Explosives or pyrophorics - hydrogen	Flammable hydrogen mixture and ignition source	Hydrogen release from tube to operating deck Hydrogen release from tube to vault Hydrogen release from MCO to tube plus 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 Runaway reaction in MCO	Controlled generation rates Minimize accumulation of hydrogen (building HVAC) Provide confinement with inert helium atmosphere to preclude inleakage of air Systems to ensure adequate purging Oxygen getters MCO penetrations are limited in size to reduce the rate of hydrogen release The carbon steel tube material will maintain its integrity up to 700 °F.	Periodic pressure monitoring, purging, and inerting will be performed by qualified operators using facility-specific procedures.	S3	F1	Refer also to VL-J-06, "Explosives or pyrophorics -hydrogen" for a details relative to hazards associated with hydrogen accumulation in the vault area. F-1 was selected until the potential for air ingress (such as through a relief valve) is evaluated. It may then be changed to F-0.

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 5 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
CSB operating area OA-J-10	Blocks 36-43, 53-62	Explosives or pyrophorics -plutonium and uranium metal	Pyrophoric material exposed to air and sufficient surface area and temperature are present	MCO breach Human error in failing to inert the MCO	Pyrophoric material ignites	Personnel injury Contamination release Damage to the MCO	The structural design of the MCO is such that breaches have a very low probability of occurring.	CVDF personnel will be trained according to CVDF-specific procedures regarding the inerting process for the MCO before shipment to the CSB.	S3	F1	F-1 was selected until the potential for air ingress (such as through a relief valve) is evaluated. It may then be changed to F-0.
CSB operating area OA-K-01	Blocks 36-43, 53-62	Nuclear criticality - vaults					CSB cannot be flooded by rain or a water main break	General training of operators; operators will not disassemble an MCO		F0	This hazard is addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6.0; no new hazards were identified.
CSB operating area OA-K-04	Blocks 36-43, 53-62	Nuclear criticality - filters (cart and tube plug)					CSB cannot be flooded by rain or a water main break	General training of operators; operators will not disassemble an MCO		F0	This hazard is addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6.0; no new hazards were identified.
CSB operating area OA-K-12	Blocks 36-43, 53-62	Nuclear criticality - cranes and lifts					CSB cannot be flooded by rain or a water main break	General training of operators; operators will not disassemble an MCO		F0	This hazard is addressed in HNF-SD-SNF-RPT-004,[b] Chapter 6.0; no new hazards were identified.
CSB operating area OA-L-11	Blocks 36-43, 53-62	Flammable materials - hydrogen									Refer to OA-J-06, "Explosives or pyrophorics - hydrogen" for an evaluation of this hazard.
CSB operating area OA-L-13	Blocks 35-62	Flammable materials - organics (MHM neutron absorber)									These hazards are addressed by the preliminary fire hazards analysis. Refer to the white papers on occupational classification[c,d] and the deviation and exemption request letters[e,f] that cover this topic.
CSB operating area OA-L-15	Blocks 35, 42-45, 52-54, 61-62	Flammable materials - hydraulic fluid for tube service cart, plug cover hoist	High heat	Leaky seals Breach of system Ignition source Sloppy housekeeping Human error	Fluid fire	Operations delay personnel injury Equipment damage Heating and exploding gas bottles Contamination (low levels) caused by damage to filters and other internally contaminated cart systems Toxic gases (tires and upholstery)	Fire extinguishers on cart and throughout building TBD (automatic and manual shutdown of hydraulic systems) TBD (hoses are double encased)	Regular cart maintenance is performed using appropriate procedures.	S2	F2	The preliminary fire hazard analysis has addressed fires that fully involve the cart except internal low-level contaminant release. Heated or exploded gas bottles are addressed under SA-H-05, "Pressure/volume - gas bottles." ISSUE: The service cart design is not finalized. When it is, the hazards analysis needs to evaluate further potential hazards. (Issue #16)
CSB operating area OA-M-05	Blocks 35, 42-45, 52-54, 61-62	Hazardous materials - corrosives (batteries)	Leaking battery	Cracked case Overfill Overcharge Faulty battery	Acid leak affects plug seals Acid on the floor Acid on personnel Acid on cart and cart equipment, and electrical systems	Leaking seal Corroded floor Personnel injury Failure of cart and/or cart equipment and systems Electrical shorts		Periodic maintenance includes battery inspection. "Never-fill" batteries used (TBD). Written charging procedures used. Reputable battery vendor used.	S1	F3	ISSUE: The service cart design is not finalized. When it is, the hazards analysis needs to evaluate further potential hazards. (Issue #16)

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 6 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
CSB operating area OA-M-07	Blocks 36-43, 53-62	Hazardous materials - toxics	Toxic material carried by gases under high pressure	Excessive gas generation in MCO Improper or insufficient conditioning performed on the MCO before receipt at the CSB Failure of the MCO relief valve because of manufacturing flaws or damage Failure of the MCO rupture disk because of manufacturing flaws or damage Improperly closed ports at the CVDF Failure of MHM-floor seal	MCO rupture disk ruptures MCO relief valve discharges MCO exists in: - MHM until inserted in tube - In tube and MHM when removed to go to HCS - In MHM coming back from HCS - In tube after hot conditioning (At no time is the MCO outside of a secondary confinement) Sufficient pressure within the storage tube to lift the tube plug after plug hold downs are undone and before MHM is in place	Contaminated personnel (during plug blowout scenario) Personnel injury Spread of contamination Contamination of storage tube Operations delay	Relief valve design (has HEPA) Secondary confinement (MHM and tube) present	Drawing a vacuum in the storage tube before removing plug.	S2	F3	
CSB operating area OA-N-01 OA-N-03	Blocks 36-43, 53-62	Ionizing radiation sources - fissile and radioactive material	Contact exposure Release of fissile and/or radioactive materials entrained in pressurized gases within the MCO	A process delay causes the MCO to exceed its calculated transport window before placement in a storage tube Improper or insufficient conditioning performed on the MCO before receipt at the CSB Failure of the MCO relief valve because of manufacturing flaws or damage Failure of the MCO rupture disk because of manufacturing flaws or damage Improper closing of the MCO process ports at the CVDF Tube plug not installed on empty tubes when adjacent tubes contain MCOs Failure of MHM-floor seal	Release of fissile and/or radioactive materials: - MCO rupture disk relieves (because of excessive pressures within the MCO) - Failure of the rupture disk at lower pressures (because of manufacturing flaws or damage)	An MCO release inside the MHM or storage tube, by itself, has no safety consequences beyond contamination of the MHM or storage tube with fissile and/or radioactive materials (recovery actions are dealt with separately); the MHM or storage tube will contain the release. If the MHM or storage tube fails to contain the release following an MCO release or breach, or the MCO release occurs while the tube plug tie-downs are removed and before the MHM is mated to the tube, fissile and/or radioactive materials are released to the operating area	The MCO rupture disk is designed with protective features such as a recessed location and a protective steel plate to minimize the potential for damage. The relief valve is recessed to minimize the potential for damage. The relief valve contains a HEPA filter to minimize the potential for radioactive particulate releases. The MHM provides HEPA-filtered secondary confinement in the event of an MCO pressure release.	Personnel are trained to facility-specific procedures regarding MCO shipping, movement, handling, and site radiological control. The drying process at the CVDF provides a calculated transport window during which an MCO overpressurization is precluded. This will ensure MCO pressures are relatively low until the MCO is installed in the storage tube. CVDF personnel are trained in the proper procedures for closing the MCO process ports. A pressure test is performed on the transport cask before the lid is removed. This prevents fissile and/or radioactive releases associated with exposing an MCO that has already experienced pressure relief. Tube pressures will be monitored on a regular schedule to alert operations to an MCO pressure relief situation. A pressure drawdown of the storage tube before moving the MCO to hot conditioning from staging will provide a window of time during which MCO pressure will remain sufficiently below the relief valve setpoint.	S2	F3	

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 7 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
CSB operating area OA-N-04	Blocks 36-43, 53-62	Ionizing radiation sources - radioactive source	Exposure to direct radioactive shine	Direct shine associated with MCO during transfer and storage	Shine from MCO during transport if MHM shield skirt is not in place Shine from adjacent tube if tube plug is not in place	Worker exposure caused by shine from adjacent tubes during storage or from MCO during transfer into or out of storage tube	MHM, shielding, operating deck, and tube plug		S1	F1	ASSUMPTION: The tube plugs will be installed in all tubes before MCO installation in any single tube. (Assumption #12)
CSB operating area OA-P-01	Blocks 35-62	External events - explosion	External explosion resulting in a shock wave introduces dust, heat, and/or projectiles into the operating area	Explosion of nearby gas delivery truck, propane delivery truck, or gas station	Shock wave from the explosion impacts the facility Flying debris hits personnel Workers exposed to heat from the explosion	Structural damage or failure Personnel injury from flying debris Operational delays from structural damage, personnel injury, or from the need to evacuate the facility cause the MCO to exceed its available transport window resulting in MCO pressure relief before placement within the storage tube Delays that cause the MCO to approach the relief valve set pressure after the tube pressure drawdown result in MCO pressure relief in the MHM	The CSB is isolated from major roads, reducing the possibility of explosions outside the facility from 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.	S1	F2	
CSB operating area OA-P-02	Blocks 35-62	External events - fire	External fire introduces heat and smoke into the service area (low visibility)								Based upon the current design, there is no external energy source that would have greater consequences than a fire inside the facility. These hazards are addressed by the preliminary fire hazards analysis. Refer to the white papers on occupational classification[c,d] and the deviation and exemption request letters[e,f] that cover this topic.
CSB operating area OA-P-03	Blocks 35-62	External events - nearby facilities	Accidents at nearby facilities introduce radioactive material, toxic material, and direct radiation 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.[b]	Descriptions of potential accidents at nearby facilities and their resulting consequences are addressed in Chapter 1.0 of HNF-SD-SNF-RPT-004.[b]	Personnel exposure to radioactive and toxic material from the nearby facility Contamination of the CSB from nearby facility releases makes the building uninhabitable Operational delays evacuate the facility or take cover cause the MCO to exceed its available transport window and result in MCO pressure relief before placement within the storage tube Delays cause the MCO to approach the relief valve set pressure after the tube pressure drawdown resulting in MCO pressure relief in the MHM	The distance of the CSB from other facilities and the shielding the structure provides reduces the consequences of external events on the CSB.	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S1	F1	

