2. To: (Receiving Organization) Distribution		3. From: (Originating Organization) CVDF W-441		4. Related EDT No.: N/A				
5. Proj./Prog./Dept./Div.: SNF Project/W-441		6. Design Authority/ Design Agent/Cog. Engr.: B. A. Crea		7. Purchase Order No.: N/A				
8. Originator Remarks: Generated for original release.				9. Equip./Component No.: NA				
				10. System/Bldg./Facility: 142-K/CVDF				
11. Receiver Remarks: 11A. Design Baseline Document? ☒ Yes ☒ No <i>108 11/10/99</i>				12. Major Assm. Dwg. No.: N/A				
				13. Permit/Permit Application No.: N/A				
				14. Required Response Date: N/A				
15. DATA TRANSMITTED								
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Design- nator	(G) Reason for Trans- mittal	(H) Originator Disposition	(I) Receiver Disposition
1	SNF-4955	ALL	0	Application of Seismic Design Requirement	S ^N Q	1	1	

16.										KEY									
Approval Designator (F)				Reason for Transmittal (G)						Disposition (H) & (I)									
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)				1. Approval 2. Release 3. Information		4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)				1. Approved 2. Approved w/comment 3. Disapproved w/comment		4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged							
17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)																			
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN								
1	1	Design Authority	S. A. Brisbin	11/10/99	R3-86	3		CVD Library	A. N. Artzer		R3-86								
1	/	Design Authority	J. J. Irwin	11/10/99	R3-86	3		CVD Satellite Library			X3-25								
1	1	Design Authority	C. R. Miska	11/10/99	R3-86	3		SNF Project Files			R3-11								
1	1	Design Authority	R. Whitehurst	11/10/99	R3-86	3		Startup Library			B2-64								
1	1	Cog. Mgr.	C. S. Haller	11/10/99	R3-11	1	1	Design Authority	E. Ocoma	11/10/99	B4-40								
1	1	QA	S. L. Mischke	11/10/99	R3-86														
1	1	Safety	J. R. Brehm	11/10/99	R3-26														

18. B. Crea Signature of EDT Date Originator	19. T. Choho Authorized Representative Date for Receiving Organization	20. C. Haller Design Authority/ Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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APPLICATION OF SEISMIC DESIGN REQUIREMENTS TO COLD VACUUM DRYING FACILITY STRUCTURES, SYSTEMS AND COMPONENTS

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

EDT/ECN: 627115

UC: 620

Org Code: 2G300

Charge Code: 105545BA00

B&R Code: 39EW40400

Total Pages: 1011

ja HMF50041

Key Words:

Application of Seismic Design Requirements to Cold Vacuum Drying Facility (CVDF) Structures, Systems and Components

Abstract:

The methodology followed in assignment of Performance Class (PC) for Natural Phenomena Hazards (NPH) seismic loads for Cold Vacuum Drying Facility (CVDF) Structures, Systems and Components is defined. The loading definition associated with each PC and structure, system and component is then defined.

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Janis Arada 11-15-99
Release Approval Date

Release Stamp

Approved For Public Release

**APPLICATION OF SEISMIC
DESIGN REQUIREMENTS TO
COLD VACUUM DRYING FACILITY
STRUCTURES, SYSTEMS AND COMPONENTS**

11/3/99

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Fluor Daniel Northwest, Inc.

October 1999

Introduction:

The Cold Vacuum Drying (CVD) Facility is a Hazard Classification 2, non-reactor nuclear facility. The mission of the CVD facility is to accept fuel from the K-Basins in multi-canister overpacks (MCOs) filled with water, drain the water, and dry the fuel using a vacuum drying process. Safety analysis of the facility and the processes has determined that the CVD facility has both safety-class and safety-significant equipment to protect the general public and the facility workers. Selected portions of the facility and its associated structures, systems and components (SSCs) are required to be functional or to retain pressure boundary or structural integrity following postulated seismic events. This document explains the methodology used to assign Performance Classification (PC) to CVD Facility SSCs. It also provides the associated loading definition for each PC.

