RMIS View/Print Document Cover Sheet

This document was retrieved from the Boeing ISEARCH System. It is intended for Information only and may not be the most recent or updated version. Contact a Document Service Center (see Hanford Info for locations) if you need additional retrieval information.

Accession #: D295183544

Document #: SD-SNF-DB-004

Title/Desc:

NRC EQUIVALENCY EVALUATION REPORT

Pages: 40

NOV 28 1995

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT No 612977

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) SNF Project Regulatory Programs	4. Related EDT No.: N/A
5. Proj./Prog./Dept./D v.: Spent Nuclear Fuel Project	6. Cog. Engr.: L. J. Garvin	7. Purchase Order No.: N/A
8. Originator Remarks: NRC Equivalence Seismic Criteria. Document has been reviewed and comments resolved. Regulatory Requirements Team has approved document.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
11. Receiver Remarks:		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date:

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	WHC-SD-SNF-DB-004	--	0	Nuclear Regulatory Commission Equivalency Evaluation Report	ESQ	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

(G)	(H)	17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)						(G)	(H)
Reason	Disposition	(J) Name	(K) Signature (M) MSIN	(L) Date	(J) Name	(K) Signature (M) MSIN	(L) Date	Reason	Disposition
1	/	Cog.Eng., LJ Garvin	<i>[Signature]</i>	11/3/85					
1	/	Cog. Mgr., LJ Garvin	<i>[Signature]</i>	R3-85					
1	/	QA, DW Smith	<i>[Signature]</i>	11/16/95					
1	/	Safety, JT Vistica	<i>[Signature]</i>	11/22/95					
1	/	Env., JE Turnbaugh	<i>[Signature]</i>	11/14/95					
1	/	MK Mahaffey	<i>[Signature]</i>	11/16/95					
1	/	GC Mooers	<i>[Signature]</i>	11/14/95					

18. L. J. Garvin <i>[Signature]</i> Signature of EDT Date Originator	19. _____ Authorized Representative Date for Receiving Organization	20. <i>[Signature]</i> Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
---	---	--	---

RELEASE AUTHORIZATION

Document Number: WHC-SD-SNF-DB-004, REV 0

Document Title: Nuclear Regulatory Commission Equivalency Evaluation Report

Release Date: 11/27/95

**This document was reviewed following the
procedures described in WHC-CM-3-4 and is:**

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Kara Broz

11/27/95

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy. Available in paper copy. Printed in the United States of America. To obtain copies of this report, contact:

Westinghouse Hanford Company - Document Control Services
P.O. Box 1970, Mailstop H6-08, Richland, WA 99352
Telephone: (509) 372-2420; Fax: (509) 376-4989

SUPPORTING DOCUMENT

1. Total Pages 36

2. Title

Nuclear Regulatory Commission Equivalency
Evaluation Report

3. Number

WHC-SD-SNF-DB-004

4. Rev No.

0

5. Key Words

NRC, Seismic, Performance Category, Safety
Equivalency

6. Author

Name: L. J. Garvin

Signature

Organization/Charge Code 5B100/LA015

7. Abstract

8. RELEASE STAMP

OFFICIAL RELEASE
BY WHC

DATE NOV 28 1995

Signature

SPENT NUCLEAR FUEL PROJECT SEISMIC DESIGN CRITERIA

NUCLEAR REGULATORY COMMISSION EQUIVALENCY EVALUATION REPORT

October 1995

**Prepared for the U.S. Department of Energy
Spent Nuclear Fuels Division**

**Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352**

CONTENTS

EXECUTIVE SUMMARY	1
1.0 INTRODUCTION	1
2.0 DOE AND NRC SEISMIC DESIGN CRITERIA	2
2.1 Safety Goals	2
2.2 NRC Seismic Design Criteria	2
2.3 DOE Seismic Design Criteria	3
2.4 Comparison of NRC Versus DOE Seismic Design Methodology	3
3.0 APPLICATION OF SEISMIC DESIGN CRITERIA TO THE CSB	5
3.1 Process and Design Description	5
3.2 Preliminary Safety Analyses	5
3.3 Safety Class and Performance Category Correlation	8
4.0 200 EAST AREA CSB SITE SEISMIC RESPONSE	9
5.0 SAFETY EQUIVALENCY DISCUSSION	12
5.1 Seismic Safety Risks	12
5.2 Cost Considerations	14
5.3 Existing CSB Design	14
5.4 Impact of Upgrade to the 10 CFR 100, Appendix A, Seismic Criteria	16
5.5 Qualitative Effects from an NRC Design Earthquake	17
6.0 CONCLUSION	18
7.0 REFERENCES	19
7.0 REFERENCES	20
7.0 REFERENCES	21
APPENDIX A	A-1
APPENDIX B	B-1
APPENDIX C	C-1