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 8 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
CSB operating area OA-R-01a	Blocks 35-62	Natural phenomena - earthquake (equal to or loss than the DBE) (storage tubes, MCOs)	Forces on the facility from lateral and horizontal accelerations	Earthquake	Structural damage or collapse Damage to facility systems, structures, or components (e.g., receiving crane, cable trays, MHM) Damage to MCOs (while in storage tube or MHM) Relief valve actuation on several MCOs, releasing hot gas pressure to the storage tubes and causing a release to the operating deck through the tube plug vent valves Increased surface exposure of MCO contents, providing the potential for increased reactions	Personnel injury Release of radiation from a breached MCO Loss of facility power Operational delays that cause an MCO to exceed its available transport window and may result in MCO pressure relief before placement within the storage tube Flammable atmospheres formed on the operating deck	The facility (including both the facility structure and systems such as the receiving crane and MHM) is designed with consideration of impacts to safety systems from the failure of non-safety systems. The CSB is built to appropriate seismic criteria. The relief valves are designed with small internal areas and will be oriented in various directions in the storage tubes. This will minimize both the number of tubes that could vent and the amount of gas released from them.	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S2	F2	
CSB operating area OA-R-01b	Blocks 35-62	Natural phenomena - earthquake (equal to or less than the DBE) (service carts hooked to a tube plug for purging)	Forces from lateral and horizontal accelerations	Earthquake	Service cart movement or relocation Broken connection	Exposure of storage tube internals, with resulting - Hydrogen release - Contamination release - Air inleakage and potential pyrophoric reactions and/or deflagration	The connections to the storage tube plug are designed to not fail when exposed to seismic forces.		S1	F2	This hazard is more of an initiator for pyrophoric reactions.
CSB operating area OA-R-03	Blocks 35-62	Natural phenomena - lightning	High electrical energy	Lightning strike	Strike on the facility	Loss of power Damage to systems, structures, or components Personnel injury Operational delays that cause the MCO to exceed its available transport window and result in MCO pressure relief before placement within the storage tube Delays that cause the MCO to approach the relief valve set pressure after the tube pressure drawdown resulting in MCO pressure relief in the MHM	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.	S1	F2	

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 9 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features: Engineering features	Safety features: Administrative features	Consq categ	Freq categ	Remarks
CSB operating area OA-R-04	Blocks 35-62	Natural phenomena - rain	Water intrusion into the operating area	Leaks through the roof Volume of rain exceeds the capacity of the facility grading and drainage system to carry off rainwater	Water in electrical systems such as cable trays or MHM components Flooded floors (including storage tubes)	Personnel injury from slips Loss of power Loss of equipment or personnel injury from electrical shorts Operational delays that cause the MCO to exceed its available transport window result in MCO pressure relief before placement within the storage tube	The facility is designed to prevent water intrusion and to provide shelter for workers. The electrical design within the facility minimizes potential consequences (electrical conduit inhibits fire spread). Site grading is designed to prevent rain intrusion into the facility. The facility design takes into consideration the need for tactile (non-skid) surfaces.		S0	F1	
CSB operating area OA-R-05	Blocks 35-62	Natural phenomena - snow, freezing weather	Snow loading Extreme cold	Snow storm, cold weather	Roof collapse	Personnel injury from collapsed roof or cold exposure Ice buildup Operational delays that cause the MCO to exceed its available transport window result in MCO pressure relief before placement within the storage tube	The building is designed to withstand anticipated snow loads. The operating area is heated. The facility provides shelter for workers.	MCO shipping during adverse weather conditions is prohibited.	S0	F3	ACTION ITEM: The Safety Analysis Report for Packaging definition of "adverse weather conditions," when established, will be included here. (Action Item #64)
CSB operating area OA-R-06	Blocks 35-62	Natural phenomena - straight wind	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Systems, structures, or components damaged by flying debris Visibility reduced Debris accumulates	Personnel injury Restricted access to the facility Operational delays arising from damaged equipment or the need to clear debris cause the MCO to exceed its available transport window and result in MCO pressure relief before placement within the storage tube	The facility structure is designed to withstand a 200 mi/h wind. The facility provides shelter for workers.		S0	F3	Winds in excess of the design basis were not considered. The consequences of this phenomenon are less than they were in the truck vestibule. This area is less susceptible to straight winds.
CSB operating area OA-R-08	Blocks 35-62	Natural phenomena - tornado (40 mi/h translational, 160 mi/h rotational; missiles, 40 mi/h; wind loads, 200 mi/h)	Wind pressure Flying debris Dust	Pressure gradient	Personnel struck by flying debris Systems, structures, or components damaged by flying debris (e.g., MHM, service carts) Visibility reduced Debris accumulates	Personnel injury Restricted access to the facility Operational delays that arise from damaged equipment or the need to clear debris cause the MCO to exceed its available transport window and result in MCO pressure relief before placement within the storage tube	The facility superstructure is designed to withstand the forces of design basis tornado missiles and wind loads. The facility provides shelter for workers. A probability analysis for the vulnerability of all safety class systems to tornado missiles shows that it is incredible for a tornado missile to strike the safety class systems within the CSB.		S3	F0	
CSB operating area OA-R-09	Blocks 35-62	Natural phenomena - ashfall	Ash loading on roof	Volcanic eruption	Roof collapse Ash intrusion	Personnel injury Equipment damage Operational delays that cause the MCO to exceed its available transport window result in MCO pressure relief before placement within the storage tube	The building is designed to withstand anticipated ash loadings.		S1	F2	

Table 3-16. Canister Storage Building Hazard Analysis: Operating Area. (sheet 10 of 10)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
CSB operating area OA-R-10	Blocks 35-62	Natural phenomena - range fire	Windborne embers Smoke	Dry conditions and ignition	Loss of power Reduced visibility Secondary fire caused by flying embers	Personnel injury Operational delays that cause the MCO to exceed its available transport window result in MCO pressure relief before placement within the storage tube	The facility is designed with non-combustible materials (Type II-N).	Personnel control and clear the vegetation in the vicinity of the CSB to reduce the impact of range fires.	S1	F3	The operating area is less vulnerable than the truck vestibule with regards to a range fire, except in the area of loss of power.
attendees	Fluor Daniel Northwest; Duke Engineering and Services Hanford, Incorporated; XWest Group; Numatec Hanford Corporation; Fluor Daniel, Incorporated; Science Applications International Corporation										

[a] ASME, 1995, *Rules for Construction of Overhead and Gantry Cranes (Top-Running Bridge, Multiple Girder)*, ASME NOG-1-1995, American Society of Mechanical Engineers, New York, New York.
[b] Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.
[c] Ares, 1996, *Canister Storage Building Fire Code Equivalency Evaluation*, Report 951107-001, Rev. 0, Ares Corporation, Richland, Washington.
[d] 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.
[e] 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.
[f] 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 SystemRequirements* (Letter 9655233 to E. D. Sellers, U.S. Department of Energy, Richland Operations Office, November 14), 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).
HCS = Hot Conditioning System.
HVAC = heating, ventilating, and air conditioning.
MCO = multicanister overpack.
MHM = multicanister overpack handling machine.
TBD = to be determined.

Table 3-17. Canister Storage Building Hazard Analysis: Vault. (sheet 1 of 2)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Vault (including intake structure and exhaust stack) VL-B-07 VL-B-10 VL-R-07 VL-R-09 VL-R-10		Thermal - radioactive decay heat and chemical reaction	High heat in vault, tubes, and MCO	Excessive decay heat and/or chemical reactions Loss or degradation of natural convection caused by - Accumulation of dust, tumbleweeds, ash, bugs, 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, earthquake forces, or aircraft impact - Range fire smoke and heat	Rise in fuel temperature, resulting in runaway chemical reactions Pressurization of MCOs and storage tubes Structural degradation of vault Rise in fuel center line temperatures Rise in storage tube temperatures	Excessive temperatures for - MCOs - Concrete - Storage tubes Design pressure limits for MCOs and storage tubes exceeded Multiple MCO pressure releases Loss of structural integrity of vault walls and ceiling	Height and orientation of inlets and outlets reduce the likelihood of blockage. Temperature and radiation monitors are located on the outlet stack and provide indication of undesired trends and unexpected releases. The stacks are designed to withstand significant forces without failing.		S3	F2	ISSUE: There is no way to check the vault area for conditions that could degrade the heat rejection capability under normal operating conditions. (Issue #20)
Vault VL-H-06		Volume, pressure - pressure vessels									See OA-H-06
Vault VL-J-06		Explosives or pyrophorics - hydrogen	Flammable mixture of hydrogen and air present in the vault and an ignition source ignites it	Breach of storage tubes results in hydrogen leakage into the vault area	Deflagration in the vault area	Ignition of other combustible materials accumulated within the vault (e.g., tumbleweed debris) Rise in vault temperature	The carbon steel tube material will maintain its integrity up to 700 °F. Inlet plenum design minimizes debris intrusion (grated, elevated). Vault design provides for passive cooling. A temperature and radiation monitor is present for the exhaust stack. Tube pressure monitoring devices indicate pressure rises caused by temperature effects.	Periodic pressure monitoring of tubes is performed TBD (routine maintenance procedures, building and site-specific)	S0	F0	This is a potential initiator for VL-B-07, "Thermal - radioactive decay heat and chemical reaction." There will be a one-time integrity test conducted after tube installation in compliance with ASME Section 3 requirements. ACTION ITEM: Verification that the preoperational test procedures include this integrity test must be made. (Action Item #65)
Vault VL-L-11		Flammable materials - hydrogen									Refer to VL-J-06, "Explosives or pyrophorics - hydrogen," for evaluation of the hazard.
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	Forces on vault from lateral and horizontal accelerations	Earthquake			Vault structures are designed to withstand a design basis earthquake without failing.		S0	F2	
Vault VL-R-04		Natural phenomena - rain	Modified criticality parameters								This hazard is addressed in HNF-SD-SNF-RPT-004," Chapter 6.0; no new hazards were identified.

