S

ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 659308

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [ ] Direct Revision [x] Change ECN [ ] Temporary [ ] Standby [ ] Supersedure [ ] Cancel/Void [ ]	R. D. Crowe / SNF-NS/R3-26 376-8028	[X] Yes ~~[x] No~~ 7/18/00	7/17/00
	6. Project Title/No./Work Order No. Spent Nuclear Fuel Project	7. Bldg./Sys./Fac. No. W-441	8. Approval Designator S^N, Q
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-SD-SNF-HIE-004, Rev. 4	10. Related ECN No(s). N/A	11. Related PO No. N/A

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

13a. Description of Change 13b. Design Baseline Document? [ ] Yes [x] No

The changes to HNF-SD-SNF-HIE-004 are used as input to the Cold Vacuum Drying Facility Final Safety Analysis Report, HNF-3553, Annex B, Revision 1. The changes reflect evaluation of:

1) USQ-Like CVD-00-0209, change in facility from 4 process bays to 2
2) use of spare bays for decontamination and in activities as an interim location for Cask/MCO storage
3) USQ-Like CVD-00-0208, MCO lift due to Cask overpressure.

USQ: CVD-00-1289 MM 7/18/00

14a. Justification (mark one)

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

14b. Justification Details

See block 13a.

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

Distribution sheet attached.

RELEASE STAMP

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ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1) 659308

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

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

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

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

Document Number/Revision	Document Number/Revision	Document Number Revision
	N/A	

21. Approvals

	Signature	Date	Signature	Date
Cog. Eng. R. D. Crowe	Ralph Crowe 7/17/00			
Cog. Mgr. C. T. Miller	by [signature]	7/27/00		
Safety[N] J. R. Brehm	Jo Ann R Brehm	7/18/00		
QA R. K. Ramsgate	[signature] Ramsgate	7/18/00		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

HNF-SD-SNF-HIE-004
Revision 5

Cold Vacuum Drying Facility Final Hazard Analysis Report

Abstract: This report describes the methodology used in conducting the Cold Vacuum Drying Facility (CVDF) Hazard Analysis to support the CVDF Final Safety Analysis Report 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*."

Key Words: hazard, analysis

HNF-SD-SNF-HIE-004
Revision 5

Cold Vacuum Drying Facility Final Hazard Analysis Report

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

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

Fluor Hanford
P.O. Box 1000
Richland, Washington

HNF-SD-SNF-HIE-004
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Cold Vacuum Drying Facility Final Hazard Analysis Report

Division: SNF

R. D. Crowe
XWest Group, Inc.

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

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

Fluor Hanford
P.O. Box 1000
Richland, Washington

8/7/00
Release Approval Date

RECORD OF REVISION	(1) Document Number HNF-SD-SNF-HIE-004, Rev. 5	Page 1
(2) Title Cold Vacuum Drying Facility Final Hazard Analysis Report		

CHANGE CONTROL RECORD					
(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release			
		(5) Cog. Engr.	Date	(6) Cog. Mgr.	Date
	(7)				
0	**EDT: 607696**				
1	**ECN: 630494** *This hazard analysis has been updated to reflect continuing design progress to date. Revision 1 of this document reflects design information as provided in the Cold Vacuum Drying Facility Safety Analysis Report, Phase II, HNF-SD-SNF-SAR-002, Revision 3.*				
2	**ECN: 637182** *This revision of the hazard analysis has been updated to reflect the elimination of the MCO relief valve during processing. This also reflects information as provided in the Cold Vacuum Drying Facility Safety Analysis Report, Phase II, HNF-SD-SNF-SAR-002, Revision 4.*				
2A	**ECN: 637191** *This revision reflects the changes in the Cold Vacuum Drying Facility Safety Analysis Report, Phase II, HNF-SD-SNF-SAR-002, Revision 4A.*				
3	**ECN: 647505** *This revision reflects the changes in the Cold Vacuum Drying Facility Final Safety Analysis Report, HNF-3553 Annex B, Revision 0.*				
4	**ECN: 656326** *This revision is used as input in the Annex B volume of HNF-3553.*				
5 RS	**ECN: 659308** *This revision reflects evaluation of:* *1) USQ-Like CVD-00-~~020~~, 0202 change in facility from 4 process bays to 2* *2) use of spare bays for decontamination and in activities as an interim location for Cask/MCO storage* *3) USQ-Like CVD-00-0200, MCO lift due to Cask overpressure.*	R. D. Crowe	7/17/00	C. T. Miller	7/18/00

HNF-SD-SNF-HIE-004
Rev.5

COLD VACUUM DRYING FACILITY HAZARD ANALYSIS REPORT

HNF-SD-SNF-HIE-004
Revision 5

July 2000

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LIST OF TERMS

CVDF	Cold Vacuum Drying Facility
DOE	U.S. Department of Energy
FSAR	final safety analysis report
MCO	multi-canister overpack

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COLD VACUUM DRYING FACILITY HAZARD ANALYSIS REPORT

1.0 INTRODUCTION

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

The hazard analysis process identified hazardous conditions and material at risk, determined causes for potential accidents, identified preventive and mitigative features, and qualitatively estimated the frequencies and consequences of specific occurrences. The hazard analysis was performed by a team of cognizant CVDF operations and design personnel, safety analysts familiar with the CVDF, and technical experts in specialty areas. Attachment A lists the members of the hazard analysis team and describes the background and experience of each.

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

2.0 SCOPE OF THE HAZARD ANALYSIS

The hazard analysis documented in this report, conducted to support the CVDF FSAR, covered normal, intended, CVDF operations to remove free water from the multi-canister overpacks (MCOs) containing spent nuclear fuel. The hazard analysis process, described in Chapter 3.0, examined:

- Routine activities to maintain the facility and to prepare for processing operations
- Receiving the trailer containing the cask–MCO, moving it into one of the facility's process bays, positioning and securing the trailer, and finalizing bay preparations for processing (processing operations are not planned in the spare bays)

- Operations involved with venting the cask-MCO, removing the cask lid, preparing the MCO for processing, installing process equipment, and establishing process connections to the MCO
  - Process hood/seal ring
  - MCO process port connectors
  - Tempered water system
- Verification and testing of equipment and connections prior to processing
- Monitoring and controlling process operations utilizing the monitoring and control system and the safety-class instrumentation and control system during the following processing modes
  - Heatup Mode
  - Drain Mode
  - Purge/Flush Mode
  - Drying Mode
  - Proof Mode
  - Pressure Test Mode
- Establishing MCO conditions for shipping, MCO port valve leak-testing, removing the process connections, reinstalling the process port covers, draining and drying the cask, and reinstalling the cask lid
- Preparing the trailer and bay for shipping, connecting the trailer to the transporter, and releasing the cask–MCO for shipment to the Canister Storage Building.

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

- HNF-3553, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex B, "Cold Vacuum Drying Facility Final Safety Analysis Report"
  - Chapters B2.0 and B4.0 for facility design and operations information
  - Chapter B3.0 for the facility radioactive materials inventory
  - Chapter B6.0 for evaluating the potential for hazards from nuclear criticality
- SNF-4268, *Fire Hazard Analysis for the Cold Vacuum Drying Facility*
- HNF-SD-TP-SARP-017, *Safety Analysis Report for Packaging, Onsite, Multi-Canister Overpack Cask*, for coverage of accidents involving the transporter and transportation cask and for definition of assumptions inherent in defining the transportation window
- HNF-SD-SNF-SARR-005, *Multi-Canister Overpack Topical Report*, for criteria and assumptions related to the MCO design

- The latest available process information as presented in SNF-2356, *Spent Nuclear Fuel Project Cold Vacuum Drying Facility Operations Manual*
- Representatives from the design authority and from facility operations for details of design, operating modes, and procedures.

3.0 HAZARD ANALYSIS METHODOLOGY

This section presents the methodology used to perform the CVDF hazard analysis for normal operations. The hazard identification process systematically and comprehensively identified hazards that can contribute to the uncontrolled release of radioactive or hazardous materials or that can threaten the safety of facility workers. In addition to DOE Order 5480.23 and DOE-STD-3009-94, guidance provided in HNF-PRO-704, *Hazard and Accident Analysis Process*, and *Guidelines for Hazard Evaluation Procedures* (AIChE 1985), was used to develop the hazard analysis process. Specifically, the analysis followed the American Institute of Chemical Engineers preliminary hazard analysis method, and included elements of the process/systems checklists and "what-if" analysis methods.

3.1 HAZARD IDENTIFICATION

The hazard analysis included identification of the hazards associated with CVDF design and operations based on descriptions provided in Chapters B2.0 and B4.0 of the CVDF FSAR (HNF-3553, Annex B) on an operational flow diagram, an operating sequence contained in the operations manual, and the other referenced material (see Section 4.0). The hazard analysis team included design authorities, operations personnel and hazard and accident analysts. The team met in facilitated sessions and communicated informally throughout the process. The team defined hazards as radioactive or hazardous materials (material at risk), system or process characteristics, or energy sources that represent a potential for an accident that could have an adverse effect on facility workers, the CVDF, the environment, or the public. Table 1 summarizes the material at risk for the CVDF in terms of type, form, and quantity.

A standardized checklist, Table 2, was used to identify potentially hazardous materials and energy sources present in each of the following six facility areas:

- Administrative area (AA)
- Transfer corridor and mechanical corridor (TC)
- Process bays 4 and 5 (PB)
- Spare bays 1, 2, and 3 (SB)
- Process water room (PW)
- Outside (OU).

Figure 1 provides a simplified drawing of the CVDF.

Tables 3 through 8 show the hazard identification results for each area. Each identified hazard was assigned a unique designator to allow for tracking. The hazard identification checklists were developed by a subgroup of the hazard analysis team and reviewed and accepted by the entire team.

3.2 HAZARD EVALUATION

The hazard evaluation was a structured and systematic examination of the CVDF and its operations using standard industry (American Institute of Chemical Engineers) hazard evaluation techniques. The first step in the hazard evaluation, once the hazards had been identified, was to screen the potentially hazardous materials and energy sources for those that presented only standard industrial hazards. These hazards are defined in DOE-STD-3009-94 as those that "are routinely encountered in general industry and construction, and for which national consensus codes and/or standards (e.g., Occupational Safety and Health Administration, transportation safety) exist to guide safe design and operation without the need for special analysis to define safe design and/or operational parameters." Tables 9 through 14 list, by facility area, the standard industrial hazards that do not contribute to the uncontrolled release of radioactive or hazardous material. The standard industrial hazards listed are controlled through the implementation of institutional safety programs as described in the programmatic sections of the CVDF FSAR (HNF-3553, Annex B). The hazard analysis team agreed by consensus to the results of the screening for standard industrial hazard items.

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

The completed hazard analysis worksheets, included in this report in Attachment 2 as Table A2-1, show the results of the hazard evaluation as compiled by the hazard analysis team. The evaluation results are based on the hazard identification results, material-at-risk summaries, reviews of the systems designs and planned operations, existing safety documentation, and the experience of hazard analysis team members. Each column of the hazard analysis tables is explained below to aid in understanding the information contained therein.

Location/checklist entry. This column contains each hazard's unique identifier, which indicates the facility area, the hazard checklist category, and the specific hazard. For example, a designator of TV-F-01 would represent the truck vestibule (TV), a linear kinetic hazard (F) from a car, truck, or bus (01). If a single hazard could result in more than one consequence, a lowercase letter is appended to the identifier (e.g., TV-F-01a, TV-F-01b).

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

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

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

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

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

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

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

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

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

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

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

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

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

S3 On the basis of material at risk and causes postulated, there is sufficient material and release energy to affect a receptor at the nearest point of uncontrolled public access.

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

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

S0 On the basis of material at risk and causes postulated, there is insufficient material released to affect facility workers.

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

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

3.3 CANDIDATE ACCIDENT SELECTION

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

The team used the four-step process described below to identify specific hazardous conditions that, together, represented the "complete set of bounding conditions" requiring further analysis. In summary, the process involved creating representative sets (or "bins") of hazardous conditions having similar release characteristics, similar initiators, and/or similar controls, and identifying (using the Attachment A, Figure A3-1 ranking matrix) the hazardous condition that represented the most severe consequences and the highest risk in each bin. The highest ranking hazardous condition in each bin bounded the other hazardous conditions in the bin and, therefore, lead to candidate accidents needing further analysis. These hazardous conditions and candidate accidents represent the "complete set of bounding conditions" for the CVDF accident analysis.

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

1. Initial screening

2. Assignment of release attributes

3. Creation of hazardous material release bins

4. Selection of representative bounding hazardous conditions for each release attribute category.

To capture and record the relational nature of the data developed in the four steps, the results have been organized into two tables, Table A3-1 in Attachment A and Table A4-1 in Attachment B. The following sections describe each step, and identify where in Table A3-1 and Table A4-1 the related information is located.

Initial Screening. All hazardous conditions with a frequency of F1 (extremely unlikely) or greater and unmitigated consequences assessed as S3 (offsite consequences) or S2 (collocated worker consequences) were chosen for consideration as representative accidents. These hazardous conditions are listed in Table A3-1, with their frequency and consequence rankings listed under the column entitled "Frequency/consequence codes." There were no hazardous conditions assessed as S1 (facility worker consequences) involving radiological hazards requiring detailed accident analysis. The S1 hazardous conditions are addressed qualitatively in the CVDF FSAR (HNF-3553, Annex B). Hazard conditions having no consequences (S0) were dropped from consideration.

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

- Hazardous source (Attachment A, Table A3-1)
- Hazardous conditions and initiators (Attachment A, Table A3-1).

Creation of Hazardous Material Release Bins. As the hazardous material release attributes were identified, each hazardous condition was assigned to a bin category. Assignment to a bin category was based upon the potential accident release characteristics, initiators, and/or proposed mitigative or preventative controls. Table A3-1 in Attachment 3 lists the bin category assignment for each hazardous condition under the "Bin" column heading. The final step in creating the release attribute bins was to assemble hazardous conditions having the same bin category into a listing. This listing is the basis for Table A4-1, in which the hazardous conditions are grouped into their bin categories under the "Candidate accident" column.

Selection of Representative Bounding Hazardous Conditions for each Release Attribute Category. Within each bin category, the most severe hazardous condition, considering consequences, and the highest risk accident were identified using the three-by-three likelihood and consequence ranking matrix described in DOE-STD-3009-94 (see Attachment A, Figure A3-1). In Table A4-1 of Attachment 4, the bin category hazardous conditions are listed in descending order with the highest ranking hazardous condition at the top. In each accident bin, more than one condition may have been required to provide the necessary bounding conditions for a bin. Table A4-1 identifies the bounding condition, or when necessary, bounding conditions for each bin.

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

3.4 HAZARD ANALYSIS SUMMARY

The final list of candidate accidents includes all hazardous conditions with a frequency of F1 (extremely unlikely) or greater and whose unmitigated consequences were assessed as S3 (offsite consequences) or S2 (collocated worker consequences). Attachment 4, Table A4-1 provides the final list of candidate accidents. The table also identifies the hazardous condition, or conditions, chosen as representative and bounding of all other conditions listed in the bin.

4.0 REFERENCES

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

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

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SNF-4942, 1999, *Spent Nuclear Fuel Cold Vacuum Drying Facility Implementation Plan for Fire Hazard Analysis Suggested Actions*, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.

Figure 1. Main Areas of the Cold Vacuum Drying Facility.