Classification of SSCs:

Hazard analysis and bounding accident analysis for each class of accidents has been performed for the CVD facility. Hazard analysis (Ref. 1) identifies all the hazards within the facility (e.g., radiological, toxicological, industrial, offsite events, natural phenomena events, etc.). The hazard evaluation analysis process identified hazardous conditions, determined causes and preventive and mitigative features, and qualitatively estimated the consequences and frequencies of occurrence. The hazard analysis was performed in accordance with DOE-STD-3009-94 (Ref. 2) and implements the requirements of DOE Order 5480.23 (Ref. 3).

Accident analysis carries on the activities of hazard analysis, placing each similar type of accident within an accident bin. Enveloping accidents for each bin are analyzed and, if they bound a release category, become design basis accidents (DBAs). DBAs have been selected for the CVD to ensure that the range of accident scenarios analyzed represents a complete set of representative and bounding conditions. For the CVD, six bounding DBAs have been selected:

- Gaseous Release
- Liquid Release
- MCO external hydrogen explosion
- MCO internal hydrogen explosion
- MCO thermal runaway reaction
- MCO over pressurization

In all cases, the bounding DBAs for the CVD are either prevented, or represent relatively slow acting events with limited energy release (i.e., the DBAs for the CVD, unlike a commercial nuclear reactor, do not have long term energy drivers resulting in long-term release potentials). This permits relatively unsophisticated instrumentation and system responses, directed at filtering and containing (instead of dealing with the commercial reactor scenarios where long-term heat removal is critical to accident termination), and provides opportunity for manual intervention to interrupt accident precursor sequences or terminate events in progress.

Each of these accidents is analyzed to determine the events sequence associated with the accident, to determine the SSCs credited with prevention or mitigation of the accident, to determine the consequences of the accident, and compare the consequences to release limits and risk evaluation guidelines. SSCs, which prevent or mitigate the DBAs, are classified as follows:

- Safety Class (SC) - Those SSCs which prevent or mitigate radiological consequences above risk guidelines to the general public.
- Safety Significant (SS) - Those SSCs which prevent or mitigate radiological consequences above risk guidelines to the onsite worker; or which prevent or mitigate toxicological consequences to the general public or the onsite worker.
- General Service (GS) - Other SSCs.

For the CVD, certain DBA sequences are initiated by a seismic event, while others are not. Information on the initiating event sequences is provided in HNF-SD-SNF-HIE-004 (Ref. 1). SSCs required to prevent or mitigate DBAs are tabulated in the Safety Equipment List (SEL) (Ref. 12), which also indicates the Natural Phenomenon Hazard seismic qualification requirements for the SSC.

Seismic performance requirements are determined in accordance with DOE Standard 1021 (Ref. 4), through the assignment of Performance Categories (PC). When an SSC must operate or retain pressure boundary/structural integrity during and after a DBA accident sequence that includes a seismic event, the SSC is qualified to the seismic loading defined for the specified PC. Specifically for the CVD facility, SSCs classified as SC are either designed to accommodate the PC-3 earthquake, or are protected by a SC seismic trip. If the SSC is protected by the seismic trip, it is designated PC-1. This trip is activated at a fraction of the PC-3 acceleration values (0.05g per Ref. 11).

The seismic loading associated with each PC is as follows:

- PC-3 (Refer to WHC-SD-SNF-DB-010 (Ref. 9))
- PC-2* (Ref. 10, Table 1)
- PC-1* (for occupied facilities) (Ref. 10, Table 1)

* As defined for the Hanford Site, and for CVD, the seismic peak ground acceleration associated with PC-1 and PC-2 are identical (0.20g) (Ref. 7).