Table 3-17. Canister Storage Building Hazard Analysis: Vault. (sheet 2 of 2)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Vault VL-R-05		Natural phenomena - snow, freezing weather	Modified criticality parameters								This hazard is addressed in HNF-SD-SNF-RPT-004,* Chapter 6.0; no new hazards were identified.
attendees	Fluor Daniel Northwest	Duke Engineering and Services Hanford, Incorporated			XWest Group	Numatec Hanford Corporation	Fluor Daniel, Incorporated	Science Applications International Corporation			

* Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report -- Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
MCO = multicanister overpack.
TBD = to be determined.

Table 3-18. Canister Storage Building Hazard Analysis: Support Building. (sheet 1 of 2)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Support building SB-F-02		Linear kinetic - forklifts, dollies, carts	Moving equipment impacts facility support systems	Human error Mechanical failure	Damage to systems, structures, or components (e.g., ventilation, diesel generators, inert gas line) from moving equipment or resulting missile hazard	Personnel injury Loss of power Operational delays Loss of primary inert gas supply	Vehicles are equipped with braking systems.	Personnel are trained in the proper use of facility equipment and follow established procedures. Periodic maintenance of vehicles is performed according to established procedures to keep the vehicles in good working order.	S1	F3	
Support building SB-L-01 SB-L-10 SB-L-02 SB-L-11 SB-L-04 SB-L-13 SB-L-07 SB-L-16 SB-L-08		Flammable materials - building contents, packing materials, rags, lubricating oil, diesel fuel, grease, hydrogen, organics, clothing	Fire in the support building	Ignition caused by - Human error - Equipment failure (e.g., electrical short)	Fire in the support building	Release of contamination from filters in the filter room Loss of electrical power (primary and backup)	Support building structural materials have been selected to minimize flammability. The support building is equipped with a sprinkler system. A fire barrier separates the two diesel generators	Flammable material inventories are controlled (quantity and location). Emergency response procedures are in place.	S1	F3	Under normal operating conditions, support building filters do not contain a loading of radioactive material. ACTION ITEM: Filter housing design must be check for fire retardation properties. (Action item #62)
Support building SB-N-03		Ionizing radiation sources - radioactive material (HVAC filters)	Radioactive material accumulates on HVAC filters	Previous release of radioactive material from off-normal conditions	Fire involving HVAC filters (see SB-L-x) Pressure differential blowing out filters (ashfall, moisture, pressure pulse from upstream deflagration) Personnel exposure	Release of contamination from filters Personnel injury	Facility CAMs alert personnel to presence of radioactive material. Stack monitor alerts personnel to presence of radioactive material.	Periodic filter testing and change out and other ALARA practices reduce the likelihood of radioactive material being present in the HVAC filters.	S1	F3	
Support building SB-P-01		External events - explosion	External explosion resulting in a shock wave introduces dust, heat, and/or projectiles into the support building	Explosion of nearby gas delivery truck, propane delivery truck, or gas station	The shock wave from the explosion impacts the support building Flying debris hits personnel Workers exposed to heat from the explosion	Structural damage or failure (including housed support functions) Personnel injury from flying debris	The CSB is isolated from major roads, reducing the possibility of external explosions affecting the support building. The facility structure is designed to withstand significant external phenomena (e.g., tornado winds, design basis earthquake).	Personnel are trained in sitewide and facility-specific emergency response procedures.	S1	F2	
Support building SB-P-02		External events - fire	External fire introduces heat and smoke into support building (low visibility)								Based upon 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 hazards analysis,[a] the white papers on occupational classification,[b,c] and the deviation and exemption request letters[d,e] that cover this topic.
Support building SB-P-03		External events - nearby facilities	Radioactive material, toxic material, and direct 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 support building from nearby facility releases, potentially making the building uninhabitable	The distance of the CSB and the support building from other facilities and the shielding the structure provides reduce the consequences of external events.	Personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S1	F1	

Table 3-18. Canister Storage Building Hazard Analysis: Support Building. (sheet 2 of 2)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Support building SB-R-01		Natural phenomena - earthquake	Forces exerted on the facility from lateral and horizontal accelerations	Earthquake	Structural damage or collapse (including housed support functions)	Loss of - Ventilation (primary) - Primary inert gas supply - Primary facility power Release of radiation caused by HVAC filter failure	The support building is designed to withstand a design basis earthquake.	Personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S1	F2	
Support building SB-R-03 SB-R-08 SB-R-04 SB-R-09 SB-R-05 SB-R-10 SB-R-06		Natural phenomena - lightning, rain, snow, freezing weather, straight wind, tornado, ashfall, range fire	Natural energy sources	Geological and/or meteorological effects	Damage to systems, structures, or components (e.g., ventilation, diesel generators, inert gas line)	Personnel injury Loss of power Operational delays Loss of primary inert gas supply	The diesel generators are designed to withstand natural phenomena hazards		S1	F3	See also action items #58 and #59.
attendees	Fluor Daniel Northwest	Duke Engineering and Services Hanford, Incorporated		XWest Group		Numatec Hanford Corporation	Fluor Daniel, Incorporated	Science Applications International Corporation			

[a] Sadanaga, C. T., 1996, *Prelim... ...e Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DRAFT, DynCorp Tri-Cities Services Northwest for Fluor Daniel Hanford, Incorporated, 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] Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

ALARA = as low as reasonably achievable.
CAM = continuous air monitor.
CSB = Canister Storage Building.
MCO = multicanister overpack.
HVAC = heating, ventilating, and air conditioning.

Table 3-19. Canister Storage Building Hazard Analysis: Outside. (sheet 1 of 2)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Outside OU-F-01 OU-F-02 OU-F-05		Linear kinetic - trucks, forklifts, and crane loads	Vehicle collisions with equipment	Human error Equipment failure	Vehicle collision with - Inert gas supply - Diesel tanks - New MCOs - Gas bottles - Transformer	Personnel injury Loss of inert gas supply Missile damage Diesel spill, fire Operations delay Loss of power	Construction of access roads reduces the likelihood of vehicle collisions. The diesel fuel tank is protected by a concrete "tub." The inert gas tube trailer is designed to withstand highway accidents.	Traffic is restricted around the CSB.	S1	F3	Additional engineered features may be included (e.g., bollards, barriers). ACTION ITEM: It must be determined whether a vehicle would have access to the transformer. (Action item #60)
Outside OU-H-05 OU-H-06		Volume, pressure - inert gas tube trailer	High-pressure release due to vessel failure	Human error Equipment failure	Vehicle collision with inert gas tube trailer Tube trailer impacts facility	Operations delay Missile damage Loss of inert gas supply Personnel injury	Construction of access roads reduces the likelihood of vehicle collisions. The inert gas tube trailer is designed to withstand highway accidents.	Traffic is restricted around the CSB.	S1	F3	
Outside OU-L-07		Flammable materials - diesel fuel									Refer to OU-F-01 for a discussion of the hazards involving the failure of the diesel fuel tanks.
Outside OU-P-01		External events - explosion	External explosion resulting in a shock wave introduces dust, heat, and/or projectiles into the service area	Explosion from passing gas or propane delivery truck or from nearby gas station	Shock wave from explosion impacts personnel Personnel are hit by debris Personnel are exposed to heat from explosion	Damage to or failure of systems, structures, or components (e.g., inert gas tube trailer, diesel fuel tanks, transformers) Personnel injury	The CSB is isolated from major roads, reducing the possibility of explosions outside the facility affecting the CSB.		S1	F2	
Outside OU-P-02		External events - fire	External fire introduces heat and smoke								Based upon 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 hazards 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 direct radiation	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	The distance of the CSB from other facilities reduces the consequences of external events.		S1	F1	
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				F0	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]

Table 3-19. Canister Storage Building Hazard Analysis: Outside. (sheet 2 of 2)

Location/ checklist entry	Operating sequence mode/ block	Hazard energy source/material	Hazardous condition	Cause	Potential accident	Consequence	Safety features		Consq categ	Freq categ	Remarks
							Engineering features	Administrative features			
Outside OU-Q-04		Vehicles in motion - truck/bus/car									Refer to OU-F-01 for a discussion of the hazards involving vehicle collisions.
Outside OU-R-01		Natural phenomena - earthquake	Forces exerted on the facility from lateral and horizontal accelerations	Earthquake	Damage to or failure of systems, structures, or components	Loss of - Inert gas tube trailer - Diesel fuel tanks - Transformer	CSB facility structure is built to appropriate seismic criteria.		S1	F2	
Outside OU-R-03 OU-R-07 OU-R-04 OU-R-08 OU-R-05 OU-R-09 OU-R-06 OU-R-10		Natural phenomena - lightning, rain, snow, freezing weather, straight wind, dust devil, tornado, ashfall, range fire	Natural energy sources	Geological and/or meteorological effects	Damage to systems, structures, or components (e.g., inert gas tube trailer, diesel fuel tank, transformer)	Personnel injury Loss of power Operational delays Loss of primary inert gas supply	The CSB facility is equipped with lightning protection that includes lightning rods, grounding, and ground fault detectors. The facility structure is designed to withstand natural phenomena hazard loads.	CSB personnel are trained in sitewide and facility-specific emergency response procedures that include steps to place the facility in the safest possible condition.	S1	F3	
attendees	Fluor Daniel Northwest; Duke Engineering and Services Hanford, Incorporated; XWest Group; Numatec Hanford Corporation; Fluor Daniel, Incorporated; Science Applications International Corporation										

[a] Sadanaga, C. T., 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DRAFT, DynCorp Tri-Cities Services Northwest for Fluor Daniel Hanford, Incorporated, 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] Gavin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

CSB = Canister Storage Building.
MCO = multicanister overpack.