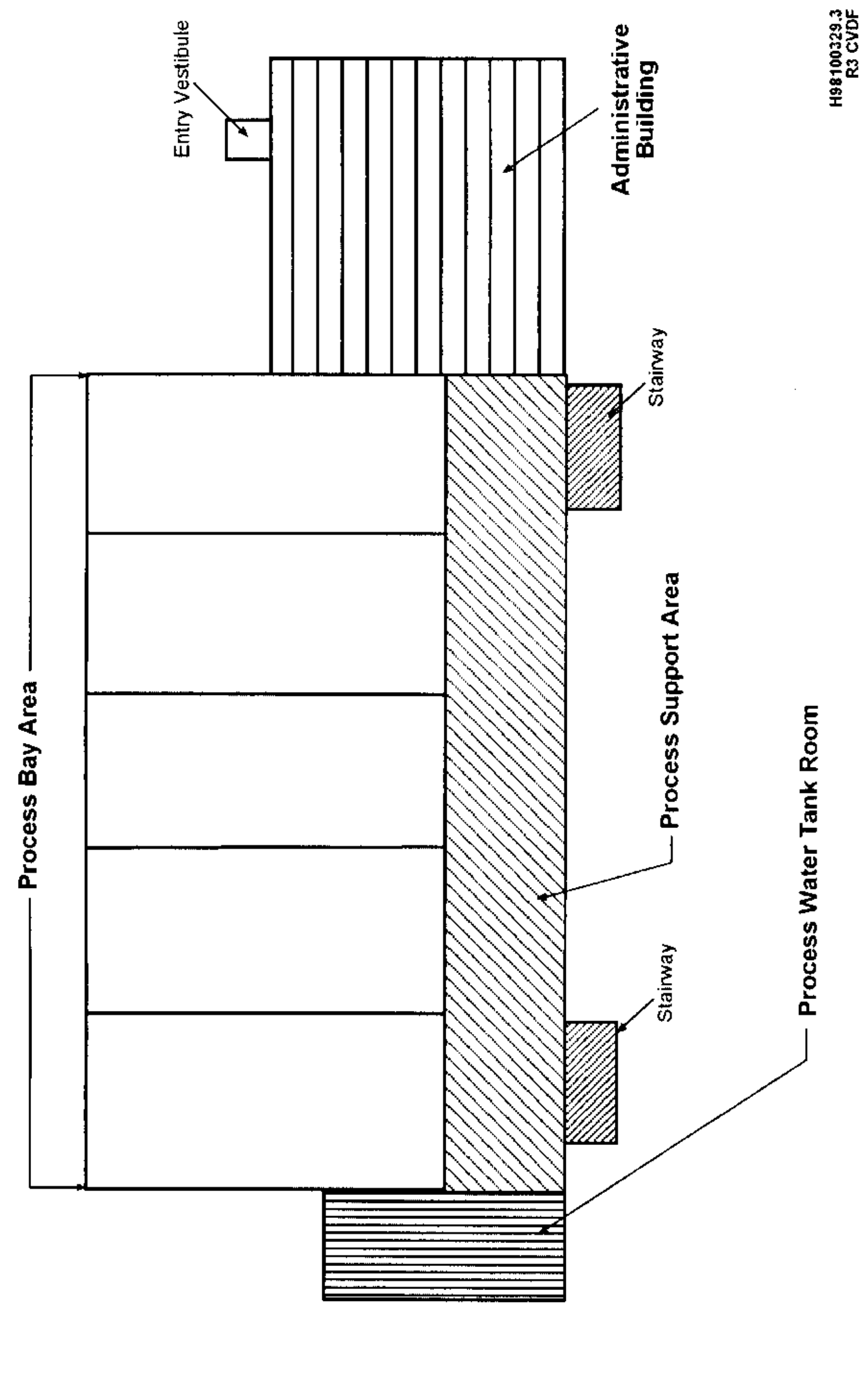

Table 1. Cold Vacuum Drying Facility Material at Risk (Type, Form, and Quantity). (2 sheets)

Field name or location	MAR-subject	MAR-description	MAR-classification	Capacity	Material type	Physical form	Volume or activity	Transient	Quantity	Comments
Process bay	MCO in cask	SNF and particulate matter in MCO (including contaminated water)	SNF in MCO	1,000 L per MCO; consisting of five to six baskets, SNF, water MCO estimated to contain 25 kg of particulate matter after cold vacuum drying and shipping to CSB (upper bound)	Spent fuel from N Reactor (upper bound)	Solid consisting of fuel and particulate corrosion products	6.8 MTU at 26,200 Ci/MTU	Yes, particulate is transient	Upper bound mass is 6.8 MTU per MCO	
		Hydrogen gas	Combustible gas	Approximately 1 m^3 of hydrogen gas per MCO generated over entire CVDF process at pressures from less than 12 torr to 4 lb/in^2 gauge (nominal)	Hydrogen gas	Gas	Approximately 1 m^3 of hydrogen gas per MCO	Yes	Approximately 1 m^3 hydrogen gas per MCO	
	Truck fuel tank	Diesel fuel	Diesel fuel	80 gal	Fuel	Liquid	~80 gal	Yes	Two tanks per truck	
	Other vehicles	Gasoline or propane fuel	Vehicle fuel	In accordance with fire hazard analysis limits	Fuel	Liquid or gas	In accordance with fire hazard analysis limits	Yes	In accordance with fire hazard analysis limits	
	SCHe system	Helium gas cylinders	Helium	~240 ft^3 per cylinder 4 cylinders	Helium	Gas	~960 ft^3 total ~2,400 lb/in^2 gauge per cylinder	No		
Spare bay	Truck fuel tank	Diesel fuel	Diesel fuel	80 gal	Fuel	Liquid	~80 gal	Yes	Two tanks per truck	
	Other vehicles	Gasoline or propane fuel	Vehicle fuel	In accordance with fire hazard analysis limits	Fuel	Liquid or gas	In accordance with fire hazard analysis limits	Yes	In accordance with fire hazard analysis limits	
	Tanker truck residual contamination	Residual contaminated liquid in tanker truck heel	Radioactive particulate matter	A few gallons of low-level contaminated liquid in heel; bounded by safety basis of 1.5 kg	Low-level waste	Dissolved and/or suspended solids	–	Yes	Varies with heel volume; upper bound is 1.5 kg	
	MCO in cask (temporary staging)	SNF and particulate matter in MCO (including contaminated water)	SNF in MCO	1,000 L per MCO; consisting of five to six baskets, SNF, water MCO estimated to contain 25 kg of particulate matter after cold vacuum drying and shipping to CSB (upper bound)	Spent fuel from N Reactor (upper bound)	Solid consisting of fuel and particulate corrosion products	6.8 MTU at 26,200 Ci/MTU	Yes, particulate is transient	Upper bound mass is 6.8 MTU per MCO	
		Hydrogen gas	Combustible gas	Approximately 200 L of hydrogen per cask–MCO	Hydrogen gas	Gas	Approximately 200 L of hydrogen gas per cask–MCO	Yes	Approximately 200 L of hydrogen gas per cask–MCO	
Transfer corridor/ mechanical equipment room	Particulate on HVAC filters (general and local)	Finely divided radioactive particulate from MCOs	Radioactive particulate matter	No more than 94 g	NA	Solid	Up to 94 g	Yes, particulate is transient	94 g	

Table 1. Cold Vacuum Drying Facility Material at Risk (Type, Form, and Quantity). (2 sheets)

Field name or location	MAR-subject	MAR-description	MAR-classification	Capacity	Material type	Physical form	Volume or activity	Transient	Quantity	Comments
Process water conditioning room	Process water conditioning system components and piping	SNF and particulate drained from MCO	Radioactive particulate matter	Safety basis (bounding) of no more than 1.5 kg	Spent fuel from N Reactor	Solid consisting of particulate corrosion products	0.0015 MTU at 26,200 Ci/MTU	Yes, particulate is transient	Upper bound is 1.5 kg	
Outside area	Inert gas storage	Helium used to inert MCOs and overpack storage tubes	Helium	~185,000 ft^3 in storage tubes on trailer	Helium	Gas	~185,000 ft^3 (at standard temperature and pressure) ~1,800 lb/in^2 gauge to 3,500 lb/in^2 gauge	No		
	Standby power diesel supply	Diesel fuel	Diesel fuel	550 gal	Fuel	Liquid	550 gal	No	Day tank and supply tank	

CSB = Canister Storage Building.
CVDF =Cold Vacuum Drying Facility.
HVAC = heating, ventilation, and air conditioning (filter).
IXM = ion exchange module.
MAR = material at risk.
MCO = multi-canister overpack.
MTU = metric ton of uranium.
NA = not applicable.
SNF = spent nuclear fuel.

Table 2. 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. 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. Vacuum
- ☐ ☐ 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

Table 3. Hazardous Material/Energy Source Checklist: Administrative Area (AA).

Location: *Administrative Area, Cold Vacuum Drying Facility*

Y	N	A. **Electrical**
■	□	1. Battery banks (UPS)
■	□	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. Decon solution
□	■	5. High temperature waste
□	■	6. Other ________

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

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

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 (portal monitor)
■	□	6. Pressure vessels
□	■	7. Stressed members
□	■	8. Gas receivers
□	■	9. Vacuum
□	■	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 (batteries)
□	■	7. Gases, others
□	■	8. Nitrates
□	■	9. Peroxides
□	■	10. Pu and U metal
□	■	11. Sodium
□	■	12. Other ________

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

Y	N	L. **Flammable Materials**
■	□	1. Packing materials
■	□	2. Rags
□	■	3. Gasoline
□	■	4. Lube oil
□	■	5. Coolant oil
■	□	6. Paint solvent
□	■	7. Diesel fuel
■	□	8. Buildings & contents
□	■	9. Trailers & contents
□	■	10. Grease
■	□	11. Hydrogen (batteries)
□	■	12. Nitric acid
□	■	13. Organics
□	■	14. Gases - others
□	■	15. Liquids - others
■	□	16. Other (aerosol propellent)

Y	N	M. **Hazardous Materials**
■	□	1. Alkali metals
■	□	2. Asphyxiants
□	■	3. Biologicals
□	■	4. Carcinogens
■	□	5. Corrosives
■	□	6. Oxidizers
■	□	7. Toxics
■	□	8. Heavy metals (mercury in relays)
□	■	9. Other ________

Y	N	N. **Ionizing Radiation Sources**
□	■	1. Fissile material
□	■	2. Radiography equipment
□	■	3. Radioactive material
■	□	4. Radioactive sources (sealed 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

Table 4. Hazardous Material/Energy Source Checklist: Transfer Corridor and Mechanical Corridor (TC).

Location: *Transfer Corridor and Mechanical Corridor, Cold Vacuum Drying Facility*

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. Decon solution
□	■	5. High temperature waste
□	■	6. Other ________

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

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

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 (air compressor)
□	■	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. Vacuum
□	■	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
□	■	12. Other ________

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

Y	N	L. Flammable Materials
■	□	1. Packing materials
■	□	2. Rags
■	□	3. Gasoline
■	□	4. Lube oil
■	□	5. Coolant oil
■	□	6. Paint solvent
□	■	7. Diesel fuel
■	□	8. Buildings & contents
□	■	9. Trailers & contents
■	□	10. Grease
■	□	11. Hydrogen
□	■	12. Nitric acid
■	□	13. Organics
■	□	14. Gases - others
■	□	15. Liquids - others
■	□	16. Other (aerosol propellent)

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

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

Table 5. Hazardous Material/Energy Source Checklist: Process Bays 4 and 5 (PB).

Location: *Process Bays 4 and 5, Cold Vacuum Drying Facility*

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 (MCO contents)

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

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

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

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

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 (elevated platform)

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. Vacuum
□	■	10. Steam headers and lines
■	□	11. Other (pressurized liquid/gas lines, truck tires, air ride suspension, air brakes)

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

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

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 & contents
■	□	10. Grease
■	□	11. Hydrogen
□	■	12. Nitric acid
■	□	13. Organics
■	□	14. Gases - others (acetylene torch, propane)
■	□	15. Liquids - others (alcohol)
■	□	16. Other (aerosol propellent)

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

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

Table 6. Hazardous Material/Energy Source Checklist: Spare Bays 1, 2, and 3 (SB).

Location: *Spare Bays 1, 2, and 3, Cold Vacuum Drying Facility*

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 (vehicle brakes)

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

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

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

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. Vacuum
□	■	10. Steam headers and lines
■	□	11. Other (truck tires, air ride suspension, air brakes)

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

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

Y	N	L. **Flammable Materials**
■	□	1. Packing materials
■	□	2. Rags
■	□	3. Gasoline
■	□	4. Lube oil
■	□	5. Coolant oil
■	□	6. Paint solvent
■	□	7. Diesel fuel
■	□	8. Buildings & contents
□	■	9. Trailers & contents
■	□	10. Grease
■	□	11. Hydrogen
□	■	12. Nitric acid
■	□	13. Organics
■	□	14. Gases - others
■	□	15. Liquids - others
■	□	16. Other (aerosol propellent)

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

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

Table 7. Hazardous Material/Energy Source Checklist: Process Water Room (PW).

Location: *Process Water Room, Cold Vacuum Drying Facility*

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. Decon solution
□	■	5. High temperature waste
□	■	6. Other ________

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

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

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 (roof hatch)

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. Vacuum
□	■	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
■	□	12. Other (uranium hydride)

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

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 & contents
■	□	10. Grease
■	□	11. Hydrogen
□	■	12. Nitric acid
■	□	13. Organics
■	□	14. Gases - others
□	■	15. Liquids - others
■	□	16. Other (aerosol propellent)

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

Table 8. Hazardous Material/Energy Source Checklist: Outside (OU).

Location: *Outside, Cold Vacuum Drying Facility*

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 (vehicle brakes)

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

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

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

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 (roof)

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. Vacuum
□	■	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
□	■	12. Other ________

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

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 & contents
■	□	10. Grease
■	□	11. Hydrogen
□	■	12. Nitric acid
■	□	13. Organics
■	□	14. Gases - others
■	□	15. Liquids - others
■	□	16. Other (aerosol propellent)

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
■	□	4. Loss of external power

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

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

Table 9. Standard Industrial Hazards: Administrative Area. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Electrical	Battery banks (uninterruptible power supply)	AA-A-01
	Cable runs	AA-A-02
	Electrical equipment	AA-A-04
	Motors	AA-A-07
	Power tools	AA-A-09
	Switchgear	AA-A-10
	Wiring	AA-A-15
Thermal	Bunsen burner/hot plates	AA-B-01
	Furnaces/boilers/heater	AA-B-03
	Power tools	AA-B-09
Friction	Fans	AA-C-03
	Power tools	AA-C-06
Corrosives	Acids	AA-D-01
	Caustics	AA-D-02
	Natural chemicals	AA-D-03
Kinetic - rotational	Motors	AA-E-02
	Shop equipment	AA-E-06
Kinetic - linear	Forklifts, dollies, carts	AA-F-02
Mass, gravity, height	Bucket and ladder	AA-G-04
	Jacks	AA-G-09
	Scaffold and ladders	AA-G-10
	Vessels	AA-G-13
Pressure - volume	Gas bottles (portal monitor)	AA-H-05
	Pressure vessels	AA-H-06
Explosives/pyrophorics	Scrub chemicals	AA-J-04
Hazardous materials	Alkali metals	AA-M-01
	Asphyxiants	AA-M-02
	Corrosives	AA-M-05
	Oxidizers	AA-M-06
	Toxics	AA-M-07
	Heavy metals (mercury in relays)	AA-M-08

Table 9. Standard Industrial Hazards: Administrative Area. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Ionizing radiation sources	Radioactive sources (sealed sources)	AA-N-04

*Hazard checklist identification numbers XX-Y-## represent a specific line item on a hazardous material/energy source checklist (see Table 2) where:

XX = facility area.
Y = hazard type.
= checklist designator.

Table 10. Standard Industrial Hazards: Transfer Corridor and Mechanical Corridor. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Electrical	Cable runs	TC-A-02
	Electrical equipment	TC-A-04
	HVAC heaters	TC-A-05
	High voltage	TC-A-06
	Motors	TC-A-07
	Power tools	TC-A-09
	Switchgear	TC-A-10
	Service outlets, fittings	TC-A-11
	Transformers	TC-A-12
	Wiring	TC-A-15
Thermal	Electrical equipment	TC-B-02
	Furnaces/boilers/heater	TC-B-03
	Power tools	TC-B-09
Friction	Belts	TC-C-01
	Bearings	TC-C-02
	Fans	TC-C-03
	Gears	TC-C-04
	Motors	TC-C-05
	Power tools	TC-C-06
Corrosives	Acids	TC-D-01
	Caustics	TC-D-02
	Decon solution	TC-D-04
Kinetic - rotational	Motors	TC-E-02
	Shop equipment	TC-E-06
Mass, gravity, height	Human effort	TC-G-01
	Stairs	TC-G-02
	Bucket and ladder	TC-G-04
	Slings	TC-G-06
	Hoists	TC-G-07
	Jacks	TC-G-09
	Scaffold and ladders	TC-G-10
	Elevated doors	TC-G-12
	Vessels (air compressor)	TC-G-13

Table 10. Standard Industrial Hazards: Transfer Corridor and Mechanical Corridor. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Pressure - volume	Gas bottles	TC-H-05
	Pressure vessels	TC-H-06
Explosives/pyrophorics	Scrub chemicals	TC-J-04
	Hydrogen	TC-J-06
	Gases, others	TC-J-07
Flammable Materials	Grease	TC-L-10
	Gasoline	TC-L-03
	Organics	TC-L-13
Hazardous materials	Asphyxiants	TC-M-02
	Biologicals	TC-M-03
	Carcinogens	TC-M-04
	Corrosives	TC-M-05
	Oxidizers	TC-M-06
	Toxics	TC-M-07
	Heavy metals	TC-M-08
Ionizing radiation sources	Radiography equipment	TC-N-02
	Radioactive sources	TC-N-04
Vehicles in motion (external to facility)	Train	TC-Q-03

*Hazard checklist identification numbers XX-Y-## represent a specific line item on a hazardous material/energy source checklist (see Table 2) where:

XX = facility area.
Y = hazard type.
= checklist designator.