Performance Categorization for NPH Seismic Loads of CVD SSCs

Utilizing the guidance and methodology outlined above, CVD SSCs have been categorized with respect to:

- Safety Classification (SC, SS or GS)
- Safety Function (from the SSC function assumed in the DBA event tree):

- Must retain pressure boundary integrity during and/or after a seismic event
- Seismic 3/1 - must maintain structural integrity during and after a seismic event to preclude damage to higher classified equipment (i.e., PC-3 SC SSC)

Appropriate information regarding the classification and categorization of each SSC is provided in the CVD Safety Equipment List (SEL)/Master Equipment List (MEL).

Design/Qualification Requirements for CVD SSC:

- Safety Class SSC - SC SSC which must retain pressure boundary/structural integrity during and after a seismic event shall be designed for or tested to the loading defined by PC-3 seismic response spectra (as defined in ref 8). In-structure response spectra must be developed for SSCs supported by the structure. Qualification of components by testing shall be in accordance with IEEE-344 (Ref. 6). Where calculations form the basis for seismic qualification, such as for the basic structure, they shall be independently checked (i.e., independent verification) (Ref. 13).

For SC PC-3 equipment, procurement specification requirements mandate that the equipment supplier provide seismic qualification testing procedures that meet the requirements of IEEE-344 (Ref. 6) for project review and approval. The equipment must be qualified in accordance with the approved testing procedures, which are reviewed as part of the documentation package. This documentation package must be provided with the equipment and will be checked as part of equipment receipt inspection.

- Safety Significant SSC - SS SSC that must retain pressure boundary/structural integrity under seismic loading shall be designed to PC-2 requirements. These designs shall be performed in accordance with seismic accelerations specified in HNF-PRO-097, Rev. 0, "Engineering Design and Evaluation," (Ref 9). Anchorage of PC-2 systems, components, and equipment (SCE) shall be designed to the requirements of HNF-SD-GN-DGS-30006, "Guidelines for Assessing the Seismic Adequacy of Existing Performance Category Equipment at the Hanford Site," (Ref. 7).

A summary of these anchorage design requirements for SCE seismic loads based on the SCE location and rigidity follows:

<u>Location</u>	<u>Horizontal Seismic Acceleration</u>
At or below grade - Rigid	0.15g
Above grade - Rigid	0.23g
At or below grade - Flexible	0.30g
Above grade - Flexible	0.45g

For SS passive equipment (e.g., equipment operation is not assumed as part of the event tree), qualification consists of specific design features which provide assurance that the equipment anchorage will not fail. Where calculations are used for seismic qualification, they shall be checked by a qualified engineering professional, who may be part of the project team (Ref. 13).

The active (e.g., the component must operate (e.g., a fan) or be able to change position (e.g., a damper)) SS equipment contained in the CVDF is not required to remain functional following a seismic event. Design/Qualification of it is limited to 3/1 types of evaluation to ensure that failure of mounting provisions or release of stored energy (such as in the wheel of a fan) doesn't damage SC equipment or provide a hazard to facility personnel.

For SS equipment whose failure (e.g., falling, tipping, etc.) during a seismic event may damage SC equipment, evaluation is performed in accordance with HNF-SD-GN-DGS-30006 (Ref. 7) for "Seismic 3/1." This evaluation is performed based upon conservative ground acceleration values (e.g., the peak ground acceleration assumed is 0.35g) and conservative building response for the PC-3 seismic event. Note that the PC-3 seismic value is based upon conservative Hanford Site envelope criteria, and is not indicative of a disconnect or erroneous compilation relative to the PC-3 values specified for SC equipment. Refer to Section 2 of Reference 6 for a detailed derivation of these seismic acceleration values. These results for equipment loads are summarized as follows, based on the equipment location and rigidity:

<u>Location</u>	<u>Horizontal Seismic Acceleration</u>
At or below grade - Rigid	0.39g
Above grade - Rigid	1.56g
At or below grade - Flexible	0.78g
Above grade - Flexible	3.12g

These evaluations are performed in accordance with HNF-SD-GN-DGS-30006, (Ref. 7). The emphasis of the guide is to provide specific guidance for the evaluation of equipment anchorages, and of falling, overturning and impact interactions between lower classified equipment and higher classified equipment, using qualitative and limited quantitative evaluation processes. This guide forms the basis for the "Seismic Adequacy Review of Non-Safety Class (PCO12) Systems, Component and Equipment that are Potential Seismic Interaction Hazards with Safety Class (PC3) SSC at the CVD Facility," (Ref. 8), which addresses the potential failure of all equipment within the zone of influence of SC SSCs.