4.0 REFERENCES

29 CFR 1910, "Occupational Safety and Health Standards," Code of Federal Regulations, as amended.

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

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DOE Order 5480.23, 1992, *Nuclear Safety Analysis Reports*, DOE 5480.23, U.S. Department of Energy, Washington, D.C.

DOE Standard 3009-94, 1994, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009-94, U.S. Department of Energy, Washington, D.C.

Garvin, L. J., 1997, *Canister Storage Building Safety Analysis Report — Phase 3: Safety Analysis Documentation Supporting Canister Storage Building Construction*, HNF-SD-SNF-RPT-004, Rev. 7, Duke Engineering and Services Hanford for Fluor Daniel Hanford, Incorporated, Richland, Washington.

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NFPA, 1995, *Lightning Protection Systems*, NFPA 780, National Fire Protection Association, Quincy, Massachusetts.

RFS, 1996, *Preliminary Safety Analysis Report for Packaging (Onsite) Multiple Canister Overpack Cask*, HNF-SD-TP-SARP-017, Rev. 0, DRAFT, Rust Federal Services Northwest for Fluor Daniel Hanford, Incorporated, Richland, Washington.

Sadanaga, C. T., 1996, *Preliminary Fire Hazard Analysis for the Canister Storage Building*, HNF-SD-SNF-FHA-002, Rev. 2, DRAFT, DynCorp Tri-Cities Services, Incorporated, for Fluor Daniel Hanford, Incorporated, Richland, Washington.

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

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

ATTACHMENT 1

CANISTER STORAGE BUILDING OPERATIONS FLOW DIAGRAM

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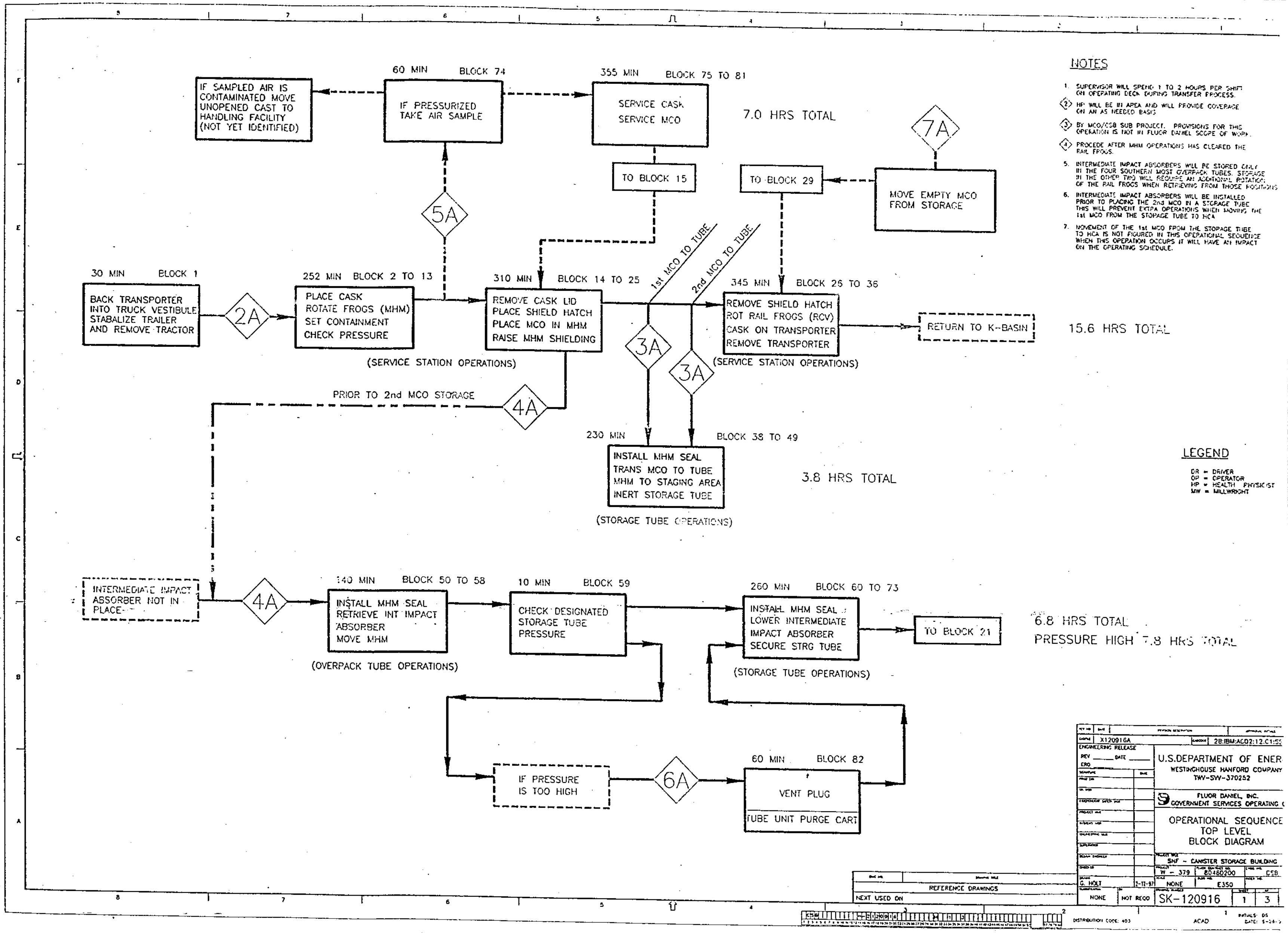
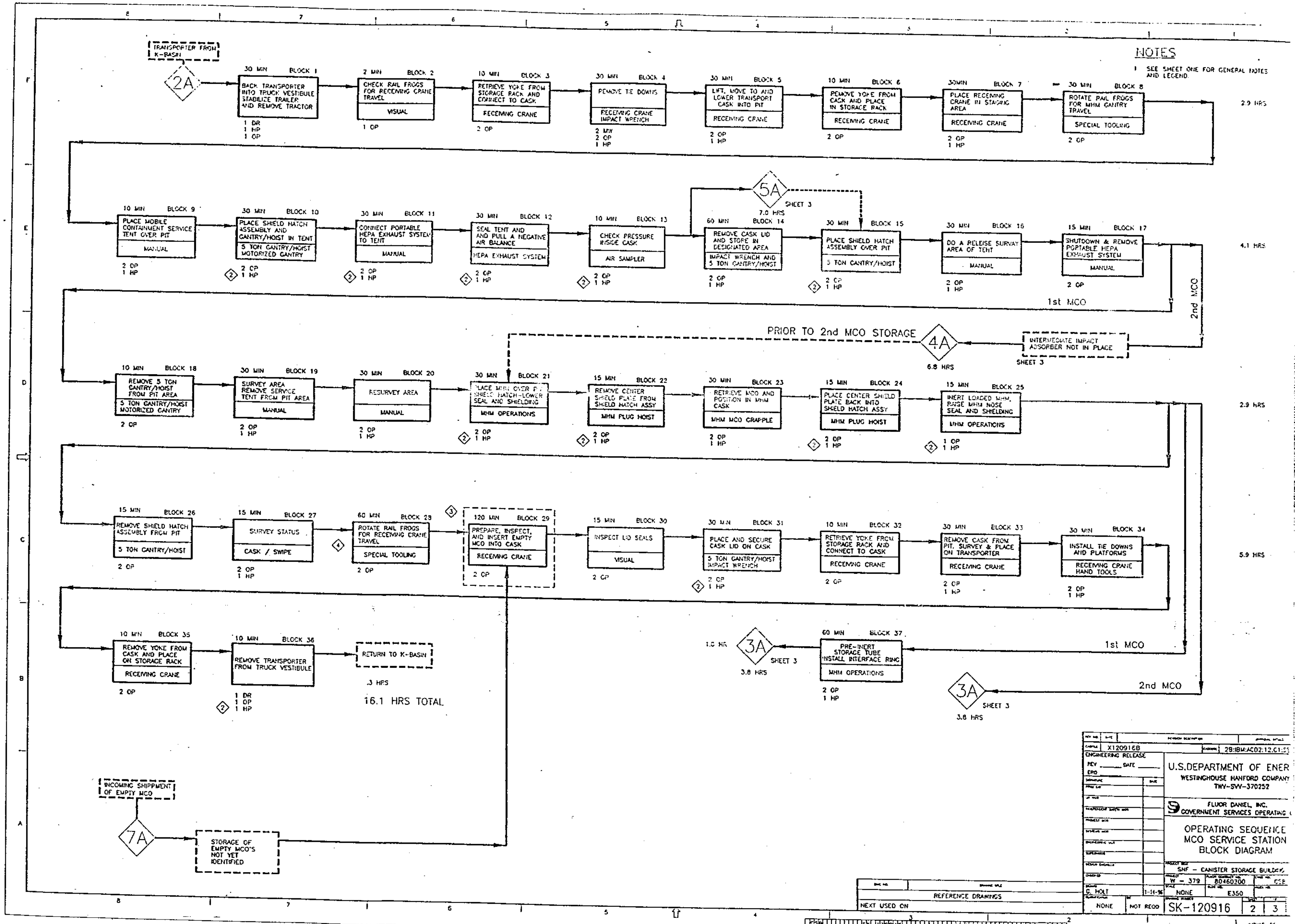
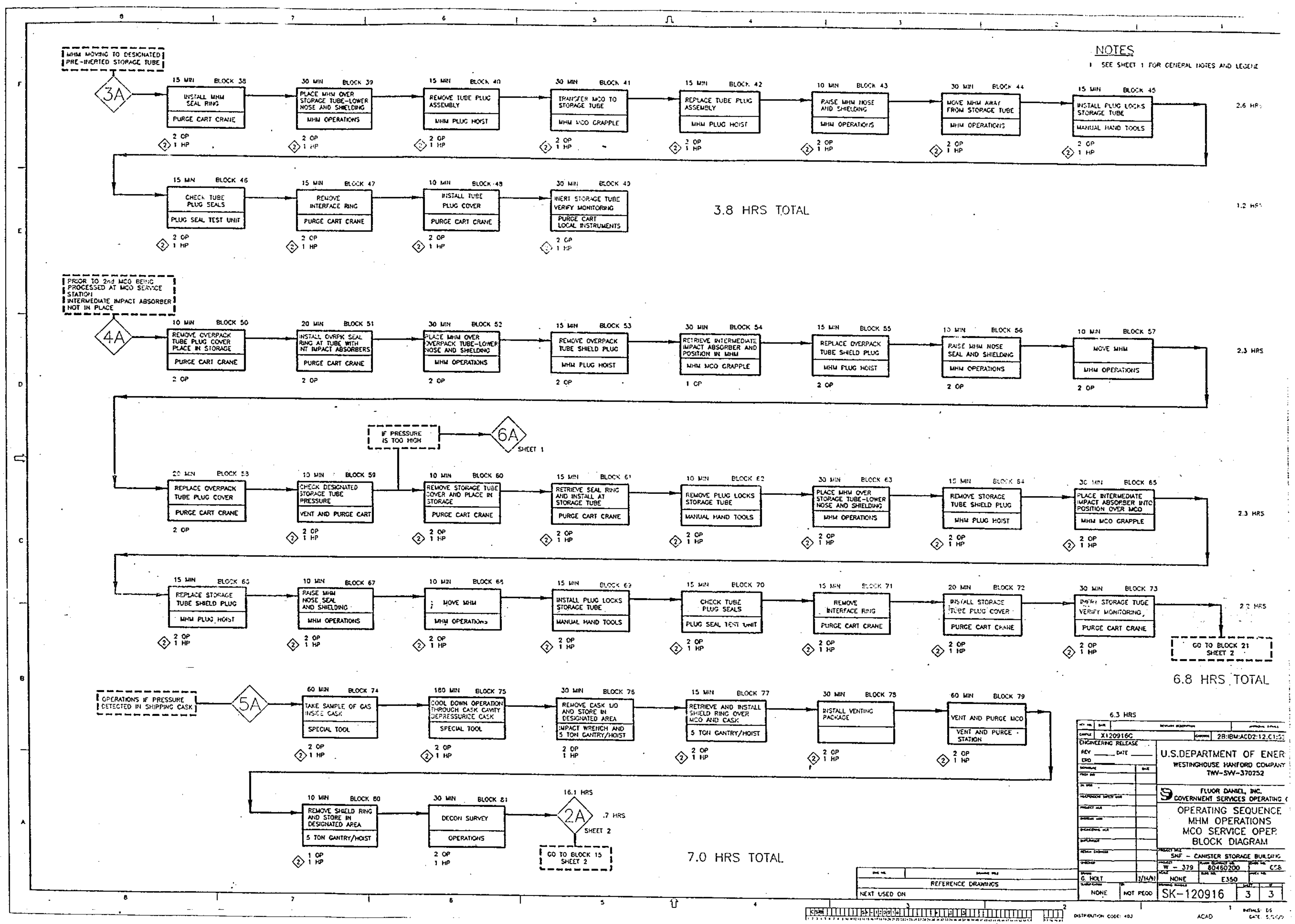