Table 11. Standard Industrial Hazards: Process Bays. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Electrical	Cable runs	PB-A-02
	HVAC heaters	PB-A-05
	High voltage	PB-A-06
	Motors	PB-A-07
	Pumps	PB-A-08
	Power tools	PB-A-09
	Switchgear	PB-A-10
	Service outlets, fittings	PB-A-11
	Transformers	PB-A-12
	Wiring	PB-A-15
Thermal	Welding torch/arc	PB-B-05
	Radioactive decay heat	PB-B-07
	Exposed components	PB-B-08
	Power tools	PB-B-09
	Convective	PB-B-10
Friction	Belts	PB-C-01
	Bearings	PB-C-02
	Fans	PB-C-03
	Gears	PB-C-04
	Motors	PB-C-05
	Power tools	PB-C-06
	Other (vehicle brakes)	PB-C-07
Corrosives	Acids	PB-D-01
	Caustics	PB-D-02
	Decon solution	PB-D-04
Kinetic - rotational	Motors	PB-E-02
	Pumps	PB-E-03
	Fans	PB-E-04
	Shop equipment	PB-E-06
Kinetic - linear	Obstructions	PB-F-04
	Pressure Vessel Blowdown	PB-F-06

Table 11. Standard Industrial Hazards: Process Bays. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Mass, gravity, height	Human effort	PB-G-01
	Stairs	PB-G-02
	Lifts and cranes	PB-G-03
	Bucket and ladder	PB-G-04
	Trucks	PB-G-05
	Slings	PB-G-06
	Hoists	PB-G-07
	Jacks	PB-G-09
	Scaffold and ladders	PB-G-10
	Elevated doors	PB-G-12
	Other (elevated platform)	PB-G-14
Pressure - volume	Surge tanks	PB-H-02
	Gas bottles	PB-H-05
	Gas receivers	PB-H-08
	Vacuum	PB-H-09
Explosives/pyrophorics	Scrub chemicals	PB-J-04
Nuclear criticality	Shipping and receiving area	PB-K-03
	Trucks, forklifts, dollies	PB-K-10
Hazardous materials	Asphyxiants	PB-M-02
	Biologicals	PB-M-03
	Carcinogens	PB-M-04
	Corrosives	PB-M-05
	Oxidizers	PB-M-06
	Toxics	PB-M-07
	Heavy metals	PB-M-08
Ionizing radiation sources	Radiography equipment	PB-N-02
	Radioactive sources	PB-N-04
External events	Fire	PB-P-02

*Hazard checklist identification numbers XX-Y-## represent a specific line item on a hazardous material/energy source checklist (see Table 2) where:
XX = facility area.
Y = hazard type.
= checklist designator.

Table 12. Standard Industrial Hazards: Spare Bays. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Electrical	Cable runs	SB-A-02
	Electrical equipment	SB-A-04
	Motors	SB-A-07
	Pumps	SB-A-08
	Power tools	SB-A-09
	Service outlets, fittings	SB-A-11
	Wiring	SB-A-15
Thermal	Electrical equipment	SB-B-02
	Welding torch/arc	SB-B-05
	Power tools	SB-B-09
Friction	Bearings	SB-C-02
	Gears	SB-C-04
	Motors	SB-C-05
	Power tools	SB-C-06
	Other (vehicle brakes)	SB-C-07
Corrosives	Acids	SB-D-01
	Caustics	SB-D-02
	Natural chemicals	SB-D-03
	Decon solution	SB-D-04
Kinetic - rotational	Motors	SB-E-02
	Pumps	SB-E-03
	Shop equipment	SB-E-06
Kinetic - linear	Obstruction	SB-F-04
	Crane loads	SB-F-05
Mass, gravity, height	Human effort	SB-G-01
	Lifts and cranes	SB-G-03
	Bucket and ladder	SB-G-04
	Trucks	SB-G-05
	Slings	SB-G-06
	Hoists	SB-G-07
	Jacks	SB-G-09
	Scaffold and ladders	SB-G-10
	Elevated doors	SB-G-12

Table 12. Standard Industrial Hazards: Spare Bays. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Pressure - volume	Gas bottles	SB-H-05
Explosives/pyrophorics	Scrub chemicals	SB-J-04
	Hydrogen	SB-J-06
Flammable materials	Grease	SB-L-10
	Organics	SB-L-13
Hazardous materials	Asphyxiants	SB-M-02
	Biologicals	SB-M-03
	Carcinogens	SB-M-04
	Corrosives	SB-M-05
	Oxidizers	SB-M-06
	Toxics	SB-M-07
	Heavy metals	SB-M-08
Ionizing radiation sources	Radiography equipment	SB-N-02
	Radioactive sources	SB-N-04
Vehicles in motion (external to facility)	Train	SB-Q-03

*Hazard checklist identification numbers XX-Y-## represent a specific line item on a hazardous material/energy source checklist (see Table 2) where:

XX = facility area.
Y = hazard type.
= checklist designator.

Table 13. Standard Industrial Hazards: Process Water Room. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Electrical	Cable runs	PW-A-02
	Electrical equipment	PW-A-04
	High voltage	PW-A-06
	Motors	PW-A-07
	Pumps	PW-A-08
	Power tools	PW-A-09
	Switchgear	PW-A-10
	Service outlets, fittings	PW-A-11
	Transformers	PW-A-12
	Wiring	PW-A-15
Thermal	Electrical equipment	PW-B-02
	Welding torch/arc	PW-B-05
	Radioactive decay heat	PW-B-07
	Power tools	PW-B-09
	Solar	PW-B-11
Friction	Bearings	PW-C-02
	Motors	PW-C-05
	Power tools	PW-C-06
Corrosives	Acids	PW-D-01
	Caustics	PW-D-02
	Decon solution	PW-D-04
Kinetic - rotational	Motors	PW-E-02
	Pumps	PW-E-03
	Shop equipment	PW-E-06
Kinetic - linear	Forklifts, dollies, carts	PW-F-02
	Crane loads	PW-F-05
	Pressure vessel blowdown	PW-F-06
Mass, gravity, height	Human effort	PW-G-01
	Stairs	PW-G-02
	Bucket and ladder	PW-G-04
	Slings	PW-G-06
	Hoists	PW-G-07
	Jacks	PW-G-09

Table 13. Standard Industrial Hazards: Process Water Room. (2 sheets)

Hazard category	Hazard type	Hazard checklist identification number*
Mass, gravity, height (cont.)	Scaffold and ladders	PW-G-10
	Vessels	PW-G-13
	Other (roof hatch)	PW-G-14
Pressure - volume	Test loops	PW-H-04
	Gas bottles	PW-H-05
	Pressure vessels	PW-H-06
Explosives/pyrophorics	Scrub chemicals	PW-J-04
	Gases, other	PW-J-07
Flammable materials	Packing materials	PW-L-01
	Gasoline	PW-L-03
	Lube oil	PW-L-04
	Coolant oil	PW-L-05
	Paint solvent	PW-L-06
	Grease	PW-L-10
	Organics	PW-L-13
Hazardous materials	Asphyxiants	PW-M-02
	Biologicals	PW-M-03
	Carcinogens	PW-M-04
	Corrosives	PW-M-05
	Toxics	PW-M-07
	Heavy metals	PW-M-08
Ionizing radiation sources	Radiography equipment	PW-N-02
Vehicles in motion (external to facility)	Train	PW-Q-03
Natural phenomena	Earthquake	PW-R-01

*Hazard checklist identification numbers XX-Y-## represent a specific line item on a hazardous material/energy source checklist (see Table 2) where:

XX = facility area.
Y = hazard type.
= checklist designator.

Table 14. Standard Industrial Hazards: Outside. (3 sheets)

Hazard category	Hazard type	Hazard checklist identification number
Electrical	Cable runs	OU-A-02
	Diesel generators	OU-A-03
	Electrical equipment	OU-A-04
	HVAC heaters	OU-A-05
	High voltage	OU-A-06
	Motors	OU-A-07
	Pumps	OU-A-08
	Power tools	OU-A-09
	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
Thermal	Bunsen burner/hot plates	OU-B-01
	Electrical equipment	OU-B-02
	Furnaces/boilers/heater	OU-B-03
	Welding torch/arc	OU-B-05
	Diesel units/fire box/exhaust line	OU-B-06
	Power tools	OU-B-09
	Solar	OU-B-11
Friction	Belts	OU-C-01
	Bearings	OU-C-02
	Fans	OU-C-03
	Gears	OU-C-04
	Motors	OU-C-05
	Power tools	OU-C-06
	Other (vehicle brakes)	OU-C-07
Corrosives	Acids	OU-D-01
	Caustics	OU-D-02
	Decon solution	OU-D-04

Table 14. Standard Industrial Hazards: Outside. (3 sheets)

Hazard category	Hazard type	Hazard checklist identification number
Kinetic - rotational	Motors	OU-E-02
	Pumps	OU-E-03
	Shop equipment	OU-E-06
Kinetic - linear	Forklifts, dollies, carts	OU-F-02
	Railroad	OU-F-03
	Crane loads	OU-F-05
	Pressure vessel blowdown	OU-F-06
	Other (gas bottles)	OU-F-07
Mass, gravity, height	Human effort	OU-G-01
	Lifts and cranes	OU-G-03
	Bucket and ladder	OU-G-04
	Trucks	OU-G-05
	Slings	OU-G-06
	Hoists	OU-G-07
	Jacks	OU-G-09
	Scaffold and ladders	OU-G-10
	Pits and excavations	OU-G-11
	Elevated doors	OU-G-12
	Vessels	OU-G-13
	Other (roof)	OU-G-14
Pressure - volume	Gas bottles	OU-H-05
	Pressure vessels	OU-H-06
Explosives/pyrophorics	Gases, others	OU-J-07
Flammable materials	Buildings and contents	OU-L-08
	Hydrogen	OU-L-11
Hazardous materials	Asphyxiants	OU-M-02
	Biologicals	OU-M-03
	Carcinogens	OU-M-04
	Corrosives	OU-M-05
	Oxidizers	OU-M-06
	Toxics	OU-M-07
	Heavy metals	OU-M-08

Table 14. Standard Industrial Hazards: Outside. (3 sheets)

Hazard category	Hazard type	Hazard checklist identification number
Ionizing radiation sources	Radiography equipment	OU-N-02
	Radioactive sources	OU-N-04
Vehicles in motion (extermal to facility)	Train	OU-Q-03

*Hazard checklist identification numbers XX-Y-## represent a specific line item on a hazardous material/energy source checklist (see Table 2) where:

XX = facility area.
Y = hazard type.
= checklist designator.

ATTACHMENT 1

COLD VACUUM DRYING FACILITY HAZARD ANALYSIS TEAM MEMBERS

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ATTACHMENT 1

COLD VACUUM DRYING FACILITY HAZARD ANALYSIS TEAM MEMBERS

The key members of the Cold Vacuum Drying Facility Hazards Analysis brought to the study the following experience.

Walter Alaconis

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

JoAnn Brehm

B.S., Biology, Mechanical Engineering. Twenty-two years experience in the nuclear industry, including sodium test reactor startup and operations, major DOE and international decontamination and decommissioning projects, and technology transfer. Six years direct experience in providing project management and preparing nuclear safety analysis documents for DOE facilities, including the Shippingport Station Decommissioning Project, Spent Nuclear Fuel Project, and the Waste Encapsulation and Storage 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.

John J. Irwin

B.S. Degree in Mechanical Engineering and in Aeronautical Engineering, Masters of Science Program in Mechanical Engineering. Principal Engineer at the Numatec Hanford Corporation, with 24 years experience. Formerly with Space Division of the Rockwell Corporation as a member of the technical staff. Worked as a mechanical engineer on the Space Shuttle Program, Fast Flux Test Facility (FFTF) Reactor, Fusion Materials Irradiation Test Facility, SP100 Space Reactor Test Facility, and the K Basin 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.

Curt Miska

B. S., Chemical Engineering. Seventeen years experience with Westinghouse Hanford Company/Rockwell Hanford Operations. Operations supervisor for PUREX Head End, PUREX Solvent Extraction, PUREX Plutonium Processing, and Uranium Conversion Facility (U03 Plant). Lead/cognizant process engineer for PUREX Solvent Extraction, PUREX Plutonium Processing, and B Plant cesium ion exchange systems. Currently an engineer for the Spent Nuclear Fuel Project. Developed preconceptual design concepts for potential fuel stabilization facilities. Provided technical input to DOE Spent Nuclear Fuel Programmatic Environmental Impact Statement for N Reactor fuel stabilization, including developing bases for information such as construction and operating resources and personnel required, and routine and accidental radiological and nonradiological releases. Provided major input for and coordinated completion of Dry Storage Technical Evaluation, including development of preliminary processing scheme, material balance, cycle time, and life-cycle cost estimates.

Paul Patterson

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

Carole Pili-Vincens

Graduate Engineer, Environment, Health and Safety; Technological Hazards Management; Reliability and Maintainability Studies. Six years experience in the nuclear industry performing safety analyses, managing a safety group, and defining safety analysis methods for French nuclear facilities (including high-level waste treatment and storage). Specialist in pyrophoricity reaction risks and environmental analyses. Two years experience performing safety and environmental analyses and assessments as a consultant for industrial facilities (chemical and oil plants).

Richard Whitehurst

Over 27 years experience in nuclear-related instrumentation and controls, operations, and project management. Design/project lead engineer for computer-controlled processes, including the 300 Area Treated Effluent Disposal Facility and the K East Basin monitoring and control systems. Cognizant engineer at the FFTF with direct responsibilities for a number of process systems, including safety-class systems such as Seismic Monitoring, Safe Shutdown Monitoring, and Emergency Dump Heater Exchanger Control System. Experience in operations with both the FFTF and the U.S. Nuclear Navy. Performed duties as test director and test engineer at K Basins, 300 Area Treated Effluent Disposal Facility, and the FFTF. Involved in safety equipment and procedures since 1979 at FFTF.