- General Service SSC - HNF-SD-GN-DGS-30006 (Ref. 7) specified that the seismic goal for GS buildings is to ensure that collapse is prevented and safe egress and access from and to the facility is possible. Engineering standards for equipment achieve a similar goal by specifying sufficient anchorage to preclude falling or movement that might cause injury or block access and egress. Uniform Building Code (UBC - 1994) requirements are adopted as the basis for seismic demand, based primarily upon the relatively good performance of equipment anchored to those requirements in previous earthquakes.

For GS equipment whose failure during a seismic event may damage SC equipment, evaluation is performed in accordance with HNF-SD-GN-DGS-30006 (Ref. 7) for "Seismic 3/1." This evaluation is performed based upon conservative ground acceleration values (e.g., the peak ground acceleration assumed is 0.35g) and conservative building response for the PC-3 seismic event. These results for equipment loads are summarized as follows, based on the equipment location and rigidity:

<u>Location</u>	<u>Horizontal Seismic Acceleration</u>
At or below grade - Rigid	0.39g
Above grade - Rigid	1.56g
At or below grade - Flexible	0.78g
Above grade - Flexible	3.12g

As discussed previously, a limitation in the guide is that it is only applicable to static components (i.e., those that need not operate following a seismic event).

The emphasis of the guide is to provide specific guidance for the evaluation of equipment anchorages, and of falling, overturning and impact interactions between lower classified equipment and higher classified equipment, using qualitative and limited quantitative evaluation processes. This guide forms the basis for the "Seismic Adequacy Review of Non-Safety Class (PCO12) Systems, Component and Equipment that are Potential Seismic Interaction Hazards with Safety Class (PC3) SSC at the CVD Facility," (Ref. 8) which addresses the potential failure of all equipment within the zone of influence of SC SSCs.

As the seismic accelerations for the PC-2 and PC-1 seismic events are identical, there is no need to perform a specific evaluation of the impacts of PC-1 SSC failing and impacting PC-2 SS SSCs.

Qualification of SC Equipment Required to Function following a Seismic Event:

Equipment qualification is performed in accordance with IEEE 344 (Ref. 6), utilizing shake table testing. The attributes of the CVD seismic equipment testing include:

- Witness Points - Seismic testing is a witness point, where the vendor must give advance notification to project technical personnel so they may be present and witness the seismic testing.
- Equipment functional testing - functional testing shall demonstrate equipment performance following each seismic test, as specified in the SEL (Ref. 12).
- Seismic Response Spectra - The SC equipment shall be qualified for the PC-3 earthquake.

- Equipment mounting for testing - Each piece of equipment shall be mounted in a prototypic manner. The combination of the seismic table acceleration and the mounting arrangement will ensure that the accelerations calculated to be present at the equipment operational location form a lower bound to the test accelerations.
- Accelerometers - There shall be three (3) control accelerometers, one vertical and two horizontal located on the shake table. There shall be two sets of response accelerometers, one vertical and two horizontals per set, located in the middle and at the top of the test fixture. Prior to mounting, Cognizant Engineers will direct the exact location of the accelerometers.
- Test Reports - After completion of the testing sequence for each piece of equipment, the final test reports and other deliverables (e.g., Test Response Spectra digitized time-histories and videotapes) shall be provided for permanent equipment data files.