60 MIN BLOCK 74
IF PRESSURIZED TAKE AIR SAMPLE
IF SAMPLED AIR IS CONTAMINATED MOVE UNOPENED CAST TO HANDLING FACILITY (NOT YET IDENTIFIED)
355 MIN BLOCK 75 TO 81
SERVICE CASK SERVICE MCO
7.0 HRS TOTAL
TO BLOCK 15
TO BLOCK 29
MOVE EMPTY MCO FROM STORAGE
7A
5A
30 MIN BLOCK 1
BACK TRANSPORTER INTO TRUCK VESTIBULE STABALIZE TRAILER AND REMOVE TRACTOR
2A
252 MIN BLOCK 2 TO 13
PLACE CASK ROTATE FROGS (MHM) SET CONTAINMENT CHECK PRESSURE
(SERVICE STATION OPERATIONS)
310 MIN BLOCK 14 TO 25
REMOVE CASK LID PLACE SHIELD HATCH PLACE MCO IN MHM RAISE MHM SHIELDING
1st MCO TO TUBE
2nd MCO TO TUBE
345 MIN BLOCK 26 TO 36
REMOVE SHIELD HATCH ROT RAIL FROGS (RCV) CASK ON TRANSPORTER REMOVE TRANSPORTER
(SERVICE STATION OPERATIONS)
RETURN TO K-BASIN
15.6 HRS TOTAL
3A
3A
PRIOR TO 2nd MCO STORAGE
4A
230 MIN BLOCK 38 TO 49
INSTALL MHM SEAL TRANS MCO TO TUBE MHM TO STAGING AREA INERT STORAGE TUBE
(STORAGE TUBE OPERATIONS)
3.8 HRS TOTAL
INTERMEDIATE IMPACT ABSORBER NOT IN PLACE
4A
140 MIN BLOCK 50 TO 58
INSTALL MHM SEAL RETRIEVE INT IMPACT ABSORBER MOVE MHM
(OVERPACK TUBE OPERATIONS)
10 MIN BLOCK 59
CHECK DESIGNATED STORAGE TUBE PRESSURE
260 MIN BLOCK 60 TO 73
INSTALL MHM SEAL LOWER INTERMEDIATE IMPACT ABSORBER SECURE STRG TUBE
(STORAGE TUBE OPERATIONS)
TO BLOCK 21
6.8 HRS TOTAL
PRESSURE HIGH 7.8 HRS TOTAL
IF PRESSURE IS TOO HIGH
6A
60 MIN BLOCK 82
VENT PLUG
TUBE UNIT PURGE CART
NOTES
1. SUPERVISOR WILL SPEND 1 TO 2 HOURS PER SHIFT ON OPERATING DECK DURING TRANSFER PROCESS.
2 HP WILL BE IN AREA AND WILL PROVIDE COVERAGE ON AN AS NEEDED BASIS
3 BY MCO/CSB SUB PROJECT. PROVISIONS FOR THIS OPERATION IS NOT IN FLUOR DANIEL SCOPE OF WORK.
4 PROCEDE AFTER MHM OPERATIONS HAS CLEARED THE RAIL FROGS.
5. INTERMEDIATE IMPACT ABSORBERS WILL BE STORED ONLY IN THE FOUR SOUTHERN MOST OVERPACK TUBES. STORAGE IN THE OTHER TWO WILL REQUIRE AN ADDITIONAL ROTATION OF THE RAIL FROGS WHEN RETRIEVING FROM THOSE POSITIONS
6. INTERMEDIATE IMPACT ABSORBERS WILL BE INSTALLED PRIOR TO PLACING THE 2nd MCO IN A STORAGE TUBE THIS WILL PREVENT EXTRA OPERATIONS WHEN MOVING THE 1st MCO FROM THE STORAGE TUBE TO HCA
7. MOVEMENT OF THE 1st MCO FROM THE STORAGE TUBE TO HCA IS NOT FIGURED IN THIS OPERATIONAL SEQUENCE WHEN THIS OPERATION OCCURS IT WILL HAVE AN IMPACT ON THE OPERATING SCHEDULE.
LEGEND
DR = DRIVER
OP = OPERATOR
HP = HEALTH PHYSICIST
MW = MILLWRIGHT
REFERENCE DRAWINGS
NEXT USED ON
X120916A
ENGINEERING RELEASE
28:IBM:ACO2:12:C1:S
U.S.DEPARTMENT OF ENER
WESTINGHOUSE HANFORD COMPANY
TWV-SW-370252
FLUOR DANIEL, INC.
GOVERNMENT SERVICES OPERATING
OPERATIONAL SEQUENCE
TOP LEVEL
BLOCK DIAGRAM
SNF - CANISTER STORAGE BUILDING
W - 379
80460200
CSB
G. HOLT
2-12-97
NONE
E350
NOT RECO
SK-120916
1
3
ACAD