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ATTACHMENT 2

COLD VACUUM DRYING FACILITY HAZARD ANALYSIS

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Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 1 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Administrative Area AA-F-06	Linear kinetic - other (gas bottles)	Stored gas bottles become missiles	Earthquake damage, dolly and hand cart impact	Bottle becomes missile, damages structure and/or equipment	Personnel injury, structure and/or equipment damage to the administrative area only. no damage to SSCs		F3	F3	Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity).	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard
Administrative Area AA-J-06 and 12	Explosives / Pyrophorics - hydrogen (batteries)	Explosive gas mixtures	Batteries give off hydrogen gas	Explosion of explosive gases	Reduced capacity or loss of Administrative Area affects facility power, MCS control, and operations from control room Personnel injury	No credited prevention, safe process shutdown does not rely on input from the Administrative Area	F2	F2		S1	S1	
Administrative Area AA-L-01 AA-L-02 AA-L-06 AA-L-08 AA-L-11 AA-L-16	Flammable material - packing materials, rags, paint solvent, building and contents, hydrogen from batteries, other (aerosol propellent)	Fire due to ignition	Human error Electrical shorts	Fire, heat and/or heat in the administrative area with the potential to propagate to other areas.	Reduced capacity or loss of Administrative Area affects facility power, MCS control, and operations from control room Fire spreads Personnel injury	Combustible loading requirements from the FHA[a] are imposed Safe process shutdown does not rely on input from the Administrative Area Walls between the Administrative Area and the process bays are fire rated for 2 hours Fire sprinkler system	F3	F0		S1	S1	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Cask-MCO and SCIC confinement design Facility evacuation to protect workers Fire alarm and fire department response
Administrative Area AA-P-01 AA-P-02 AA-P-03 AA-Q-01 AA-Q-02 AA-Q-04 AA-R-01 -- R-10	Various external events affecting the Administrative Area, see Outside Events Sections OU-P, OU-Q and OU-R for discussion of these events											
Transfer corridor, mechanical room TC-B-05	Thermal - welding torch/arc	High temperature	Human error during welding operations near sprinkler fusible links	Actuation of fire protection sprinkler(s)	Water sprays on equipment	Equipment required for safe shutdown is designed to environmental qualifications	F2	F2		S0	S0	Site hot work procedures and training address precautionary measures for hot work
Transfer corridor, mechanical room TC-F-07	Linear kinetic - other (gas bottles)	Gas bottles used in portal monitors become missiles	Earthquake damage Valve breaks off bottle	Bottle becomes missile, damages structure and/or equipment	Personnel injury, structure and/or equipment damage		F3	F3	Sturdy walls (4- to 8-in.-thick concrete) between the transfer corridor and the process bays Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity).	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 2 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Transfer corridor, mechanical room TC-J-12	Explosives/ Pyrophorics - explosive gases	Explosive gas used for maintenance	Maintenance gases released to area then into ventilation system	External explosion (E.6) (gases in ventilation system)	Dispersion of HEPA filter contents	Maintenance procedures for hot work	F3	F2	Radioactive material loading on HEPA filter is restricted	S2	S1	Emergency response procedures and training, alarm response procedures and training
Transfer corridor, mechanical room TC-K-4	Nuclear Criticality - Filters	Fissile material accumulated on HEPA filters	Fissile material released from MCO during normal operation	Potential for criticality due to accumulation of material	High local doses to personnel nearby	No credible mechanism for transferring the required amount of material to the filters identified	F0					
Transfer corridor, mechanical room TC-L-01 TC-L-02 TC-L-04 TC-L-05 TC-L-06 TC-L-08 TC-L-11 TC-L-14 TC-L-15 TC-L-16	Flammable material - packing materials, rags, lubricating oil, coolant oil, paint solvent, building and contents, hydrogen, other gases and liquids, other (aerosol propellent)	Fire due to ignition	Human error (e.g., improper storage practices) Electrical shorts Propagation from other facility areas	Fire in the transfer corridor or mechanical room	Equipment and/or structural damage Personnel injury	Combustible loading requirements from the FHA[a] are imposed Safe process shutdown does not rely on input from the transfer corridor or mechanical room Equipment in the mechanical room required for safe shutdown is designed to environmental qualifications Fire sprinkler system	F3	F0		S1	S1	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Cask-MCO and SCIC confinement design Facility evacuation to protect workers Fire alarm and fire department response
TC-M-02	Hazardous materials - helium as an asphyxiant	Helium supply pipe break or leak releases helium in quantity large enough for asphyxiation	Material failure, seismic event or human error		Personnel injury	Design feature -- helium system piping installed to national codes and standards	F2			S1		
Transfer corridor, mechanical room TC-N-03	Ionizing radiation sources - radioactive material	HEPA filter loading of radioactive material	Inadvertent contamination spread	HEPA filter failure and subsequent particulate release	Radioactive particulate release through stack	Multiple HEPA filter stages exist within the local and general exhaust system No credible mechanism for complete HEPA filter loading release identified	F1 - for failure releasing fraction of loading	F0 - for failure releasing entire filter loading		S1	S1	HEPA filters are monitored regularly and changed out according to approved facility-specific procedures.
Transfer corridor, mechanical room TC-P-01 TC-P-02 TC-P-03 TC-Q-01 TC-Q-02 TC-Q-04 TC-R-02 -- R-10	Various external events affecting the transfer corridor or mechanical room, see Outside Events Sections OU-P, OU-Q and OU-R for discussion of these events											
Transfer corridor, mechanical room TC-R-01	Natural phenomena - earthquake (DBE)	Fuel reactions due to equipment damage caused by seismic event	Seismic event causes process support system or supply loss	Gaseous release (G.3) External hydrogen explosion (E.8)	Hydrogen and/or radioactive particulate release	MCO and SCHe confinement design TSR -- Process vent HEPA filter loading	F2	F0	HVAC systems provide confinement, dilution and filtration	S2	S1	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 3 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-B-02a	Thermal - electrical equipment	Bay temperatures in excess of electrical equipment design limits with annulus water flow	HVAC failure causes high temperature, equipment becomes unreliable	Internal hydrogen explosion (I.2) External hydrogen explosion (E.2)	Hydrogen and/or radioactive particulate release	TSR -- Safety systems are declared inoperable if environmental conditions are exceeded MCO and SCHe confinement design MCO design withstands internal explosion energy	F3	F0	HVAC systems provide confinement and dilution	S2	S1	
Process bays 4-5 PB-B-02b	Thermal - electrical equipment	Bay temperatures in excess of electrical design limits no annulus water flow	HVAC failure Bay recirculation heaters continue to run (fail on)	Thermal runaway reaction (T.2)	High temperatures in the MCO and the potential for radioactive particle release	SCIC actuates SCHe on high bay temperature SCHe establishes He flow through MCO directly to local exhaust MCO and SCHe confinement design TSR -- Crane movement restricted during MCO processing	F3	F0	HVAC systems provide confinement	S3	S1	HVAC maintains operating temperatures in the bay
Process bays 4-5 PB-B-02c	Thermal - electrical equipment	Bay temperatures below electrical equipment design limits with annulus water flow	HVAC failure causes low temperature, equipment becomes unreliable	Internal hydrogen explosion (I.2) External hydrogen explosion (E.2)	Hydrogen and/or radioactive particulate release	TSR -- Safety systems are declared inoperable if environmental conditions are exceeded MCO and SCHe confinement design MCO design withstands internal explosion energy	F3	F0	HVAC systems provide confinement and dilution	S2	S1	
Process bays 4-5 PB-B-03a	Thermal - heaters (tempered water heater)	Tempered water heated to temperatures above 50 °C	Mechanical or software failure resulting in loss of tempered water heat control	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4) Thermal runaway reaction (T.2) MCO Overpressurization (P.1)	Heatup increases fuel reaction with water producing more heat and hydrogen leading to potential hydrogen and/or radioactive particulate release, or thermal runaway reaction	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design 30 lb/in^2 rupture disk and vent path	F3	F0	HVAC systems provide confinement and dilution 150 lb/in^2 rupture disk MCO design withstands internal explosion energy	S3	S1	GSHe safety-class flow instrumentation 10 lb/in^2 process relief valve
Process bays 4-5 PB-B-03b	Thermal - heaters (tempered water heater)	Insufficient heating of tempered water	Software failure or human error in programming resulting in inaccurate heater control leading to potential for inaccurate pressure rebound test and proof of dryness demonstration	External hydrogen explosion (E.3) Hydrogen generation and potential for runaway at the CSB	Excessive water remaining in MCO reacts with the fuel producing heat and hydrogen leading to potential hydrogen and/or radioactive particulate release Over long term, potential for release at CSB	TSR -- Procedure to verify the results of the pressure rebound tests before continuing process steps (Note: Pressure rebound test utilizes different instrumentation than does the tempered water system)	F2	F1	HVAC systems provide confinement and dilution	S2	S1	This consequence is a concern for the SARP[c] or the CSB FSAR.[2] Initial pressure rebound test Final pressure rebound test

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 4 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-B-13a	Thermal - MCO contents ≤ 75 °C for centerline of fuel	High fuel temperatures air ingress	Process line failure or process upset causing significant air ingress into MCO, or HVAC failure	Internal hydrogen explosion (I.1, DBA) Gaseous release from MCO (G.1) External hydrogen explosion (E.4)	Pressurization of the MCO leads to hydrogen and/or radioactive particulate release, or explosion inside the MCO	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design	F3	F0	HVAC systems provide confinement, filtration, and dilution PWC drain line qualification Cask-MCO design withstands internal explosion energy	S2	S1	Tempered water system
Process bays 4-5 PB-B-13b	Thermal - MCO contents ≤ 75 °C for centerline of fuel	High fuel temperatures react with water during drying mode or pressure rebound test	Leak back of deionized (DI) water during vacuum Bulk water added to hot MCO	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4)	Fuel reaction with water produces heat and hydrogen leading to potential hydrogen and/or radioactive particulate release	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design	F3	F0	HVAC systems provide confinement and dilution Cask-MCO design withstands internal explosion energy	S2	S1	Tempered water system
Process bays 4-5 PB-B-13c	Thermal - MCO contents ≤ 75 °C for centerline of fuel	No tempered water or low tempered water level in the annulus	Tempered water line leak or break from earthquake or operator error	External hydrogen explosion (E.4) Thermal runaway reaction (T.1, DBA) MCO Overpressurization (P.1, DBA)	Heatup increases fuel reaction with water producing more heat and hydrogen, leading to potential hydrogen and/or radioactive particulate release, or thermal runaway reaction	TSR -- Crane movement restricted during processing to preclude common mode failure of tempered water line SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design 30lb/in² rupture disk and vent path	F3	F0	HVAC systems provide confinement and dilution 150lb/in² rupture disk TW System antisiphon valves Manual cask annulus refill piping and vent port	S3	S1	GSHe safety-class flow instrumentation 10 lb/in² process relief valve
Process bays 4-5 PB-B-13d	Thermal - MCO contents ≤ 75 °C for centerline of fuel, proof - of - dryness	Excessive amount of water remains in the MCO	Human error - misread instrument and positioned SCIC switch and MCO from Drying Mode to Proof Mode, or from Proof Mode to Pressure Test Mode without adequate drying	External hydrogen explosion (E.3) Thermal runaway reaction (T.1) MCO Overpressurization (P.1)	Excessive water remaining in MCO reacts with the fuel producing heat and hydrogen leading to potential hydrogen and/or radioactive particulate release, or thermal runaway reaction	TSR -- Procedure to verify the results of the pressure rebound tests before continuing process steps	F3	F1	HVAC systems provide confinement and dilution	S3	S1	MCS will not allow out-of-sequence operation Initial pressure rebound test Final pressure rebound test
Process bays 4-5 PB-B-13e	Thermal - MCO contents, a concern at CVDF	High fuel temperatures **NOTE**: Temperature at CVDF is important for adding helium to MCO so don't need extra gettering material added	MCO not adequately cooled (due to human error, mechanical failure, or software failure)	Higher than expected MCO temperatures. Internal hydrogen explosion in the MCO at CSB	No release, with less than 200 grams of free water, pressure created is not in excess of cask-MCO design		F2			S0		[1]This consequence is a concern for the SARP[2] or the CSB FSAR.[3]

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 5 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-B-13f	Thermal - MCO contents, a concern at CSB	High fuel temperatures	Inadequate cooling prior to shipping AND a failure of MCO seals allowing elevated hydrogen generation to leak out to the air filled cask annulus	Hydrogen explosion in cask at CSB	Hydrogen and or radioactive particulate release from cask	TSR -- Procedure for cooling MCO and helium filling prior to shipment to CSB	F2	F1		S1	S1	This consequence is a concern for the SARP or the CSB FSAR.
Process bays 4-5 PB-B-13g	Thermal - MCO contents	High MCO temperatures on receipt	Shipping time exceeds window Improper fuel loading (insufficient water or improper fuel configurations) MCO water leakage	External hydrogen explosion (E 1)	Hydrogen formed in MCO explodes outside of MCO when cask-MCO is vented	TSR -- Receipt transportation window Cask-MCO confinement function Cask vent orifice and interlock with HVAC for dilution	F3	F0	TSR -- HVAC HEPA filter loading limit	S2	S1	No leak path below water line in MCO Cask vent line enters HVACC/PV piping away from operator
Process bays 4-5 PB-F-01a	Linear kinetic - transportation cask trailer	Trailer impacts within the process bay	Human error Mechanical failure	Striking walls, personnel, outer bay doors	Personnel injury.		F3	F3	Bollards and other structural steel devices near the process bay doors and within the process bay protect the outer doors and the back wall of the process bay The mezzanine supports protect the process bay side wall from damage	S1	S1	Painted lines on the bay floor are present to aid in guiding the trailer in correctly Vehicles are operated by qualified personnel and enter and exit the bays at a slow speed. Operators direct the truck driver during entry and exit. Breach of building confinement in other bays is not considered possible.
Process bays 4-5 PB-F-01b	Linear kinetic - transportation cask trailer	Trailer impacts within the process bay	Human error Mechanical failure	Striking the process skid or mezzanine supports	Damage to equipment on the process skid and subsequent release of contaminated material at levels below the administrative controls provided by the Radiation Protection and ALARA Programs. Processing is not underway during event. Personnel injury.		F3	F3	Bollards and other structural steel devices near the process bay doors and within the process bay protect the outer doors and the back wall of the process bay	S1	S1	Continuous Air Monitors The mezzanine supports protect the process skid from damage Painted lines on the bay floor are present to aid in guiding the trailer in correctly Vehicles are operated by qualified personnel and enter and exit the bays according to approved procedure
Process bays 4-5 PB-F-01c	Linear kinetic - transportation cask trailer	Trailer impacts within the process bay	Human error Mechanical failure	Damage to cask	The cask is qualified for all anticipated transport accidents, which bound the low-velocity impact associated with this hazard Personnel injury.		F3	F3	The cask is qualified for all anticipated transport accidents, which bound the low-velocity impact associated with this hazard	S1	S1	Painted lines on the bay floor are present to aid in guiding the trailer in correctly. Vehicles are operated by qualified personnel and enter and exit the bays according to approved procedure
Process bays 4-5 PB-F-01d	Linear kinetic - transportation cask trailer	Cask in trailer impacts PWC drain line within the process bay	Human error Mechanical failure	None -- this collision is not physically possible due to the elevation of the drain line		None -- this collision is not physically possible due to the elevation of the drain line	F0					

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 6 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-F-02a	Linear kinetic - forklifts, dollies, carts	Forklift impacts within an empty process bay, striking instrument air lines or normal helium supply, outer bay doors, electrical panel, demineralized water line, chilled water line, or adjacent bay wall affecting processing operations in other bays.	Human error Mechanical failure	Fork lifts do not have room to operate in bays occupied by MCO trailer. Collisions in an empty bay potentially lead to accidents in bay where process is underway: Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.4) MCO Overpressurization (P.2)	Process upset due to loss of support system, leads to potential hydrogen formation and release, and/or radioactive particle release. Damage to equipment on the process skid in the empty bay and subsequent release of contaminated material Personnel injury Loss of power Breach confinement	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO and vent to local exhaust Cask-MCO AND SCHe confinement design 30 lb/in² gauge rupture disk TSR: Receipt transportation window	F3	F0	HVAC systems provide confinement and dilution 150 lb/in² gauge rupture disk	S3	S1	Forklifts are operated by qualified personnel. 10 lb/in² process relief valve
Process bays 4-5 PB-F-02b	Linear kinetic - forklifts, dollies, carts	Forklift impacts MCO drain line within the process bay -- bay is empty	Human error Mechanical failure	None -- this collision is not physically possible due to the elevation of the drain line		None -- this collision is not physically possible due to the elevation of the drain line	F0					Fork lifts do not have room to operate in bays occupied by MCO trailer.
Process bays 4-5 PB-F-05 and PB-G-03a	Linear kinetic - crane loads and Load drops -- Mass gravity, height - lifts and cranes	Crane load impacts or drops striking instrument air lines or normal helium supply, electrical panel or demineralized water line, during processing operations	Human error Mechanical failure	Gaseous release (G.1) Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.4)	Process upset due to loss of support system, leads to potential hydrogen formation and release, and/or radioactive particle release. Damage to equipment on the process skid with subsequent release of contaminated material Personnel injury Loss of power Breach confinement	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO and vent to local exhaust Cask-MCO AND SCHe confinement design 30 lb/in² gauge rupture disk TSR -- crane movement is restricted during MCO processing	F3	F0	HVAC systems provide confinement and dilution 150 lb/in² gauge rupture disk Cask-MCO withstands internal explosion energy	S3	S1	Restricted movement of crane by design. Crane is operated by qualified personnel following approved procedures. Crane maintenance conducted according to approved procedures All lifts by crane passing over safety-class equipment follow DOE guidelines for such lifts. HVAC - sweeps H_2 away from operators Continuous air monitor - local area alarm Response procedure - evacuate 10 lb/in² process relief valve
Process bays 4-5 PB-F-07	Linear kinetic - other (gas bottles)	Helium gas cylinders are damaged and become missiles	Earthquake, trailer impacts, forklift impacts	Bottle becomes missile, damages structure and/or equipment	Personnel injury, structure and/or equipment damage		F3	F3	Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity).	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 7 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-G-03b	Mass, gravity, height - elevated crane equipment, overhead door	Crane trolley falling from overhead railing, door falling on cask	Human error Mechanical failure	Crane hoist is connected to a cask lid which has not been unbolted from the transportation cask and attempts to lift. Lack of maintenance on overlift protection feature causes crane supports to fail.	Crane trolley falls onto cask or MCO. Crane trolley falls onto process equipment resulting in contamination spread. Personnel injury Door falls on cask	Design feature -- motor can't generate enough force to cause potential accident Cask design withstands door impact	F0	F0	HVAC systems provide confinement and filtration	S1	S1	Process bay structure with HEPA ventilation provides building confinement. Crane designed with overlift protection. Personnel are trained in the proper use of the crane and the correct procedure for processing, and follow approved procedures for same. Crane maintenance is conducted according to approved procedures.
Process bays 4-5 PB-G-03c	Mass gravity height - elevated crane load	Elevated cask lid falling could potentially damage MCO, injure personnel	Human error Mechanical failure	Elevated cask lid or process hood falls from crane onto MCO due to improper connection or equipment failure	Cask lid impacts MCO Personnel injury	Design feature -- HNF-SD-SNF-DP-007, Appendix B,[3] documents that the cask lid impacting the MCO from a drop in the CVDF does not result in unacceptable damage or consequences	F2			S1		
Process bays 4-5 PB-H-06a	Pressure, volume - pressure vessels (MCO and cask)	Pressurized release of hydrogen from MCO	Failure to vent the transportation cask Exceeding the shipping window Improper loading at fuel retrieval (e.g. insufficient water contents, improper fuel loading, improper MCO sealing)	Pressurized release of hydrogen from the MCO during cask lid removal, or process line hook-up, with subsequent ignition	Personnel injury due to hydrogen ignition Worker exposure to radioactive particulate		F3	F3	HVAC systems provide confinement and filtration	S1	S1	HEPA filter in MCO minimizes the amount of particulate released Personnel trained in the correct process steps prior to connecting process lines (including required actions for MCOs that have exceeded their established transport window)
Process bays 4-5 PB-H-06b	Pressure, volume - pressure vessels	Release of cask annulus water from between the MCO and the transportation cask	Human error or mechanical failure resulting in tempered water system quick disconnect leak, process hood seal ring deflates while TW system is under pressure, or failure of the cask drain port during shipment (undiscovered until cover port is removed)	Spray or leak of water onto the process bay floor	Surface contamination Drainage of basin water to the process bay floor Release of contaminated material, processing is not underway during event		F3	F3		S1	S1	Alarm occurs on seal ring pressure loss through the MCS. Procedural step to check tempered water system quick disconnect for leaks following installation. TW system connection to cask is double walled. The cask loading process uses a system to maintain clean water in the cask, minimizing the expected contamination.