References:

1. HNF-SD-SNF-HIE-004, "Cold Vacuum Drying Facility Final Hazard Analysis Report," Rev. 3, dated October 20, 1999.
2. DOE-STD-3009-94, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports," dated July 1994.
3. DOE Order 5480.23, "Nuclear Safety Analysis Reports," Change Notice 1, dated March 12, 1994.
4. DOE Standard 1021, "Natural Phenomena Hazards Performance Categorization Guidelines for Structures Systems and Components," Change Notice 1, dated January 1996.
5. DOE Standard 1020, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities," Change Notice 1, dated January 1996.
6. IEEE Std. 344-1987, "Recommended Practices for Seismic Qualification of Safety Class Equipment for Nuclear Power Generating Stations".
7. HNF-SD-GN-DGS-30006, "Guidelines for Assessing the Seismic Adequacy of Existing Performance Category Equipment at the Hanford Site," Rev. 2, dated September 30, 1997.
8. HNF-4291, "Seismic Adequacy Review of Non-Safety Class (PC012) Systems, Component and Equipment that are Potential Seismic Interaction Hazards with Safety Class (PC3) SCE at the CVD Facility," Rev. 0, dated September 15, 1999.
9. WHC-SD-SNF-DB-010, "Cold Vacuum Drying System Natural Phenomenon Hazards," Rev. 1, dated September 9, 1996.
10. HNF-PRO-097, "Engineering Design and Evaluation," Rev. 0, dated October 15, 1997.
11. SNF-3091, "Cold Vacuum Drying Safety Class Instrumentation and Control System Design Description," Rev. 0, dated July 2, 1999.
12. HNF-SD-SEL-002, "Spent Nuclear Fuel Project Cold Vacuum Drying Facility Safety Equipment List" Rev. 7, dated September 23, 1999
13. SNF-4148, "Spent Nuclear Fuel Project Cold Vacuum Drying Facility Master Equipment List", Rev. 1, dated September 21, 1999
14. HNF-SD-SNF-DRD-002, "CVD Design Requirements Document," Rev. 4, dated April 1, 1999.

Summary of Seismic Load definition source as a function of the classification of a SSC and the safety functions required

Safety Function	SC SSC	SS SSC	GS SSC
Structure required to function during and following seismic DBA	PC-3/DB-010 Response Spectrum	PC-2/HNF-PRO-097	PC-1/HNF-PRO-097
Structure whose failure has no impact on seismic DBA	PC-1 HNF-PRO-097	PC-1 HNF-PRO-097	PC-1 HNF-PRO-097
Ground Mounted System required to function during and following seismic DBA	PC-3/DB-010 Response Spectrum	PC-2/HNF-PRO-097	PC-1/HNF-PRO-097
Structure Mounted System required to function during and following seismic DBA	PC-3/ ISRS based on DB-010 Response Spectrum	N/A	N/A
Ground Mounted active Component required to function during and following seismic DBA	PC-3/ Tested per IEEE 344 protocol to DB-010 Response Spectrum	N/A	N/A
Structure Mounted Component required to function during and following seismic DBA	PC-3/ Tested per IEE 344 protocol to ISRS based on DB-010 Response Spectrum	N/A	N/A
Structures whose failure could impact SC SSC's	N/A	N/A	PC-3/DB-010 Response Spectrum
Structures whose failure could impact SS SSC's	N/A	N/A	PC-2/HNF-PRO-097
Ground Mounted System and components whose failure could impact SC SSC's	DGS 30006	DGS 30006	DGS 30006

Ground Mounted Systems and Components whose failure could impact SS SSC's	N/A	DGS-30006	DGS-30006
Structure Mounted Systems and Components whose failure could impact SC SSC's	DGS-30006 Structural Amplification factor verified by ISRS performed to DB-010	DGS-30006 Structural Amplification factor verified by ISRS performed to DB-010	DGS-30006 Structural Amplification factor verified by ISRS performed to DB-010
SSCs with potential of interaction due to proximity	PC-3/DB-010 either Ground spectrum or ISRS as appropriate	N/A	N/A

[illegible]