NOTES
1 SEE SHEET ONE FOR GENERAL NOTES AND LEGEND
TRANSPORTER FROM K-BASIN
2A
30 MIN BLOCK 1 BACK TRANSPORTER INTO TRUCK VESTIBULE STABILIZE TRAILER AND REMOVE TRACTOR
1 DR 1 HP 1 OP
2 MIN BLOCK 2 CHECK RAIL FROGS FOR RECEIVING CRANE TRAVEL VISUAL
1 OP
10 MIN BLOCK 3 RETRIEVE YOKE FROM STORAGE RACK AND CONNECT TO CASK RECEIVING CRANE
2 OP
30 MIN BLOCK 4 REMOVE TIE DOWNS RECEIVING CRANE IMPACT WRENCH
2 MW 2 OP 1 HP
30 MIN BLOCK 5 LIFT, MOVE TO AND LOWER TRANSPORT CASK INTO PIT RECEIVING CRANE
2 OP 1 HP
10 MIN BLOCK 6 REMOVE YOKE FROM CASK AND PLACE IN STORAGE RACK RECEIVING CRANE
2 OP
30MIN BLOCK 7 PLACE RECEIVING CRANE IN STAGING AREA RECEIVING CRANE
2 OP 1 HP
30 MIN BLOCK 8 ROTATE RAIL FROGS FOR MHM GANTRY TRAVEL SPECIAL TOOLING
2 OP
2.9 HRS
10 MIN BLOCK 9 PLACE MOBILE CONTAINMENT SERVICE TENT OVER PIT MANUAL
2 OP 1 HP
30 MIN BLOCK 10 PLACE SHIELD HATCH ASSEMBLY AND GANTRY/HOIST IN TENT 5 TON GANTRY/HOIST MOTORIZED GANTRY
2 OP 1 HP
30 MIN BLOCK 11 CONNECT PORTABLE HEPA EXHAUST SYSTEM TO TENT MANUAL
2 OP 1 HP
30 MIN BLOCK 12 SEAL TENT AND AND PULL A NEGATIVE AIR BALANCE HEPA EXHAUST SYSTEM
2 OP 1 HP
10 MIN BLOCK 13 CHECK PRESSURE INSIDE CASK AIR SAMPLER
2 OP 1 HP
60 MIN BLOCK 14 REMOVE CASK LID AND STORE IN DESIGNATED AREA IMPACT WRENCH AND 5 TON GANTRY/HOIST
2 OP 1 HP
5A SHEET 3 7.0 HRS
30 MIN BLOCK 15 PLACE SHIELD HATCH ASSEMBLY OVER PIT 5 TON GANTRY/HOIST
2 OP 1 HP
30 MIN BLOCK 16 DO A RELEASE SURVAY AREA OF TENT MANUAL
2 OP 1 HP
15 MIN BLOCK 17 SHUTDOWN & REMOVE PORTABLE HEPA EXHAUST SYSTEM MANUAL
2 OP
4.1 HRS
1st MCO
2nd MCO
PRIOR TO 2nd MCO STORAGE
4A 6.8 HRS
INTERMEDIATE IMPACT ABSORBER NOT IN PLACE
SHEET 3
10 MIN BLOCK 18 REMOVE 5 TON GANTRY/HOIST FROM PIT AREA 5 TON GANTRY/HOIST MOTORIZED GANTRY
2 OP
30 MIN BLOCK 19 SURVEY AREA REMOVE SERVICE TENT FROM PIT AREA MANUAL
2 OP 1 HP
30 MIN BLOCK 20 RESURVEY AREA MANUAL
2 OP 1 HP
30 MIN BLOCK 21 PLACE MHM OVER PIT SHIELD HATCH-LOWER SEAL AND SHIELDING MHM OPERATIONS
2 OP 1 HP
15 MIN BLOCK 22 REMOVE CENTER SHIELD PLATE FROM SHIELD HATCH ASSY MHM PLUG HOIST
2 OP 1 HP
30 MIN BLOCK 23 RETRIEVE MCO AND POSITION IN MHM CASK MHM MCO GRAPPLE
2 OP 1 HP
15 MIN BLOCK 24 PLACE CENTER SHIELD PLATE BACK INTO SHIELD HATCH ASSY MHM PLUG HOIST
2 OP 1 HP
15 MIN BLOCK 25 INERT LOADED MHM, RAISE MHM NOSE SEAL AND SHIELDING MHM OPERATIONS
1 OP 1 HP
2.9 HRS
15 MIN BLOCK 26 REMOVE SHIELD HATCH ASSEMBLY FROM PIT 5 TON GANTRY/HOIST
2 OP
15 MIN BLOCK 27 SURVEY STATUS CASK / SWIPE
2 OP 1 HP
60 MIN BLOCK 28 ROTATE RAIL FROGS FOR RECEIVING CRANE TRAVEL SPECIAL TOOLING
2 OP
120 MIN BLOCK 29 PREPARE, INSPECT, AND INSERT EMPTY MCO INTO CASK RECEIVING CRANE
2 OP
15 MIN BLOCK 30 INSPECT LID SEALS VISUAL
2 OP
30 MIN BLOCK 31 PLACE AND SECURE CASK LID ON CASK 5 TON GANTRY/HOIST IMPACT WRENCH
2 OP 1 HP
10 MIN BLOCK 32 RETRIEVE YOKE FROM STORAGE RACK AND CONNECT TO CASK RECEIVING CRANE
2 OP
30 MIN BLOCK 33 REMOVE CASK FROM PIT, SURVEY & PLACE ON TRANSPORTER RECEIVING CRANE
2 OP 1 HP
30 MIN BLOCK 34 INSTALL TIE DOWNS AND PLATFORMS RECEIVING CRANE HAND TOOLS
2 OP 1 HP
5.9 HRS
10 MIN BLOCK 35 REMOVE YOKE FROM CASK AND PLACE ON STORAGE RACK RECEIVING CRANE
2 OP
10 MIN BLOCK 36 REMOVE TRANSPORTER FROM TRUCK VESTIBULE
1 DR 1 OP 1 HP
RETURN TO K-BASIN
.3 HRS
16.1 HRS TOTAL
1.0 HRS
3A SHEET 3 3.8 HRS
60 MIN BLOCK 37 PRE-INERT STORAGE TUBE INSTALL INTERFACE RING MHM OPERATIONS
2 OP 1 HP
1st MCO
2nd MCO
3A SHEET 3 3.8 HRS
INCOMING SHIPMENT OF EMPTY MCO
7A
STORAGE OF EMPTY MCO'S NOT YET IDENTIFIED
X1209168
28:IBM:AC02:12.C1:
ENGINEERING RELEASE
REFERENCE DRAWINGS
NEXT USED ON
U.S.DEPARTMENT OF ENER
WESTINGHOUSE HANFORD COMPANY
TWY-SVV-370252
FLUOR DANIEL, INC.
GOVERNMENT SERVICES OPERATING
OPERATING SEQUENCE
MCO SERVICE STATION
BLOCK DIAGRAM
SNF - CANISTER STORAGE BUILDING
W - 379
80460200
G. HOLT
NONE
E350
NOT REQD
SK-120916
2
3
ACAD