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 8 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-H-06c	Pressure, volume - pressure vessels	Pressurized relief from MCO	Prior to installing the process connectors and prior to heat-up with the port valves closed and the MCO and cask both full of water, the MCO is left for an extended period of time. Human error.	Hydrogen generation pressurizes buttoned up MCO to 150 lb/in² gauge where rupture disk relieves and H2 possibly ignites	Hydrogen deflagration in bay Personnel injury	MCO full of water limits the hydrogen/particulate release	F2	F2	HVAC systems provide confinement and filtration	S1	S1	Procedures exist for preventing long process delays - MCO is not allowed to sit in this state indefinitely.
Process bays 4-5 PB-H-06d	Pressure, volume - pressure vessels	Pressurized MCO	Process upset, processing delay or line failure, small undetected leaks from the process system could continue for a long time if there is no mitigation.	Gaseous release from MCO (G 1)	Hydrogen and/or radioactive particulate release due to pressurization	MCO design withstands MCO pressurization	F3	F3	HVAC systems provide confinement and filtration	S2	S1	
Process bays 4-5 PB-H-06e	Pressure, volume - pressure vessels	Hydrogen formation in MCO during drain interruption prior to breakthrough	Loss of power Mechanical or equipment failure in PWC room Operator error, (e.g. turning off PWC pump SCIC trip	Hydrogen forms and collects in PWC tanks	Hydrogen formed in MCO is drawn into the PWC drain line and receiver tanks when MCO drain is restarted. Hydrogen explosion in PWC drain line or receiver tanks	TSR -- shut off PWC pump (stop MCO drain) on loss of differential pressure in process water tank room TSR -- Pressure purge the MCO to dilute hydrogen	F2	F1	HVAC systems provide confinement and dilution	S1	S1	
Process bays 4-5 PB-H-06f	Pressure, volume - pressure vessels	Pressurized release due to hydrogen formation	Process line failure or process upset causing significant air ingress into MCO, or HVAC failure	Gaseous release from MCO (G.1, DBA) External hydrogen explosion (E.4)	Pressurization of the MCO leads to hydrogen and/or radioactive particulate release	Cask-MCO design withstands pressurization TSR: Confinement function verified by leak testing process port connectors	F3	F2	HVAC systems provide confinement and filtration	S2	S1	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Tempered water system
Process bays 4-5 PB-H-06g	Pressure, volume - pressure vessels	Local and or general exhaust HEPA filter fails	Random failure	Gaseous release from MCO (G 1)	Potential hydrogen and/or radioactive particulate release		F3	F3	HVAC systems provide confinement and filtration	S2	S1	
Process bays 4-5 PB-H-06h	Pressure, volume - pressure vessels	Loss of local exhaust ventilation fans (excluding loss of power)	Random failure Dampers close	Gaseous release from MCO (G 1)	Potential hydrogen and/or particulate release within the process bay Potential hydrogen release into the local exhaust while not running		F3	F3	HVAC systems provide confinement and filtration	S2	S1	

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 9 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-H-06i	Pressure, volume - pressure vessels	Hydrogen generation within MCO	Delays in shipping processed MCO from CVDF accompanied by MCO leakage or human error in closing port valves	Gaseous release (G.2) External hydrogen explosion (E.4)	Hydrogen and small amounts of fission gas may be released to the cask annulus, possibly leading to a flammable atmosphere in cask annulus with subsequent explosion, with spread of contamination Release/explosion of hydrogen and fission gasses when cask lid is vented or removed at CSB	TSR -- Proof-of-dryness demonstration	F2	F2	HVAC systems provide confinement, dilution and filtration	S2	S1	
Process bays 4-5 PB-H-06j	Pressure, volume - pressure vessels	Pressurized MCO as a result of fuel reacting with contamination	Backflow (by diffusion) of vacuum pump oil into MCO (need a pump seal failure) Condenser chilled water leak resulting in glycol entering the MCO by backflow	Contamination (oil/glycol) introduced into the MCO and reacts with fuel	Fuel reacts with contamination leading to increased hydrogen formation, other gas formation or heat generation at CVDF or long term	Contaminants and water cannot reach the MCO because they would have to flow against the helium supply pressure and overcome the height differential from the process skid to above the MCO	F0			S2		A second pressure rebound test is conducted in the last hour of the proof of dryness demonstration after the vacuum pump and all potential water sources are isolated
Process bays 4-5 PB-H-06k	Pressure, volume - pressure vessels	Fuel reacts with contaminates	Contaminated He purge gas Wrong gas hooked up, He gas received out of specification, contamination in purge line not removed after maintenance	Internal hydrogen explosion (I.7) External hydrogen explosion (E.7) Thermal runaway reaction (T.5)	Hydrogen explosion or high temperatures in the MCO leading to a potential radioactive particle release	TSR -- Shipment paperwork verified for gas bottle content during receipt TSR -- Vender documentation of supplied gas tests	F2	F0		S2		
Process bays 4-5 PB-H-06l	Pressure, volume - pressure vessels	Uncontrolled release of water from MCO	Incorrect MCO port opened during cask loadout at K Basin (e.g., long tube)	Spray or leak of MCO contents	Spread of contamination		F3	F3		S1	S1	K Basins personnel are trained in the proper cask loadout procedures at K Basins
Process bays 4-5 PB-H-06m	Pressure, volume, pressure vessels	MCO drain flow reversed due to ejector malfunction	Low flow in the ejector causes backflow of water into drain header.	Water flows back to drain header and MCO	Process delay and possible increase exposure	None -- No identified mechanism to provide backflow through ejector	F0					
Process bays 4-5 PB-H-06n	Pressure, volume, pressure vessels - MCO	Water reaction with fuel	Immediately following drain, while flushing drain lines, the MCO is refilled with water	None	No consequences other than delay (introduction of water just after draining does not cause any effects)		F2	F2		S0	S0	Duration of deionized water flush is limited by the MCS (15 min = ~ 80 gal)

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 10 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-H-06o	High pressure in cask annulus (TW or compressed air)	Direct radiaiton	MCO partially lifted from cask	TW (annulus) system valve closure pressurizes annulus and lifts MCO Valve closure during cask dryout pressurizes cask with compressed air MCS calls for cask dryout at the wrong time resulting in compressed air pressurizing cask TW cooling system failure pressurizes TW (annulus) system and cask (heat exchanger failure pressurizes TW (annulus) system from TW cooling system) TW (annulus) system heater failure generates steam that pressurizes cask (TW [annulus] system return line valve closed and TW [annulus] system pump discharge valve closed)	Elevated radiation levels Worker exposure		F3	F3		S1	S1	Failure of seal ring will cause inflatable seal to fail relieving pressure Seal ring leak occurs when MCO narrows past collar (MCO diameter is less than shield plug diameter) Seal ring restrains MCO Pressure relief valves in TW (annulus) system Pressure relief valves in compressed air system Steam output from heater insufficient to pressurize the cask vent out of the TW (annulus) system return line
Process bays 4-5 PB-H-08	Pressure, volume, vacuum	Degraded vacuum pump operations	Equipment malfunction	Thermal runaway reaction (T.1)	Heatup occurs, increasing fuel/water reaction leading to potential thermal runaway	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO. (8/4/4) MCO and SCHe confinement design	F3	F0		S3	S1	HVAC systems provide confinement and dilution
Process bays 4-5 PB-H-11a	Pressure, volume - other	Helium pressure higher than expected	Cascading failure of regulators beginning with 3000 psi regulator failure.	MCO overpressurization (P.3)	Radioactive particulate release	Normal helium supply system safety valves SCHe supply pressure control valves and rupture disks MCO design withstands pressure	F2	F0		S2		Pressure relief valve on He trailer 30 lb/in^2 gauge rupture disk and vent path 150 lb/in^2 gauge rupture disk SCHe vent

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 11 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-H-11b	Pressure, volume - other (pressurized process lines)	Inaccurate control, unreliable valves	Contaminated air within the instrument air supply leads to conditions that allow hydrogen to form and be released from the MCO	Isolation valves do not close	Hydrogen and/or radioactive particulate release	Fail-safe design for process valves isolating the MCO Redundant isolation valves	F1	F1	HVAC systems provide confinement and dilution	S1		SCIC detects process upset initiating SCHe which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design Air dryer on instrument air supply
Process bays 4-5 PB-H-11c	Pressure, volume - other (pressurized process lines)	Tempered water system lines leak	Hazard eliminated by design change -- double walled pipe									
Process bays 4-5 PB-H-11d	Pressure, volume - other (water addition to MCO)	Water addition during drying mode or pressure rebound test	Leak back of deionized (DI) water during vacuum Vacuum pump tempered water cooling water internal leak Bulk water added to hot MCO	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4)	Water addition causes hydrogen formation and release in explosive mixtures into local exhaust, or explosion inside the MCO Radioactive particulate release	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO	F3	F0	HVAC systems provide confinement and dilution Cask-MCO design withstands internal explosion energy	S2	S1	Tempered water system
Process bays 4-5 PB-H-11e	Pressure, volume - other (water addition to MCO)	Water addition during drying mode or pressure rebound test	Valves don't fully close due to particles, process upsets, operator error, vacuum conditions in MCO acts to draw water	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4)	Water addition causes hydrogen formation and release in explosive mixtures into local exhaust, or explosion inside the MCO Radioactive particulate release	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO	F3	F0	HVAC systems provide confinement and dilution Cask-MCO design withstands internal explosion energy	S2	S1	Tempered water system
Process bays 4-5 PB-H-11f	Pressure, volume - other (water addition to MCO)	Water addition after final pressure rebound test from Process Water Room through MCO drain line or deionized water line	Valves don't fully close due to particles, process upsets, operator error, vacuum conditions in MCO acts to draw water	Fuel and water reactions in long term storage Thermal runaway (T.4) Overpressurization (P.1)	Radioactive particulate release	SCIC system interlocks PWC and deionized water isolation valved closed during vulnerable stages of the cold vacuum drying process. Process unable to continue if deionized lines are open. The ability to draw water from the PWC room is physically limited because of elevation difference and PWC ejector operations or because no water is available.	F1	F0		S3	S3	Check valves in lines
Process bays 4-5 PB-J-06	Explosives/ pyrophorics - hydrogen	Hydrogen is a product of the MCO contents	Expected conditions within the MCO Hydrogen forms and collects due to process upsets	Potential accidents are evaluated in PB-L-11	See PB-L-11a – L-11g							

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 12 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-J-10	Explosives/ pyrophorics - plutonium and uranium metal	Water reaction with fuel	Immediately following drain, while flushing drain lines, the MCO is refilled with water	None	No consequences (introduction of water just after draining does not cause any effects)		F2	F2		S0	S0	
Process bays 4-5 PB-J-12	Explosives / pyrophorics - other (uranium hydrides)	Uranium hydride reactions	Oxygen intrusion into the MCO through line break in the helium normal supply	Internal hydrogen explosion	Hydrogen generation and sudden pressurization (a pulse) due to a hydride-oxygen reaction, with resulting particulate release to the process bay.	Hydride reactions cannot create enough hydrogen to generate an explosion (see HNF-2786[6])	F0					
Process bays 4-5 PB-K-04 PB-K-05 PB-K-15	Nuclear criticality - , filters, casks, other (MCOs and drain lines)	These hazards are addressed and analyzed in the CVDF FSAR, Chapter 6.0.[7]										
Process bays 4-5 PB-L-01 PB-L-02 PB-L-03 PB-L-04 PB-L-05 PB-L-06 PB-L-07 PB-L-08 PB-L-09 PB-L-10 PB-L-13 PB-L-14 PB-L-15 PB-L-16	Flammable / combustible materials - rags, gasoline, lubricating oil, coolant oil, paint solvent, diesel fuel, buildings and contents, trailers and contents, grease, propane, alcohol, aerosol propellent	Ignition of flammable material within the process bays	Human error Mechanical failure Fire within the process bay with possible spread of fire into adjacent bays that are processing MCOs	Gaseous release from MCO (G.4) Internal hydrogen explosion (I.3) External hydrogen explosion (E.6) Thermal runaway reaction (T.3) MCO overpressurization (P.5)	Fire within the process bay with possible spread of fire into adjacent bays that are processing MCOs Equipment damage leading to process upsets resulting in radioactive particulate release	TSR -- limits on combustible loading in bay	F2	F0		S2	S2	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Cask-MCO AND SCHe confinement design Facility evacuation to protect workers Fire protection system present in each bay Fire suppression present in all adjacent areas Fire department alarm and response Tempered water system cask annulus manual refill piping
Process bays 4-5 PB-L-11a	Flammable materials - hydrogen	Flammable atmosphere in local exhaust ventilation system	Expected normal condition for cask venting Shipping time exceeds window Improper fuel loading (insufficient water or improper fuel configurations) MCO water leakage	External hydrogen explosion (E.1, DBA)	Sufficient hydrogen to create a flammable atmosphere is present in the cask-MCO head spaces prior to venting, then released to local exhaust during cask vent The HEPA filters in the ventilation system may fail because of this event	TSR -- Receipt transportation window Cask-MCO confinement function Cask vent orifice and interlock with HVAC for dilution	F3	F2	TSR -- HVAC HEPA filter loading limit HVAC system provides dilution	S2	S1	No leak path below water line in MCO Cask vent line enters HVACC/PV piping away from operator

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 13 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-L-11b	Flammable materials - hydrogen	Flammable atmosphere in process bay	Failure to isolate auxiliary vacuum pump prior to cask venting releases sufficient hydrogen to the process bay to create an explosion, gas release from MCO may also contain radioactive particulate	Hydrogen explosion in the process bay Personnel exposure to radioactive particulate	Hydrogen deflagration in the process bay possible radioactive particulate release to the bay Personnel injury		F2	F2	HVAC systems provide confinement and dilution	S1	S1	Procedure to verify isolation of auxiliary vacuum pump
Process bays 4-5 PB-L-11c	Flammable materials - hydrogen	Flammable atmosphere in MCO	Failure to close the MCO port valve after cask lid removal (at receipt at CVDF) Excessive time (>12 hr) with the MCO port open because of processing delays	Hydrogen explosion in the process bay Personnel exposure to radioactive particulate	Hydrogen and/or radioactive particulate release to the bay Personnel injury	MCO still full of water limits the hydrogen and particulate release	F2	F2	HVAC systems provide confinement and dilution	S1	S1	Operators are trained in the proper process steps for MCO preparation for processing.
Process bays 4-5 PB-L-11d	Flammable materials - hydrogen	Flammable atmosphere in MCO during draining prior to breakthrough	Process line failure or process upset causing significant air ingress into MCO or HVAC failure	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4)	Hydrogen formation leading to explosion inside the MCO, or explosion in the process lines or vent system	Cask-MCO design withstands internal explosion energy	F2	F1	HVAC systems provide confinement, filtration, and dilution	S2	S1	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO
Process bays 4-5 PB-L-11e	Flammable materials - hydrogen forms during prep for shipment to CSB	Flammable atmosphere in or around MCO and cask	Failure to inert MCO Improper seating of valve plugs with resulting air ingress Failure to cool MCO sufficiently before shipment Inadequate vacuum drying Incomplete draining of cask annulus	External hydrogen explosion (E.4)	Hydrogen and/or radioactive particle release, or hydrogen explosion	With less than 200 grams of free water explosive mixtures of hydrogen are not formed	F2	F2		S0	S0	Proof-of-dryness demonstration
Process bays 4-5 PB-L-11f	Hydrogen in MCO	Hydrogen enters local vent in explosive mixtures	Manual or spurious actuation of SCIC and local exhaust not running	External hydrogen explosion (E.2)	Hydrogen and/or radioactive particle release, or hydrogen explosion		F2	F2	HVAC systems provide confinement and dilution	S2	S1	SCIC actuates SCHe on process upset SCHe establishes He flow through MCO directly to local exhaust MCO and SCHe confinement design
Process bys 4-5 PB-L-11g	Hydrogen in MCO	SCHe actuation with leaky PWC safety-class valves	Valve seal damage	Hydrogen in the PWC drain line	Hydrogen explosion in PWC drain line	Design includes redundant isolation valves	F2	F1	HVAC systems provide confinement and dilution	S1	S1	
Process bays 4-5 PB-M-08	Hazardous materials - heavy metals (TRU)	Radiological guidelines are more limiting than toxicological limits, see HNF-SD-SNF-TI-059[9]										

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 14 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-N-01	Ionizing radiation sources - fissile material	Failure of the PWC drain line in a bay with an open door while draining an upstream bay	Random failure corrosion	Gaseous release from MCO (G.1) Gaseous release due to purge flow entering into the drain line	Radioactive particulate release	PWC drain line in bay is qualified to withstand anticipated degradation effects such as corrosion and is located where it cannot be impacted	F2	F1		S2	S2	
Process bays 4-5 PB-N-03a	Ionizing radiation sources - radioactive material	Failure to correctly perform demineralized water rinse of PWC system drain lines and MCO port valve	Human error after MCS failure	Increased radiation in drain lines	Increased risk of exposure near the line		F2	F2		S1	S1	Routine radiation surveys are conducted
Process bays 4-5 PB-N-03b	Ionizing radiation sources - radioactive material	No filtration during draining	Human error in manufacturing MCO	Increased radioactive particulate in drain line and/or process water room	Increased risk of exposure near the line and in PWC Room		F1	F1		S1	S1	CAMs in PWC Room Routine radiation surveys are conducted
Process bays 4-5 PB-N-03c	Ionizing radiation sources - radioactive material	Contamination in lines	Manual or spurious actuation of SCIC causes contamination in lines and process connector to be blown into the process bay The process connectors are not attached to the MCO.	Radioactive particulate release to process bay	Radioactive particulate release to process bay		F2	F2		S1	S1	HVAC systems provide confinement and filtration Procedures Training
Process bays 4-5 PB-N-03d	Pressure, volume - other (building zoned pressure boundaries)	Ventilation upsets cause movement of hazardous materials across pressure boundaries	Failure to isolate bay ventilation before opening bay door (human error) Bay door opens unintentionally, ventilation restarts accidentally, isolation not adequate (human error or mechanical failure) Failure to reestablish ventilation after closing bay door	Loss of confinement zones (ventilation flow contrary to expected norms), potential differential pressure inversions Stagnant bay	Potential contamination spread if this occurs in conjunction with other accidents Potential for a differential pressure inversion with adjacent confinement zones		F3	F3	Differential pressure monitoring	S1	S1	Procedure for processing establishes and verifies proper HVAC conditions Operators trained to procedures
Process bays 4-5 PB-P-01 PB-P-03 PB-Q-01 -- Q-04 PB-R-01c PB-R-01d PB-R-02 -- R-10	Various external events affecting the process bay, see Outside Events Sections OU-P, OU-Q and OU-R for discussion of these events											

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 15 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process bays 4-5 PB-P-02	External events - fire	Fire external to facility introduces heat and smoke, or fire enters bay igniting flammable material within the process bays	Human error Mechanical failure Natural phenomena (range fire) Flammable materials ignite	External hydrogen explosion (E 6) Thermal runaway reaction (T 3) MCO overpressurization (P 5)	Equipment damage leading to process upsets resulting in radioactive particulate release	The facility location is remote, reducing the likelihood of occurrence TSR -- limits on combustible loading in bay	F2	F0		S2	S2	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Cask-MCO AND SCHe confinement design Facility evacuation to protect workers Fire protection system present in each bay Fire suppression present in all adjacent areas Area surrounding building is controlled to limit combustible material and plants
Process bays 4-5 PB-R-01a	Natural phenomena - earthquake (DBE)	Fuel reaction due to damage caused by seismic event	Earthquake causes process upset, equipment damage, loss of ventilation and/or trailer movement	Gaseous release (G 3) Internal hydrogen explosion (I.6) External hydrogen explosion (E.8) Thermal runaway reaction (T 6) MCO overpressurization (P.4)	Hydrogen and/or radioactive particulate release	Seismic input into SCIC initiates SCHe SCHe isolates MCO from process equipment, establishes flow through MCO MCO and SCHe confinement design 30 lb/in² gauge rupture disk and vent path TSR -- Trailer placement in bay to support seismic calculations	F2	F0	TSR -- Process vent HEPA filter loading 150 lb/in² gauge rupture disk TW annulus system HVAC systems provide confinement and dilution Cask-MCO design withstands internal explosion energy	S3	S1	10 lb/in² process relief valve
Process bays 4-5 PB-R-05	Natural phenomena - snow, freezing weather	Bay temperatures below electrical equipment design limits with annulus water flow	Loss of site power on extremely cold day HVAC failure	Internal hydrogen explosion (I.2) External hydrogen explosion (E.2)	Hydrogen and/or radioactive particulate release	TSR -- Safety systems are declared inoperable if environmental conditions are exceeded MCO and SCHe confinement design MCO design withstands internal explosion energy	F3	F0	HVAC systems provide confinement and dilution	S2	S1	
Spare bays 1-3 SB-F-01a SB-F-02a	Linear kinetic - cars, trucks, buses, forklifts, dollies, carts	Vehicle impacts within the spare bay affecting spare bay only	Human error Mechanical failure	Striking walls, personnel, outer bay doors, electrical panels, demineralized water line, or chilled water line	Personnel injury Loss of power to the spare bay Shear of demineralized water and/or chilled water line may overflow the 300-gal drain tank into its concrete vault pit		F3	F3	Vehicles are operated by qualified personnel and enter and exit the bays according to approved procedure	S1	S1	Bollards and other structural steel devices near the bay doors protect the outer doors. High-level alarms are present in drain tank. Concrete vault pit has a large capacity.

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 16 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Spare bays 1-3 SB-F-01b SB-F-02b	Linear kinetic - cars, trucks, buses, forklifts, dollies, carts	Vehicle or forklift impacts within the spare bay, striking walls, instrument air lines, normal helium supply, or electrical panel affecting processing operations in other bays	Human error Mechanical failure	Internal hydrogen explosion (I 5) External hydrogen explosion (E.5) Thermal runaway reaction (T.4) MCO overpressurization (P.2)	Personnel injury (high pressure air, noise, flying debris) Hydrogen and/or radioactive particulate release Wall damage could result in a process upset in an adjacent bay (e.g., activating a seismic switch)	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Cask-MCO AND SCHe confinement design 30 lb/in^2 gauge rupture disk TSR: Crane movement restricted during MCO processing	F3	F0	HVAC systems provide confinement and dilution 150 lb/in^2 gauge rupture disk	S3	S1	Forklifts are operated by qualified personnel Asphyxiation would only be a possible problem if ventilation were off and the leak continued for several shifts 10 lb/in^2 process relief valve
Spare bays 1-3 SB-F-01c SB-F-02c	Linear kinetic - cars, trucks, buses, forklifts, dollies, carts	Vehicle impacts within the spare bay	Human error Mechanical failure	Striking process (MCO drain) lines	Damage to process lines (e.g., drain lines from MCO), resulting in a liquid or particulate release into bay from MCO draining operations in other bays through the open path between floor drains	The common drain line is elevated and cannot be impacted by vehicles	F0					
Spare bays 1-3 SB-F-07	Linear kinetic - other (gas bottles)	Stored gas bottles become missiles	Earthquake damage, forklift impact	Bottle may move but not enough to cause damage	Personnel injury, structure and/or equipment damage to the spare bay only, no damage to SSCs		F3	F3	Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity).	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard
Spare bays 1-3 SB-H-11	Pressure, volume - other	Helium pressure higher than expected	Cascading failure of regulators beginning with helium tube trailer regulator failure.	Overpressurization of the drain line possibly causing water hammer and failure of the drain line in the spare bay with a resulting high-pressure helium blowdown	Particulate release NOTE: There is no HVAC system requirement in spare bays	Safety relief valves installed on the helium supply.	F2	F0		S1	S1	
Spare bays 1-3 SB-L-01 SB-L-02 SB-L-03 SB-L-04 SB-L-05 SB-L-06 SB-L-07 SB-L-08 SB-L-11 SB-L-14 SB-L-15 SB-L-16	Flammable materials - packing materials, rags, gasoline, lubricating oil, coolant oil, paint solvent, diesel fuel, building and contents, hydrogen, propane, alcohol, other (aerosol propellent)	Ignition of flammable material within the process bay	Human error Mechanical failure	Fire within the bay with possible spread of fire into adjacent bays that are processing MCOs	Structural damage or failure of process bay Damage to upper wall separating adjacent bays Smoke and heat in process bay Degrade the safety class seismic monitor NOTE: There is no HVAC system in spare bay 1	Partitions separate the processing bays. Combustible loading requirements from the FHA[3] are imposed	F3	F0		S1	S1	Fire department will respond. Facility evacuation to protect workers. Fire protection system (sprinklers) are present in process bays. Materials are stored in accordance with applicable local, state, and federal safety requirements.
Spare bays 1-3 SB-M-08	Hazardous materials - heavy metals (TRU)	Radiological guidelines are more limiting than toxicological limits, see HNF-SD-SNF-TI-059[9]										

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 17 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Spare bays 1-3 (spare bay) SB-N-01a	Ionizing radiation sources - fissile material	Failure of MCO drain line downstream from MCO	Random failure, corrosion	Gaseous release from MCO (G 1) Gaseous release due to purge flow entering into the drain line	Radioactivity release into spare bay	PWC drain line in bay is qualified to withstand anticipated degradation effects such as corrosion and is located where it cannot be impacted	F2	F1		S2	S2	
Spare bays 1-3 SB-N-01b	Ionizing radiation sources - fissile material	Cask–MCO on transporter staged temporarily in spare bay	MCO staged prior to processing MCO staged following processing	Worker exposure to direct radiation Radioactive particulate release	Elevated worker doses Radioactive particulate release		F3	F3		S1	S1	Cask shielding and pressure boundary (assumptions: [1] cask–MCOs temporarily staged in spare bays fall withing the appropriate transportation window, [2] while staged in a spare bay, the cask pressure boundary is not intentionally penetrated)
Spare bays 1-3 SB-N-03a	Ionizing radiation sources - radioactive material	Contaminated MCO water contents traveling through PWC system drain line	Human error (vehicle impact, for example) Mechanical failure (corrosion, for example)	MCO drain line failure	Liquid or particulate release into the spare bay	PWC drain line in bay is qualified to withstand anticipated degradation effects such as corrosion and is located where it cannot be impacted	F2	F1		S2	S2	PWC system interlocks only allow one MCO draining operation to be in effect at a time, limiting the available liquid release volumes Floor drains and catch tank collect and contain released liquid.
Spare bays 1-3 SB-N-03b	Ionizing radiation sources - radioactive material	Processed PWC tank room water being transferred to tanker truck that contains residual contamination	Line break Human Error	Spray or spill of processed water to spare bay	Potential for minor contamination spread - ALARA issue only		F3	F3		S1	S1	
Process bay 1 (spare bay) SB-P-01 SB-P-02 SB-P-03 SB-Q-01 SB-Q-02 SB-Q-04 SB-R-01 -- R-10	Various external events affecting the spare bay, see Outside Events Sections OU-P, OU-Q and OU-R for discussion of these events											
Process water room PW-F-05	Linear kinetic - other (maintenance using crane through roof hatch)	Crane hooks piping during IXM replacement	Human error	IXM replacement is not anticipated during the lifetime of the facility. Therefore, IXM removal and replacement is not within the authorization basis of this safety analysis report.								
Process water room PW-F-07	Linear kinetic - other (maintenance gas bottles)	Gas bottles used for maintenance become missiles	Earthquake damage	A gas bottle may move but will not move enough to cause any damage.	Personnel injury, structure and/or equipment damage to the spare bay only, no damage to SSCs		F3	F3	Gas bottle design precludes missile hazard to facility SSCs and limits worker hazards by limiting the orifice size if valve is broken (bottle might move on floor but with little energy or velocity).	S1	S1	Gas bottles handled in accordance with approved procedure Bottle design precludes missile hazard

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 18 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process water room PW-G-03	Mass, gravity, height - lifts and cranes	IXM replacement requires a crane lift through a roof access panel	IXM dropped due to mechanical failure of the crane or human error	IXM replacement is not anticipated during the lifetime of the facility. Therefore, IXM removal and replacement is not within the authorization basis of this safety analysis report								
Process water room PW-G-14	Mass, gravity, height - other (roof hatch probably related to IXM replacement)	IXM replacement requires a crane lift through a roof access panel	Roof hatch dropped due to mechanical failure of the crane or human error	IXM replacement is not anticipated during the lifetime of the facility. Therefore, IXM removal and replacement is not within the authorization basis of this safety analysis report.								
Process water room PW-H-06	Pressure in process water system pipes and tanks	Spray and/or gaseous release from pressurized PWC components	Process upset, processing delay or equipment failure (pipe leaks or breaks)	Liquid spray release (L.1, DBA) Gaseous release (G.1)	Hydrogen and/or radioactive particulate release		F3	F3	HVAC systems provide confinement and filtration in process bays HVAC systems provide confinement and filtration in PWC room when PWC pump is operating	S2	S1	PWC room designed to contain spills Leak detection is present to detect spills to the floor. CAMs are present in the room.
Process water room PW-H-11	Pressure, volume - other	Helium pressure higher than expected	Cascading failure of regulators beginning with 3000 psi regulator failure	Overpressurization of the drain line possibly causing water hammer and failure of the drain line in the process water room with a resulting high-pressure helium blowdown	Particulate release	Safety relief valves installed on the helium supply.	F2	F0		S1	S1	HVAC systems provide confinement and filtration
Process water room PW-J-06	Explosives / pyrophorics - hydrogen	Hydrogen collects in receiver tanks	Process upset or delay Hydrogen collects during MCO draining Inadequate or loss of local exhaust ventilation flow	External hydrogen explosion	Hydrogen mixes with air in receiver tanks to create a flammable environment then ignites		F1	F1	HVAC systems provide confinement and filtration	S1	S1	SCIC actuates SCHe on purge time limit SCHe establishes He flow through the MCO directly to local exhaust MCO and SCHe confinement design The PWC drain line and receiver tank are purged with helium prior to MCO draining Pressure purge of MCO to dilute H_2 prior to drain
Process water room PW-J-10 PW-J-12	Explosives / pyrophorics - plutonium and uranium metal	Air ingress into the IXM (normal operations)	Mechanical failure	IXM explosion due to air-hydride or water-hydride reactions		Hydride reactions do not create enough hydrogen to generate an explosion (see HNF-2786[a])	F0					Room provides confinement, including general exhaust ventilation with HEPA filtration.
Process water room PW-K-02 PW-K-04 PW-K-08 PW-K-15	Nuclear criticality	These hazards are addressed and analyzed in the CVDF FSAR,[f] Chapter 6.0 and HNF-SD-SNF-CSER-006[b]										