NOTES
1 SEE SHEET 1 FOR GENERAL NOTES AND LEGEND
MHM MOVING TO DESIGNATED PRE-INERTED STORAGE TUBE
3A
15 MIN BLOCK 38 INSTALL MHM SEAL RING / PURGE CART CRANE 2 OP 1 HP
30 MIN BLOCK 39 PLACE MHM OVER STORAGE TUBE-LOWER NOSE AND SHIELDING / MHM OPERATIONS 2 OP 1 HP
15 MIN BLOCK 40 REMOVE TUBE PLUG ASSEMBLY / MHM PLUG HOIST 2 OP 1 HP
30 MIN BLOCK 41 TRANSFER MCO TO STORAGE TUBE / MHM MCO GRAPPLE 2 OP 1 HP
15 MIN BLOCK 42 REPLACE TUBE PLUG ASSEMBLY / MHM PLUG HOIST 2 OP 1 HP
10 MIN BLOCK 43 RAISE MHM NOSE AND SHIELDING / MHM OPERATIONS 2 OP 1 HP
30 MIN BLOCK 44 MOVE MHM AWAY FROM STORAGE TUBE / MHM OPERATIONS 2 OP 1 HP
15 MIN BLOCK 45 INSTALL PLUG LOCKS STORAGE TUBE / MANUAL HAND TOOLS 2 OP 1 HP
2.6 HRS
15 MIN BLOCK 46 CHECK TUBE PLUG SEALS / PLUG SEAL TEST UNIT 2 OP 1 HP
15 MIN BLOCK 47 REMOVE INTERFACE RING / PURGE CART CRANE 2 OP 1 HP
10 MIN BLOCK 48 INSTALL TUBE PLUG COVER / PURGE CART CRANE 2 OP 1 HP
30 MIN BLOCK 49 INERT STORAGE TUBE VERIFY MONITORING / PURGE CART LOCAL INSTRUMENTS 2 OP 1 HP
1.2 HRS
3.8 HRS TOTAL
PRIOR TO 2nd MCO BEING PROCESSED AT MCO SERVICE STATION INTERMEDIATE IMPACT ABSORBER NOT IN PLACE
4A
10 MIN BLOCK 50 REMOVE OVERPACK TUBE PLUG COVER PLACE IN STORAGE / PURGE CART CRANE 2 OP
20 MIN BLOCK 51 INSTALL OVRPK SEAL RING AT TUBE WITH INT IMPACT ABSORBERS / PURGE CART CRANE 2 OP
30 MIN BLOCK 52 PLACE MHM OVER OVERPACK TUBE-LOWER NOSE AND SHIELDING / MHM OPERATIONS 2 OP
15 MIN BLOCK 53 REMOVE OVERPACK TUBE SHIELD PLUG / MHM PLUG HOIST 2 OP
30 MIN BLOCK 54 RETRIEVE INTERMEDIATE IMPACT ABSORBER AND POSITION IN MHM / MHM MCO GRAPPLE 1 OP
15 MIN BLOCK 55 REPLACE OVERPACK TUBE SHIELD PLUG / MHM PLUG HOIST 2 OP
10 MIN BLOCK 56 RAISE MHM NOSE SEAL AND SHIELDING / MHM OPERATIONS 2 OP
10 MIN BLOCK 57 MOVE MHM / MHM OPERATIONS 2 OP
2.3 HRS
IF PRESSURE IS TOO HIGH
6A SHEET 1
20 MIN BLOCK 58 REPLACE OVERPACK TUBE PLUG COVER / PURGE CART CRANE 2 OP
10 MIN BLOCK 59 CHECK DESIGNATED STORAGE TUBE PRESSURE / VENT AND PURGE CART 2 OP 1 HP
10 MIN BLOCK 60 REMOVE STORAGE TUBE COVER AND PLACE IN STORAGE / PURGE CART CRANE 2 OP 1 HP
15 MIN BLOCK 61 RETRIEVE SEAL RING AND INSTALL AT STORAGE TUBE / PURGE CART CRANE 2 OP 1 HP
10 MIN BLOCK 62 REMOVE PLUG LOCKS STORAGE TUBE / MANUAL HAND TOOLS 2 OP 1 HP
30 MIN BLOCK 63 PLACE MHM OVER STORAGE TUBE-LOWER NOSE AND SHIELDING / MHM OPERATIONS 2 OP 1 HP
15 MIN BLOCK 64 REMOVE STORAGE TUBE SHIELD PLUG / MHM PLUG HOIST 2 OP 1 HP
30 MIN BLOCK 65 PLACE INTERMEDIATE IMPACT ABSORBER INTO POSITION OVER MCO / MHM MCO GRAPPLE 2 OP 1 HP
2.3 HRS
15 MIN BLOCK 66 REPLACE STORAGE TUBE SHIELD PLUG / MHM PLUG HOIST 2 OP 1 HP
10 MIN BLOCK 67 RAISE MHM NOSE SEAL AND SHIELDING / MHM OPERATIONS 2 OP 1 HP
10 MIN BLOCK 68 MOVE MHM / MHM OPERATIONS 2 OP 1 HP
15 MIN BLOCK 69 INSTALL PLUG LOCKS STORAGE TUBE / MANUAL HAND TOOLS 2 OP 1 HP
15 MIN BLOCK 70 CHECK TUBE PLUG SEALS / PLUG SEAL TEST UNIT 2 OP 1 HP
15 MIN BLOCK 71 REMOVE INTERFACE RING / PURGE CART CRANE 2 OP 1 HP
20 MIN BLOCK 72 INSTALL STORAGE TUBE PLUG COVER / PURGE CART CRANE 2 OP 1 HP
30 MIN BLOCK 73 INERT STORAGE TUBE VERIFY MONITORING / PURGE CART CRANE 2 OP 1 HP
2.2 HRS
GO TO BLOCK 21 SHEET 2
6.8 HRS TOTAL
OPERATIONS IF PRESSURE DETECTED IN SHIPPING CASK
5A
60 MIN BLOCK 74 TAKE SAMPLE OF GAS INSIDE CASK / SPECIAL TOOL 2 OP 1 HP
180 MIN BLOCK 75 COOL DOWN OPERATION THROUGH CASK CAVITY DEPRESSURIZE CASK / SPECIAL TOOL 2 OP 1 HP
30 MIN BLOCK 76 REMOVE CASK LID AND STORE IN DESIGNATED AREA / IMPACT WRENCH AND 5 TON GANTRY/HOIST 2 OP 1 HP
15 MIN BLOCK 77 RETRIEVE AND INSTALL SHIELD RING OVER MCO AND CASK / 5 TON GANTRY/HOIST 2 OP 1 HP
30 MIN BLOCK 78 INSTALL VENTING PACKAGE 2 OP 1 HP
60 MIN BLOCK 79 VENT AND PURGE MCO / VENT AND PURGE STATION 2 OP 1 HP
6.3 HRS
10 MIN BLOCK 80 REMOVE SHIELD RING AND STORE IN DESIGNATED AREA / 5 TON GANTRY/HOIST 1 OP 1 HP
30 MIN BLOCK 81 DECON SURVEY / OPERATIONS 2 OP 1 HP
16.1 HRS
2A SHEET 2
.7 HRS
GO TO BLOCK 15 SHEET 2
7.0 HRS TOTAL
REFERENCE DRAWINGS
NEXT USED ON
X120916C
28:IBM:ACD2:12.C1:5
ENGINEERING RELEASE
U.S.DEPARTMENT OF ENER
WESTINGHOUSE HANFORD COMPANY
TWI-SW-370252
FLUOR DANIEL, INC.
GOVERNMENT SERVICES OPERATING
OPERATING SEQUENCE
MHM OPERATIONS
MCO SERVICE OPER.
BLOCK DIAGRAM
SNF - CANISTER STORAGE BUILDING
W - 379
80460200
C58
G. HOLT
7/14/97
NONE
E350
NOT PEOD
SK-120916
3
3
DISTRIBUTION CODE: 403
ACAD

ATTACHMENT 2

CANISTER STORAGE BUILDING
HAZARD ANALYSIS
TEAM MEMBERS

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ATTACHMENT 2

CANISTER STORAGE BUILDING HAZARD ANALYSIS TEAM MEMBERS

The key members of the Canister Storage Building (CSB) Hazards Analysis 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. Manager over 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.

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.

M. 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.

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.

Larry D. Kessie, AIA

B.S., Architectural Studies and 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, a design office architect, to temporary facility and site infrastructure design authority. Currently 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. One year experience at the Hanford Site performing safety analyses and safety analysis report preparation 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. Currently team lead for accident analysis for the Spent Nuclear Fuel Project Cold Vacuum Drying Facility, CSB, and Hot Conditioning System.

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.

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

- Jeff Parker, Ares Corporation, facilitator for the sessions
- Maurice Higuera, CSB design information
- Richard Hulskamp, multicanister overpack and receiving crane design information.

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ATTACHMENT 3

RELEASE CHARACTERISTICS FOR HAZARDOUS CONDITIONS ASSOCIATED WITH OFFSITE (SITE BOUNDARY) AND ONSITE (COLLOCATED WORKER) RECEPTORS

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Table A3-1. Three-by-Three Likelihood and Consequence Ranking Matrix.

F3	4		
F2	2	5	
F1	1	3	6
	S1	S2	S3

Combinations that identify situations of major concern

Combinations that identify situations of concern

Table A3-2. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors.

Designator	Hazardous energy source	Hazardous condition and initiator(s)	Bin	Release energy	Consequence/ frequency categories
TV-H-06	Pressure, volume - pressure vessels (cask-MCO system)	Gases under high pressure are released because of MCO pressure relief (rupture disk or pressure relief valve); cask is open or leaks.	Pressurized release	High	S2/F2
TV-J-10	Explosives or pyrophorics - uranium and/or plutonium metal, zirconium	Pyrophoric material is exposed to air because of MCO–cask breach or failure to inert.	Exothermic reaction	High	S3/F1
TV-R-01	Natural phenomena - earthquake	Earthquake forces cause the MCO and cask to breach or cause the MCO to breach or relieve pressure with subsequent cask opening.	Pressurized release	Medium	S2/F2
SA-E-07	Rotation kinetic - MHM turret	Rotating MHM turret exerts a shearing force on either • MCO, causing a breach • Lifting cable, causing MCO to impact the service pit with no retrieval capability.	 Fuel exposure MCO drop	 Low Low	 S2/F1 S2/F1
SA-F-05	Linear kinetic - receiving crane	Receiving crane collision with service station enclosure over a service pit containing an MCO causes MCO failure and loss of service station enclosure.	Fuel exposure	Low	S2/F2
SA-F-06	Linear kinetic - pressure vessel (MCO) blowdown	Pressurized gases within the MCO are released because of • High pressure in the MCO • Relief valve failure, rupture disk failure, or improperly closed process port.	 Pressurized release Pressurized release	 High Medium	 S2/F1 S2/F1

Table A3-2. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors.

Designator	Hazardous energy source	Hazardous condition and initiator(s)	Bin	Release energy	Consequence/ frequency categories
SA-F-07	Linear kinetic - MHM lateral movement	MHM collision with service station enclosure over a service pit containing an MCO causes MCO failure and loss of service station enclosure.	Fuel exposure	Low	S2/F2
		MHM movement while raising an MCO causes a shear force on either			
		• MCO, causing a breach	Fuel exposure	Low	S2/F2
		• Lifting cable, causing MCO to impact the service pit with no retrieval capability.	MCO drop	Low	S2/F2
SA-G-01	Mass, gravity, height - human effort	Tools or other items are dropped into the service pit causing either			
		• Failure of the MCO relief valve or rupture disk, resulting in a pressurized release	Pressurized release	Medium	S2/F3
		• A trapped object between the MCO and service pit wall, resulting in galling of the MCO as it is lifted.	Pressurized release	Medium	S2/F3
SA-G-03a	Mass, gravity, height - 5-ton gantry crane	Small parts of the gantry crane fall off into the service pit causing either			
		• Failure of the MCO relief valve or rupture disk, resulting in a pressurized release	Pressurized release	Medium	S2/F3
		• A trapped object between the MCO and service pit wall, resulting in galling of the MCO as it is lifted.	Pressurized release	Medium	S2/F3

Table A3-2. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors.

Designator	Hazardous energy source	Hazardous condition and initiator(s)	Bin	Release energy	Consequence/ frequency categories
SA-G-13	Mass, gravity, height - vessels (transportation cask, MCO)	A release could occur as a result of either			
		• An MCO–cask drop from the receiving crane as it is lowered	MCO drop	Low	S2/F2
		• An MCO drop from the MHM as it is raised.	MCO drop	Low	S2/F2
SA-H-06	Pressure, volume - pressure vessels (MCO and MCO-transportation cask system)	Pressurized gases are released because of			
		• Excessive pressure in an MCO	Pressurized release	High	S2/F2
		• Failure of MCO rupture disk or relief valve due to flaws or damage.	Pressurized release	Medium	S2/F2
SA-J-06	Explosives or pyrophorics - hydrogen	A flammable hydrogen-air mixture is ignited because of relief valve actuation or disk rupture.	Deflagration	High	S3/F1
SA-J-10	Explosives or pyrophorics - plutonium and uranium metal, zirconium	Pyrophoric material is exposed to air by MCO breach or failure to inert the MCO.	Exothermic reaction	High	S3/F1
SA-M-07	Hazardous materials - toxics (plutonium, uranium, beryllium, heavy metals)	Toxic materials are released with pressurized gases because of			
		• Excessive pressure in an MCO	Pressurized release	High	S2/F3
		• Failure of MCO rupture disk or relief valve due to flaws or damage.	Pressurized release	Medium	S2/F3
SA-N-01	Ionizing radiation - fissile material	Fissile material is released because of			
		• Excessive pressure in an MCO	Pressurized release	High	S2/F3
		• Failure of MCO rupture disk or relief valve due to flaws or damage.	Pressurized release	Medium	S2/F3

Table A3-2. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors.