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 19 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Process water room PW-L-02 PW-L-08 PW-L-14 PW-L-16	Flammable materials - rags, buildings and contents, propane, aerosol propellent	Ignition of flammable material within the process water room	Human error Mechanical failure	Liquid spray release as a result of fire damage to equipment (L.2)	Spray release into PWC room (process water)	Combustible loading requirements from the FHA[a] are imposed	F2	F2	HVAC systems provide confinement and filtration	S2	S1	Fire protection system is present (sprinklers)
Process water room PW-L-11	Flammable materials - hydrogen	Hydrogen collects in receiver tanks	Process upset or delay Hydrogen collects during MCO draining Inadequate or loss of local exhaust ventilation	External hydrogen explosion	Hydrogen mixes with air in receiver tanks to create a flammable environment, then ignites		F1	F1	HVAC systems provide confinement and filtration	S1	S1	MCO and SCHe confinement design The PWC drain line and receiver tank are purged with helium prior to MCO draining Pressure purge of MCO to dilute H_2 prior to drain
Process water room PW-M-08	Hazardous materials - heavy metals (TRU)	Radiological guidelines are more limiting than toxicological limits, see HNF-SD-SNF-TI-059[e]										
Process water room PW-N-01	Ionizing radiation sources - radioactive material	Radioactive liquid release from process water system piping and tanks	Processing upsets or delays, equipment failure, pipe break or leaks, pump leaks	Liquid spray release (L.1)	Radioactive particulate release		F3	F3	HVAC systems provide confinement and filtration in process bays HVAC systems provide confinement and filtration in PWC room when PWC pump is operating	S2	S1	PWC room designed to contain spills Leak detection is present to detect spills to the floor. CAMs are present in the room.
Process water room PW-N-03a	Ionizing radiation sources - radioactive material	Direct radiation	Collection of radioactive liquid within the process tanks or lines	Normal operations	Increased risk of exposure near the line		F3	F3		S1	S1	Area radiation monitors are provided within the PWC room. A survey program to periodically survey the process lines will be in place This is primarily an ALARA concern.
Process water room PW-P-01 PW-P-02 PW-P-03 PW-Q-01 PW-Q-02 PW-Q-04 PW-R-01 -- R-10	Various external events affecting the process water room, see Outside Events Sections OU-P, OU-Q and OU-R for discussion of these events											
Outside OU-F-01	Linear kinetic - cars, trucks, buses (helium delivery truck)	Impact with the facility	Human error Mechanical failure	Truck strikes facility	Facility design precludes damage to equipment required for safe shutdown from these events		F3	F3		S0	S0	Interior bay walls are 4- to 6-in.-thick concrete Rear bay walls are 8-in.-thick concrete Truck drivers are trained in the proper use of onsite vehicles
Outside OU-K-02 OU-K-15	Nuclear criticality - temporary storage areas, other (drain tank)	These hazards are addressed and analyzed in the CVDF FSAR, Chapter 6.0.[f]										

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 20 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-L-01 -- L-07 OU-L-09 OU-L-10 OU-L-13 -- I-16	Flammable materials	Outside fires are analyzed in OU-P-02a and OU-P-02b										
Outside OU-P-01	External events - explosion	External pressure on bay walls	Fuel truck accident / explosion Helium tank overpressure Forklift propane tank explosion	Impact on process or shutdown systems Impact on personnel	Loss of MCS in the bay Loss of power in the bay Loss of support systems in the bay Personnel injury Spread of contamination	Pressure vessels and tanks are built to industry standards . The facility location is remote, reducing the likelihood of occurrence.	F2	F2		S1	S1	HVAC systems provide confinement and filtration SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design
Outside OU-P-02a (related to process bays)	External events - fire	Fire external to facility introduces heat and smoke, or fire enters bay igniting flammable material within the process bays	Human error Mechanical failure Natural phenomena (range file) Flammable materials ignite	Gaseous release from MCO (G.4) External hydrogen explosion (E.6) Thermal runaway reaction (T.3) MCO overpressurization (P.5)	Equipment damage leading to process upsets resulting in radioactive particulate release	The facility location is remote, reducing the likelihood of occurrence TSR -- limits on combustible loading in bay	F2	F0		S2	S2	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Cask-MCO AND SCHe confinement design Facility evacuation to protect workers Fire protection system present in each bay Fire suppression present in all adjacent areas Area surrounding building is controlled to limit combustible material and plants
Outside OU-P-02b (related to all facility areas except process bays)	External events - fire	Fire external to facility introduces heat and smoke, fire spreads into transfer corridor / mechanical room	Human error Mechanical failure Natural phenomena (range file) Flammable materials ignite	Fire spreads through the facility	Equipment damage leading to process upsets resulting in radioactive particulate release Personnel injury	SCIC function for safe shutdown does not rely on input from the transfer corridor or mechanical room shutdown Equipment in the mechanical room required for safe shutdown is designed to environmental qualifications The facility location is remote, reducing the likelihood of occurrence	F2	F2	Fire sprinklers, alarm and fire department response	S1	S1	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Cask-MCO AND SCIC confinement design FHA[a] addresses combustible limits for stored materials Facility evacuation to protect workers Fire suppression present in all adjacent areas Area surrounding building is controlled to limit combustible material and plants

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 21 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-P-03	External events - other sites	Accident at another facility	Various (identified in each facility-specific FSAR)	None that impact CVDF operations -- analysis concludes								
OU-P-04	External events - Loss of power	Hydrogen forms	Loss of helium purge Process upsets MCO bottled up	Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.1) MCO overpressurization (P.2)	Hydrogen and/or radioactive particulate release	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design SCIC fail-safe design 30 lb/in^2 gauge rupture disk	F3	F0	Standby electrical power for ventilation system HVAC systems provide confinement, dilution, and filtration 150 lb/in^2 gauge rupture	S3	S1	10 lb/in^2 process relief valve
Outside OU-Q-01 OU-Q-02	Vehicles in motion - airplane, helicopter	Aircraft impact	Human error Mechanical failure	Aircraft impacts facility structure and/or key process systems	An assessment of aircraft impact frequency for the CVDF within Chapter 1.0 of the CVDF FSAR[i] concluded that such an event is beyond extremely unlikely.		F0					
Outside OU-Q-04	Vehicles in motion - truck, bus, car	Impact with the facility	Human error Mechanical failure	Truck strikes facility	Facility design precludes damage to equipment required for safe shutdown from these events		F3	F3		S0	S0	Interior bay walls are 4- to 6-in.-thick concrete Rear bay walls are 8-in.-thick concrete Truck drivers are trained in the proper use of onsite vehicles.
Outside OU-R-01a	Natural phenomena - earthquake (DBE)	Fuel reaction due to damage caused by seismic event	Earthquake causes process upset, equipment damage, loss of ventilation and/or trailer movement	Gaseous release (G.3) Internal hydrogen explosion (I.6) External hydrogen explosion (E.8) Thermal runaway reaction (T.6) MCO overpressurization (P.4)	Hydrogen and/or radioactive particulate release	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO and vents to local exhaust Cask-MCO design withstands internal explosion energy TSR – Trailer placement in bay to support seismic calculations	F2	F0	HVAC systems provide confinement, dilution and filtration TSR -- Process vent HEPA filter loading TWS annulus antisiphon valves and refill piping and parts	S3	S1	Workers are trained in emergency response procedures applicable to seismic events to place the facility in a safe-shutdown condition 10 lb/in^2 process relief valve
Outside OU-R-01b (related to process water room)	Natural phenomena - earthquake (DBE)	Acceleration forces exerted on the facility	Earthquake causes damage to process lines or tanks	Liquid spray release (L.3)	Break in process lines or tanks causes contaminated water spray release in PWC Room		F2	F2	Seismic shutdown switch for PWC pump	S2	S1	HVAC systems provide confinement and dilution

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 22 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-02 OU-R-04	Natural phenomena - flood, rain	Water introduction into facility Water intrusion into process bays Fire sprinkler actuation or pipe break	Natural phenomena	Loss of power to key facility systems causing potential for: Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.1) MCO overpressurization (P.1)	Hydrogen and/or radioactive particulate release	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design SCIC fail-safe design 30 lb/in² gauge rupture disk	F3	F0	Standby electrical power for ventilation system HVAC systems provide confinement and dilution 150 lb/in² gauge rupture disk	S3	S1	
Outside OU-R-03	Natural phenomena - lightning	Electrical surge	Natural phenomena	Loss of power to key facility systems causing potential for: Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.1) MCO overpressurization (P.2)	Hydrogen and/or radioactive particulate release	Facility designed to NFPA 780 for lightning protection. SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO MCO and SCHe confinement design SCIC fail-safe design 30 lb/in² gauge rupture disk	F2	F0	Standby electrical power for ventilation system HVAC systems provide confinement and dilution 150 lb/in² gauge rupture disk	S3	S1	
Outside OU-R-05	Natural phenomena - freezing weather	Low temperatures	Extreme cold weather	Loss of power	Cask annulus and MCO freezing causes loss of primary confinement leading to particulate release	Standby power	F2	F0	SCIC detects process upset initiating SCHe, which isolates MCO from process piping and establishes helium supply to the MCO Cask-MCO and SCIC confinement design	S2		HVAC systems provide confinement, dilution and filtration Facility emergency response procedure/guide will address loss of power in cold weather
Outside OU-R-05 OU-R-09	Natural phenomena - snow, ashfall	Excessive roof loading	Natural phenomena	Roof collapse	Personnel injury Loss of ventilation Loss of MCS control Loss of power Process upsets leading to fuel reactions with air and/or water	Building designed to withstand design basis snow loads and ashfall loads	F3	F0		S3	S3	
Outside OU-R-06 OU-R-07 OU-R-08	Natural phenomena - straight winds, dust devils, tornados	Pressure differentials and missile strikes	Wind and loose debris	Wall or roof collapse Missile impacts upon the facility	Loss of MCS control Loss of power Damage to process systems Process upsets leading to fuel reactions with air and/or water	Facility structure is designed to withstand design basis loads	F2	F0		S3		Process bay doors are closed prior to processing operations.

Table A2-1. Cold Vacuum Drying Facility Hazard Analysis. (sheet 23 of 23)

Checklist entry	Hazard energy source/ material	Hazardous condition	Cause	Potential accident	Consequence	Credited prevention	Frequency		Credited mitigation	Consequence		Defense-in-depth or worker safety features
							Without prevention	With prevention		Without mitigation	With mitigation	
Outside OU-R-10	Natural phenomena - range fire	Range fires. and other outside fires, are addressed in OU-P-02a and OU-P-02b.										

[a] SNF-4268, 1999, *Fire Hazard Analysis for the Cold Vacuum Drying Facility*, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[b] HNF-SD-TP-SARP-017, 2000, *Safety Analysis Report for Packaging (Onsite) Multi-Canister Overpack Cask*, Rev. 2, Fluor Hanford, Incorporated, Richland, Washington.
[c] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex A, "Canister Storage Building Final Safety Analysis Report," Rev. 0, Fluor Hanford, Incorporated, Richland, Washington.
[d] HNF-SD-SNF-DP-007, 1997, *Multi-Canister Overpack/Cask Drop Analysis File Documentation*, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[e] HNF-2786, 1999, *Assessment of Potential for Rapid Ignition of Submerged N Reactor Fuel*, Rev. 0, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[f] HNF-3553, 2000, *Spent Nuclear Fuel Project Final Safety Analysis Report*, Annex B, "Cold Vacuum Drying Facility Final Safety Analysis Report," Rev. 1, Fluor Hanford, Incorporated, Richland, Washington.
[g] HNF-SD-SNF-TI-059, 1999, *Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, Rev. 2, Fluor Daniel Hanford, Incorporated, Richland, Washington.
[h] HNF-SD-SNF-CSER-006, 2000, *Criticality Safety Evaluation Report for the Cold Vacuum Drying Facility's Process Water Handling System*, Rev. 3, Fluor Hanford, Incorporated, Richland, Washington.
[i] NFPA 780, 1995, *Lightning Protection Systems*, National Fire Protection Association, Quincy, Massachusetts.

ALARA = as low as reasonably achievable.
CAM = continuous air monitor.
CSB = Canister Storage Building.
CVDF = Cold Vacuum Drying Facility.
DBA = design basis accident.
DBE = design basis earthquake.
FHA = fire hazard analysis.
FSAR = final safety analysis report
GSHe = general-service helium.
HEPA = high-efficiency particulate air (filter).
HVAC = heating, ventilation, and air conditioning.
IXM = ion exchange module.
MCO = multi-canister overpack.
MCS = monitoring and control system
PWC = process water conditioning.
SARP = safety analysis report for packaging
SCHe = safety-class helium.
SCIC = safety-class instrumentation and control
SSC = structure, system, and component
TRU = transuranic.
TSR = technical safety requirement
TW = tempered water.

ATTACHMENT 3

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

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

	S1	S2	S3
F3	4	7	9*
F2	2	5	8*
F1	1	3	6*

Combinations that identify situations of major concern

Combinations that identify situations of concern

*These situations are either prevented or mitigated by safety class features.

Table A3-1. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (sheet 1 of 8)

Checklist designators	Hazard energy source	Hazardous condition and initiator(s)	Bin	Frequency / consequence categories	Risk ranking
TC-J-12	Explosive gases	Hydrogen deflagration inside the ventilation ducts due to collection of gases used during maintenance activity, deflagration disperses HEPA filter contents	External explosion (E.6)	F3/S2	7
TC-R-01	Natural phenomena - earthquake (equal to or less than the DBE)	Fuel reactions due to equipment damage caused by seismic event.	Gaseous releases (G.3) External hydrogen explosion (E.8)	F2/S2	5
PB-B-02a	Thermal - electrical equipment	HVAC failure causes bay temperatures in excess of electrical equipment design limits, condition occurs with annulus water flow	Internal hydrogen explosion (I.2) External hydrogen explosion (E.2)	F3/S2	7
PB-B-02b	Thermal - electric equipment	HVAC failure causes bay temperatures in excess of electrical equipment design limits, condition occurs without annulus water flow	Thermal runaway reaction (T.2)	F3/S3	9
PB-B-02c	Thermal - electric equipment	HVAC failure causes bay temperatures below electrical equipment design limits	Internal hydrogen explosion (I.2) External hydrogen explosion (E.2)	F3/S2	7
PB-B-03a	Thermal - heaters	Tempered water heated to temperatures above 50° C from mechanical or software failure resulting in loss of tempered water heat control.	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4) Thermal Runaway reaction (T.2) MCO overpressurization (P.1)	F3/S3	9
PB-B-03b	Thermal - tempered water heater	Insufficient heating of tempered water due to software failure or human error in programming resulting in inaccurate heater control leading to potential for inaccurate pressure rebound test and proof of dryness demonstration. Excessive water remains in MCO to react with fuel.	External hydrogen explosion (E.3) Hydrogen generation and potential for runaway at the CSB	F2/S2	5

Table A3-1. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (sheet 2 of 8)

Checklist designators	Hazard energy source	Hazardous condition and initiator(s)	Bin	Frequency / consequence categories	Risk ranking
PB-B-13a	Thermal - MCO contents	Process line failure, HVAC or process upset causing significant air ingress into MCO. Air ingress with high fuel temperatures present.	Internal hydrogen explosion (I.1) Gaseous release (G.1) External hydrogen explosion (E.4)	F3/S2	7
PB-B-13b	Thermal - MCO contents	Leak back of water into MCO while fuel temperatures are high. Fuel reacts with water.	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4)	F3/S2	7
PB-B-13c	Thermal - MCO contents	Low tempered water level, or loss of tempered water, from cask annulus raises fuel temperatures and accelerates fuel temperature and reaction with water.	External hydrogen explosion (E.4) Thermal runaway reaction (T.1) MCO overpressurization (P.1)	F3/S3	9
PB-B-13d	Thermal - MCO contents	Hydrogen release due to excessive free water in the MCO during (or after) the proof of dryness demonstration initiated by an inadequate pressure rebound test, inadequate drying, or human error	External hydrogen explosion (E3.) Thermal runaway reaction (T.1) MCO overpressurization (P.1)	F3/S3	9
PB-B-13g	Thermal - MCO contents	High fuel temperatures on receipt due to improper fuel loading at Basin or leakage, leads to increased water fuel reaction and increased hydrogen production, deflagration when cask is vented.	External hydrogen explosion (E.1)	F3/S2	7
PB-F-02a	Linear kinetic - forklifts, dollies, carts	Fork lift in empty bay strikes equipment causing process support system or utility system, causes process upset	Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.4) MCO overpressurization (P.2)	F3/S3	9

Table A3-1. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (sheet 3 of 8)

Checklist designators	Hazard energy source	Hazardous condition and initiator(s)	Bin	Frequency / consequence categories	Risk ranking
PB-F-05	Linear kinetic - crane loads	Crane load impacts or drops on instrument air line, normal helium supply line, electrical panel, or demin water line during processing	Gaseous release (G.1) Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.4)	F3/S3	9
PB-H-06d	Pressure, volume - pressure vessels	Pressurized MCO/VPS develops small undiscovered, long term leak	Gaseous release (G.1)	F3/S2	7
PB-H-06f	Pressure, volume - pressure vessels	Pressurized releases from an MCO during vacuum drying, process line failure or HVAC failure allows air ingress	Gaseous release (G.1) External hydrogen explosion (E.4)	F3/S2	7
PB-H-06g	Pressure, volume - pressure vessels	Particulate releases from HEPA filters on the local and general exhaust ventilation systems through the exhaust stack initiated by excessive pressure differential	Gaseous release (G.1)	F3/S2	7
PB-H-06h	Pressure, volume - pressure vessels	Particulate releases within a process bay initiated by failure of ventilation ductwork or loss of ventilation fans	Gaseous release (G.1)	F3/S2	7
PB-H-06i	Pressure, volume - pressure vessels	Hydrogen generation within MCO due to excessive delays in shipping	Gaseous release (G.2) External hydrogen (E.4)	F2/S2	5
PB-H-06k	Pressurized MCO	Fuel reacts with contaminates in purge gas, or with air or other contaminates due to lack of proper purging of lines following maintenance	Internal hydrogen explosion (I.7) External hydrogen explosion (E.7) Thermal runaway reaction (T.5)	F2/S2	5
PB-H-08	Pressure, volume - vacuum	Degraded vacuum pump operation leads to increased fuel temperatures and reactions forming hydrogen	Thermal runaway reaction (T.1)	F3/S3	9

Table A3-1. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (sheet 4 of 8)

Checklist designators	Hazard energy source	Hazardous condition and initiator(s)	Bin	Frequency / consequence categories	Risk ranking
PB-H-11a	Pressure, volume - other (pressurized helium recirculation system)	Pressurized release of particulate from an MCO initiated by excessive pressure in the normal helium supply	MCO overpressurization (P.3)	F2/S2	5
PB-H-11d	Pressure, volume - other (water addition to the MCO)	Water addition into MCO while drying or testing from deionized water, vacuum pump cooling water, or bulk water addition, results water fuel reaction, heat and hydrogen	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4)	F3/S2	7
PB-H-11e	Pressure, volume - other (water addition to the MCO)	Water addition into MCO while drying or testing due to isolation valves not closing fully, results in water fuel reaction, heat and hydrogen	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4)	F3/S2	7
PB-H-11f	Pressure, volume - other (water addition to the MCO)	Water addition into MCO while drying or testing because of isolation valves not closing fully results in water–fuel reaction, heat, and hydrogen.	Thermal runaway reaction (T.4) MCO overpressurization (P.1)	F1/S3	6
PB-L-01 PB-L-02 PB-L-03 PB-L-04 PB-L-05 PB-L-06 PB-L-07 PB-L-08 PB-L-09 PB-L-10 PB-L-13 PB-L-14 PB-L-15 PB-L-16	Flammable materials	Fire in the bay damages equipment	Internal hydrogen explosion (I.3) External hydrogen explosion (E.6) Thermal runaway reaction (T.3)	F2/S2	5
PB-L-11a	Flammable materials - hydrogen	Flammable atmosphere developing in local exhaust ventilation system due to hydrogen in cask upon receipt and venting	External hydrogen explosion (E.1)	F3/S2	7

Table A3-1. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (sheet 5 of 8)

Checklist designators	Hazard energy source	Hazardous condition and initiator(s)	Bin	Frequency / consequence categories	Risk ranking
PB-L-11d	Flammable materials - hydrogen	Flammable atmosphere developing within MCO during drain prior to breakthrough with air ingress	Internal hydrogen explosion (I.1) External hydrogen explosion (E.4)	F2/S2	5
PB-L-11e	Flammable materials - hydrogen	Flammable atmosphere developing around the MCO or within cask–MCO during shipping prep due to improper valve plug seating, inadequate processing, or water introduction after the proof of dryness demonstration.	External hydrogen explosion (E.4)	F2/S0	0
PB-L-11f	Flammable materials - hydrogen	Flammable atmosphere developing within the local exhaust from SCIC actuation, local exhaust not running, during heat-up and drain modes	External hydrogen explosion (E.2)	F2/S2	5
PB-N-01	Ionizing radiation sources - fissile/radioactive material	Failure of drain line in process bay with the door open while draining an upstream bay. Gaseous release due to helium purge out of break.	Gaseous Release (G.1)	F2/S2	5
PB-P-02	External events - fire	Failure of key process systems within the process bays initiated by an external fire spreading to the facility	External hydrogen explosion (E.6) Thermal runaway reaction (T.3)	F2/S2	5
PB-R-01a	Natural phenomena - earthquake	Earthquake causes process upset, equipment damage, loss of ventilation and/or trailer movement	Gaseous release (G.3) Internal hydrogen explosion (I.6) External hydrogen explosion (E.8) Thermal runaway reaction (T.6) MCO overpressurization (P.4)	F2/S3	8
PB-R-05	Natural phenomena- snow, freezing weather	HVAC failure of loss of site power on an extremely cold day causes bay temperatures below electrical equipment design limits	Internal hydrogen explosion (I/2) External hydrogen explosion (E.2)	F3/S2	7

Table A3-1. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (sheet 6 of 8)

Checklist designators	Hazard energy source	Hazardous condition and initiator(s)	Bin	Frequency / consequence categories	Risk ranking
SB-F-01b SB-F-02b	Linear kinetic - cars, trucks, buses, forklifts, dollies, carts	Vehicle or forklift impacts equipment or structure in empty bay causing process upset or loss of utility system.	Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.4) MCO overpressurization (P.2)	F3/S3	9
SB-N-01	Ionizing radiation sources - radioactive material	Release of contaminated liquid into the spare bay to a PWC drain line failure. Gaseous release due to purge flow exiting the break.	Gaseous release (G.1)	F2/S2	5
PW-H-06	Pressure in PWC pipes and tanks	Equipment failure causes spray and/or gaseous release from PWC components	Gaseous release (G.1) Liquid spray release (L.1)	F3/S2	7
PW-L-02 PW-L-08 PW-L-14 PW-L-16	Flammable materials	Ignition of flammable materials within the PWC room results in equipment damage and leak.	Liquid spray release (L2)	F2/S2	5
PW-N-01	Ionizing radiation sources - fissile/radioactive material	Radioactive liquid release from process PWC equipment.	Liquid spray release (L.1)	F3/S2	7
OU-P-02a	External events - fire	Fire causes equipment damage leading to process upsets	External hydrogen explosion (E.6) Thermal runaway reaction (T.3)	F2/S2	5
OU-P-04	External events - loss of power	Loss of power causes process upsets, hydrogen forms	Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.1) MCO overpressurization (P.2)	F3/S3	9

Table A3-1. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (sheet 7 of 8)

Checklist designators	Hazard energy source	Hazardous condition and initiator(s)	Bin	Frequency / consequence categories	Risk ranking
OU-R-01a	Natural phenomena - DBE	Fuel reacts with water or air due to damage from earthquake	Gaseous release (G.3) Internal hydrogen explosion (I.6) External hydrogen explosion (E.8) Thermal runaway reaction (T.6) MCO overpressurization (P.4)	F2/S3	8
OU-R-01b	Natural phenomena - DBE (related to the PWC room)	Earthquake causes damage to equipments, lines or tanks	Liquid spray release (L.3)	F2/S2	5
OU-R-02 OU-R-04	Natural phenomena - Flood, rain	Water is introduced into the facility, into process bays causing system upsets	Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.1) MCO overpressurization (P.1)	F3/S3	9
OU-R-03	Natural phenomena - lightning	Lightning strike on the facility causes power loss, process upsets with hydrogen forming	Internal hydrogen explosion (I.5) External hydrogen explosion (E.5) Thermal runaway reaction (T.1) MCO overpressurization (P.2)		
OU-R-02 OU-R-04	Natural phenomena - flood, rain	Runaway reactions in multiple MCOs due to a loss of facility power initiated by water intrusion from floods or rain	Runaway reactions in multiple MCOs	S3/F2	8
OU-R-03	Natural phenomena - lightning	Runaway reactions in multiple MCOs due to a loss of facility power or process control initiated by electrical surges due to lightning	Runaway reactions in multiple MCOs	S3/F2	8

Table A3-1. Release Characteristics for Hazardous Conditions Associated with Offsite (Site Boundary) and Onsite (Collocated Worker) Receptors. (sheet 8 of 8)

Checklist designators	Hazard energy source	Hazardous condition and initiator(s)	Bin	Frequency / consequence categories	Risk ranking
OU-R-05	Natural phenomena - freezing weather	Runaway reactions in multiple MCOs due to a loss of facility power initiated by freezing weather	Runaway reactions in multiple MCOs	S3/F3	9
OU-R-05 OU-R-09	Natural phenomena - snow, ashfall	Runaway reactions in multiple MCOs due to a loss of process control and facility power initiated by snow or ashfall	Runaway reactions in multiple MCOs	S3/F3	9
OU-R-06 OU-R-07 OU-R-08	Natural phenomena - straight winds, dust devils, tornados	Runaway reactions in multiple MCOs due to a loss of facility power or process control initiated by straight winds or tornados (wind and/or missiles)	Runaway reactions in multiple MCOs	S3/F2	8

CSB = Canister Storage Building.
DBE = design basis earthquake.
HEPA = high-efficiency particulate air (filter).
HVAC = heating, ventilation, and air conditioning.
MCO = multi-canister overpack.
PWC = process water conditioning.
SCIC = safety-class instrumentation and control.
VPS = vacuum purge system.

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ATTACHMENT 4

BINNED LISTING OF CANDIDATE ACCIDENTS SORTED BY RISK RANKING

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Table A4-1. Binned Listing of Candidate Accidents Sorted by Risk Ranking. (4 sheets)

	Candidate accident	Initiator type[a]	Frequency/ consequence categories[b]	Hazard analysis checklist designator[c]
	Gaseous releases (Section B3.4.2.1)			
G.1	Gaseous release due to process line failure or HVAC failure[d]	O	F3/S2	PB-B-13a PB-F-05 PB-H-06d PB-H-06f[d] PB-H-06g PB-H-06h PB-N-01 PW-H-06 SB-N-01
G.2	Gaseous release due to delays in shipping from the CVDF	O	F2/S2	PB-H-06i
G.3	Gaseous release due to line break caused by a seismic event	NP	F2/S2	TC-R-01 PB-R-01a OU-R-01a
G.4	Gaseous release due to facility fire	O	F2/S2	PB-L-01 PB-L-02 PB-L-03 PB-L-04 PB-L-05 PB-L-06 PB-L-07 PB-L-08 PB-L-09 PB-L-10 PB-L-13 PB-L-14 PB-L-15 PB-L-16 PB-P-02 OU-P-02a
	Liquid releases (Section B3.4.2.2)			
L.1	Spray release due to piping failures[d]	O, EI	F2/S2	PW-N-01 PW-H-06[d]
L.2	Spray release due to fire	O	F2/S2	PW-L-02 PW-L-08 PW-L-14 PW-L-16
L.3	Spray release due to a seismic event	NP	F2/S2	OU-R-01b
	MCO external hydrogen explosions (Section B3.4.2.3)			
E.1	Hydrogen explosion outside an MCO due to hydrogen generation within the cask[d]	O	F3/S2	PB-B-13g PB-L-11a[d]
E.2	Hydrogen explosion outside an MCO due to instrumentation failure	O	F3/S2	PB-B-02a PB-B-02c PB-L-11f PB-R-05
E.3	Hydrogen explosion outside an MCO due to excessive water in MCO	O	F3/S2	PB-B-03b PB-B-13d
E.4	Hydrogen explosion outside an MCO due to process upset of key parameters	O, NP, EI	F3/S2	PB-B-03a PB-B-13a PB-B-13b PB-B-13c PB-H-06f PB-H-06i PB-H-11d PB-H-11e PB-L-11d PB-L-11e

Table A4-1. Binned Listing of Candidate Accidents Sorted by Risk Ranking. (4 sheets)

	Candidate accident	Initiator type[a]	Frequency/ consequence categories[b]	Hazard analysis checklist designator[c]
E.5	Hydrogen explosion outside an MCO due to loss of support utilities	O, NP, EI	F3/S2	PB-F-02a, PB-F-05, SB-F-01b, SB-F-02b, OU-P-04, OU-R-02, OU-R-03, OU-R-04
E.6	Hydrogen explosion outside an MCO due to facility fire	O	F2/S2	PB-L-01, PB-L-02, PB-L-03, PB-L-04, PB-L-05, PB-L-06, PB-L-07, PB-L-08, PB-L-09, PB-L-10, PB-L-13, PB-L-14, PB-L-15, PB-L-16, PB-P-02, TC-J-12, OU-P-02a
E.7	Hydrogen explosion outside an MCO due to contamination of helium supply	O	F2/S2	PB-H-06k
E.8	Hydrogen explosion outside an MCO due to line break caused by a seismic event	NP	F2/S2	TC-R-01, PB-R-01a, OU-R-01a
	MCO internal hydrogen explosions (Section B3.4.2.4)			
I.1	Hydrogen explosion within an MCO due to process upset of key parameters (significant air ingress into the MCO)[d]	O, NP, EI	F3/S2	PB-B-03a, PB-B-13a[d], PB-B-13b, PB-H-11d, PB-H-11e, PB-L-11d
I.2	Hydrogen explosion within an MCO due to instrumentation failure (significant air ingress into the MCO)	O	F3/S2	PB-B-02a, PB-B-02c, PB-R-05
I.3	Hydrogen explosion within an MCO due to loss of MCO control caused by facility fire (significant air ingress into the MCO)	O	F2/S2	PB-L-01, PB-L-02, PB-L-03, PB-L-04, PB-L-05, PB-L-06, PB-L-07, PB-L-08, PB-L-09, PB-L-10, PB-L-13, PB-L-14, PB-L-15, PB-L-16
I.4	Hydrogen explosion within an MCO due to hydride reaction	O	F0/S2[e]	PB-J-12
I.5	Hydrogen explosion within an MCO due to loss of support utilities (significant air ingress into the MCO)	O, NP, EI	F3/S2	PB-F-02a, PB-F-05, SB-F-01b, SB-F-02b, OU-P-04, OU-R-02, OU-R-03, OU-R-04

Table A4-1. Binned Listing of Candidate Accidents Sorted by Risk Ranking. (4 sheets)

	Candidate accident	Initiator type[a]	Frequency/ consequence categories[b]	Hazard analysis checklist designator[c]
I.6	Hydrogen explosion within an MCO due to line break caused by a seismic event	NP	F2/S2	PB-R-01a OU-R-01a
I.7	Hydrogen explosion within an MCO due to contamination of helium supply	O	F2/S2	PB-H-06k
	MCO thermal runaway reactions (Section B3.4.2.5)			
T.1	Thermal runaway reaction due to internal process upset of key parameters[d]	O, NP, EI	F3/S3	PB-B-13c[d] OU-R-02 PB-B-13d OU-R-03 PB-H-08 OU-R-04 OU-P-04
T.2	Thermal runaway reaction in MCO due to instrumentation failure	O	F3/S3	PB-B-02b PN-B-03a
T.3	Thermal runaway reaction in MCO due to loss of MCO control caused by facility fire	O	F3/S3	PB-L-01 PB-L-09 PB-L-02 PB-L-10 PB-L-03 PB-L-13 PB-L-04 PB-L-14 PB-L-05 PB-L-15 PB-L-06 PB-L-16 PB-L-07 PB-P-02 PB-L-08 OU-P-02a
T.4	Thermal runaway reaction in MCO due to loss of support utilities	O, NP, EI	F3/S3	PB-F-02a SB-F-01b PB-F-05 SB-F-02b PB-H-11f
T.5	Thermal runaway reaction in MCO due to contamination of helium supply	O	F2/S2	PB-H-06k
T.6	Thermal runaway reaction in MCO due to line break caused by a seismic event	NP	F2/S3	PB-R-01a OU-R-01a
	MCO overpressurization (Section B3.4.2.6)			
P.1	Overpressurization due to internal process upset of key parameters[d]	O	F3/S3	PB-B-03a PB-H-11f PB-B-13c[d] OU-R-02 PB-B-13d OU-R-04
P.2	Overpressurization due to loss of support utilities	O, NP, EI	F2/S3	PB-F-02a OU-P-04 SB-F-01b OU-R-03 SB-F-02b

Table A4-1. Binned Listing of Candidate Accidents Sorted by Risk Ranking. (4 sheets)

	Candidate accident	Initiator type[a]	Frequency/ consequence categories[b]	Hazard analysis checklist designator[c]	
P.3	Overpressurization due to excessive helium supply pressure	O	F2/S2	PB-H-11a	
P.4	Overpressurization due to a line break caused by a seismic event	NP	F2/S3	PB-R-01a	OU-R-01a
P.5	Overpressurization caused by facility fire	O	F3/S3	PB-L-01 PB-L-02 PB-L-03 PB-L-04 PB-L-05 PB-L-06 PB-L-07 PB-L-08	PB-L-09 PB-L-10 PB-L-13 PB-L-14 PB-L-15 PB-L-16 PB-P-02 OU-P-02a

[a]O = operational; NP = natural phenomena; EI= externally initiated.

[b]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).
F0 = Beyond extremely unlikely (not credible).
F2 = Foreseeable, but unlikely.
F3 = Likely to occur during the lifetime of the facility.

[c]Hazard analysis checklist designators are described in Section 3.1.

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

[e]Normally F0 events are excluded from the accident bins, but the hydride reaction as an independent initiator is identified explicitly to demonstrate that it has been considered. Hydride reactions are included in the calculations for other design basis accidents.

CVDF = Cold Vacuum Drying Facility.
HVAC = heating, ventilation, and air conditioning.
MCO = multi-canister overpack.

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