Designator	Hazardous energy source	Hazardous condition and initiator(s)	Bin	Release energy	Consequence/ frequency categories
SA-N-03	Ionizing radiation - radioactive material	Radioactive material is released because of			
		• Excessive pressure in an MCO	Pressurized release	High	S2/F3
		• Failure of MCO rupture disk or relief valve due to flaws or damage.	Pressurized release	Medium	S2/F3
SA-P-01	External events - explosion	MCO pressurizes after transport window is exceeded because of need to evacuate the facility.	Pressurized release	High	S2/F2
SA-P-03	External events - nearby facilities	MCO pressurizes after transport window is exceeded because of need to evacuate the facility.	Pressurized release	High	S2/F1
SA-R-01	Natural phenomena - earthquake (equal to or less than the design basis earthquake)	MCO undergoes pressure relief because of earthquake forces (includes potential loss of power and exceeding available transport window).	Pressurized release	High	S2/F2
SA-R-03	Natural phenomena - lightning	MCO pressurizes after transport window is exceeded because of loss of power.	Pressurized release	High	S2/F2
SA-R-05	Natural phenomena - snow, freezing weather	MCO pressurizes after transport window is exceeded because of delays in transport.	Pressurized release	High	S2/F3
SA-R-08	Natural phenomena - tornado	MCO pressurizes after transport window is exceeded because of delays caused by tornado.	Pressurized release	High	S3/F0*
SA-R-10	Natural phenomena - range fire	MCO pressurizes after transport window is exceeded because of loss of power or facility fire (secondary to range fire) requiring evacuation.	Pressurized release	High	S2/F3
OA-B-07	Thermal - radioactive decay heat and chemical reaction	Hot storage tube gases are released because high temperatures cause failure of the service cart.	Pressurized release	High	S2/F1
OA-D-01	Corrosives - acids (cart battery)	A leaking service cart battery causes the failure of the storage tube seals.	Pressurized release	Low	S2/F1

Table A3-2. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors.

Designator	Hazardous energy source	Hazardous condition and initiator(s)	Bin	Release energy	Consequence/ frequency categories
OA-E-07	Rotational kinetic - MHM turret	Rotation of the MHM turret before the MCO is fully lowered shears either			
		• The MCO itself, causing a breach	Fuel exposure	High	S2/F1
		• The supporting cable, causing an MCO drop.	MCO drop	High	S2/F1
OA-F-07	Linear kinetic - MHM lateral movement	Movement of the MHM before the MCO is fully lowered shears either			
		• The MCO itself, causing a breach	Fuel exposure	High	S2/F2
		• The supporting cable, causing an MCO drop.	MCO drop	High	S2/F2
OA-G-13	Mass, gravity, height - vessels (MCO)	Failure of the MHM supporting cable causes an MCO drop into the storage tube.	MCO drop	High	S2/F2
OA-H-06a	Volume, pressure - pressure vessels (MCO)	Gases under high pressure are released from the MCO because of			
		• High pressure in the MCO	Pressurized release	High	S2/F3
		• Relief valve failure, rupture disk failure, or improperly closed process port.	Pressurized release	Medium	S2/F3
OA-H-06b	Volume, pressure - pressure vessels (storage tube)	Gases under abnormally high pressure are released from the storage tube because of			
		• Excessive vault temperatures and resultant chemical reactions in the MCO	Pressurized release	High	S2/F2
		• MCO relief valve actuation with both tube relief paths closed off.	Pressurized release	High	S2/F2

Table A3-2. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors.

Designator	Hazardous energy source	Hazardous condition and initiator(s)	Bin	Release energy	Consequence/ frequency categories
OA-J-06	Explosives or pyrophorics - hydrogen	A flammable hydrogen mixture is created and a deflagration occurs			
		• Above the operating deck	Deflagration	High	S3/F1
		• Within the vault	Deflagration	High	S3/F1
		• Within the storage tube.	Deflagration	High	S3/F1
OA-J-10	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.	Exothermic reaction	High	S3/F1
OA-L-15	Flammable materials - hydraulic fluid for tube service cart, plug cover hoist	High heat from a fire fails the service cart while it is servicing a storage tube, resulting in releases from the service cart and potentially from the storage tube as well.	Pressurized release	Medium	S2/F2
OA-M-07	Hazardous materials - toxics	Toxic material is carried by gases under high pressure because of			
		• High pressure in the MCO	Pressurized release	High	S2/F3
		• Relief valve failure, rupture disk failure, or improperly closed process port.	Pressurized release	Medium	S2/F3
OA-N-01, 03	Ionizing radiation sources - fissile and radioactive material	Radioactive materials are released because of MCO failure caused by			
		• High pressure in the MCO (rupture disk actuation)	Pressurized release	High	S2/F3
		• Relief valve failure, rupture disk failure, or improperly closed process port.	Pressurized release	Medium	S2/F3
OA-R-01a	Natural phenomena - earthquake	Lateral and horizontal seismic forces cause relief valve actuation on multiple MCOs and increase reaction potential due to increased surface exposure.	Pressurized release	High	S2/F2

Table A3-2. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors.

Designator	Hazardous energy source	Hazardous condition and initiator(s)	Bin	Release energy	Consequence/ frequency categories
OA-R-08	Natural phenomena - tornado	Flying debris fails the storage tube plug, and/or MCO, or service cart while servicing the storage tube.	Pressurized release	High	S3/F0*
VL-B-07, 10	Thermal - radioactive decay heat and chemical reaction	High heat in the vault tubes causes pressurization of the MCOs, runaway chemical reactions, or structural degradation of the vault.	Exothermic reaction	High	S3/F2

*The likelihood of tornado missiles striking safety-class systems has been determined by analysis to be beyond extremely unlikely; therefore, these hazards are not binned as candidate accidents.

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.
MCO = multicanister overpack.
MHM = multicanister overpack handling machine.
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.)

Table A3-3. Binned Listing of Candidate Accidents Sorted by Release Energy and Risk Ranking.

Candidate accident	Release energy	Risk ranking	Reference designator
Pressurized releases			
MCO particulate release within the service pit due to high pressure[a]	High	3 5 7 7 7 5 3 5 7 7	SA-F-06 SA-H-06 SA-M-07 SA-N-01 SA-N-03 SA-P-01 SA-P-03 SA-R-03 SA-R-05 SA-R-10
MCO particulate release within a storage tube due to high pressure	High	7 7 7 7	OA-H-06a OA-M-07 OA-N-01 OA-N-03
MCO pressurization in service pit due to earthquake forces	High	5	SA-R-01
Storage tube pressurized release due to vault temperatures	High	5	OA-H-06b
Storage tube pressurized release due to tube plug failure	High	5	OA-H-06b
Multiple MCO pressurized releases within storage tubes due to earthquake forces[b]	High	5	OA-R-01a
MCO pressurization within transportation cask with leak	High	5	TV-H-06
Service cart failure and pressurized release due to high storage tube temperatures	High	3	OA-B-07
MCO pressurized release within service pit due to MCO failure	Medium	3 7 7 5 7 7 7	SA-F-06 SA-G-01 SA-G-03a SA-H-06 SA-M-07 SA-N-01 SA-N-03

Table A3-3. Binned Listing of Candidate Accidents Sorted by Release Energy and Risk Ranking.

Candidate accident	Release energy	Risk ranking	Reference designator
MCO pressurized release within a storage tube due to MCO failure	Medium	7 7 7 7	OA-H-06a OA-M-07 OA-N-01 OA-N-03
Earthquake-induced failure of MCO (coincident with transportation cask failure or lid removal)	Medium	5	TV-R-01
Storage tube pressurized release due to service cart failure	Medium/Low	3 5	OA-D-01 OA-L-15
Exothermic reactions			
Exothermic reaction in MCO due to excessive vault temperatures[a]	High	8 8	VL-B-07 VL-B-10
Exothermic reaction in MCO due to breach and loss of inert atmosphere	High	6 6 6	TV-J-10 SA-J-10 OA-J-10
Fuel exposure			
Fuel exposure in storage tube due to MHM impact[a]	High	3 5	OA-E-07 OA-F-07
Fuel exposure in service pit due to receiving crane or MHM impact	Low	3 5 5	SA-E-07 SA-F-05 SA-F-07
MCO drops			
MCO drop from MHM into storage tube[a]	High	3 5 5	OA-E-07 OA-F-07 OA-G-13
MCO drop from MHM into service pit	Low	3 5 5	SA-E-07 SA-F-07 SA-G-13
MCO drop from receiving crane	Low	5	SA-G-13

Table A3-3. Binned Listing of Candidate Accidents Sorted by Release Energy and Risk Ranking.

Candidate accident	Release energy	Risk ranking	Reference designator
Deflagrations			
Hydrogen deflagration within the service area[a]	High	6	SA-J-06
Hydrogen deflagration within the operating area (above deck or within storage tube)	High	6	OA-J-06
Hydrogen deflagration within the vault	High	6	OA-J-06

[a]Chosen as a representative and bounding accident for further accident analysis development.
[b]Chosen as a unique hazardous condition.

MCO = multicanister overpack.
MHM = multicanister overpack handling machine.

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