LIST OF TABLES

1. Accident Analyses Results	6
2. Conservative Analyses Results	7
3. Comparison of Important Safety Items	13
A-1. Comparison of a Reactor and Canister Storage Building Total Radionuclide Inventories	A-1
A-2. Comparison of Mean Annual Seismic Induced Core Damage Frequencies From Past Reactor Probabilistic Risk Assessments	A-2
A-3. Comparison of Natural Phenomena Hazards Performance Goals and Performance Categories	A-2

LIST OF FIGURES

1. Horizontal Response Spectra for the 200 Area CSB Site	10
2. Vertical Response Spectra for the 200 Area CSB Site	11
3. Vertical Response Spectra for the 200 Area CSB Site	15
C-1. Horizontal Seismic Response Spectra for the CSB	C-1
C-2. Vertical Seismic Response Spectra for the CSB	C-2

ACRONYMS & ABBREVIATIONS

CFR	Code of Federal Regulations
CSB	Canister Storage Building
DBE	Design Basis Earthquake
DOE	U.S. Department of Energy
FR	Federal Register
HWVP	Hanford Waste Vitrification Project
HVAC	Heating, Ventilating, and Air Conditioning
ISFSI	Independent Spent Fuel Storage Installation
MCO	Multi-Canister Overpack
MEI	Maximum Exposed Individual
NPH	Natural Phenomena Hazards
NRC	U.S. Nuclear Regulatory Commission
PC	Performance Category
PRA	Probabilistic Risk Assessment
PSE	Preliminary Safety Evaluation
RG	Regulatory Guide
SC	Safety Class
SNFP	Spent Nuclear Fuel Project
SSE	Safe Shutdown Earthquake

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) established the K Basins Spent Nuclear Fuel Project (SNFP) to address safety and environmental concerns associated with deteriorating spent nuclear fuel presently stored in the Hanford Site's K Basins. The project plans are to retrieve the fuel from the K Basins, stabilize the fuel with conditioning processes, and store the fuel in the 200 Area of the Hanford site until a suitable long-term repository is established.

The DOE's policy, *K Basins Spent Nuclear Fuel Project - Regulatory Policy* (DOE 1995), requires that new processes and facilities that are to be constructed to condition and store SNFP fuel be designed to achieve a level of nuclear safety comparable to that of Nuclear Regulatory Commission (NRC) licensed facilities. This is accomplished by substituting or supplementing existing DOE orders and requirements with appropriate NRC criteria, where the NRC requirements provide a technically defensible, cost effective increase in safety.

This paper provides the basis for concluding that using the seismic design criteria, defined in DOE order 5480.28, *Natural Phenomena Hazards Mitigation*, and its implementing standards provides safety equivalent to NRC criteria.

NRC EQUIVALENCE

DOE's Regulatory Policy for the Spent Nuclear Fuel Project (DOE 1995) states ". . . the K Basin Spent Nuclear Fuel Project will achieve nuclear safety equivalency to comparable Nuclear Regulatory Commission-licensed facilities." The policy objectives are:

- to achieve a set of requirements that are technically defensible and cost-effective,
- to achieve in the design and construction of new SNFP facilities, a level of nuclear safety comparable to that of NRC-licensed commercial nuclear facilities, and
- to enhance public understanding and confidence in the safety of new facilities by following an enhanced regulatory strategy.

The Regulatory Policy and its underlying objectives can be met by the use of DOE Order 5480.28 and the resulting PC-3 performance category response spectra, anchored at approximately 0.2g for design of new SNFP facilities. The methods used to accomplish the seismic design are somewhat different than those that have been applied by the NRC, but the results obtained provide a technically defensible level of nuclear safety, comparable to that achieved by licensed nuclear reactor power plants.

The NRC approach (10 CFR 72.120) requires use of 10 CFR 100, Appendix A, *Seismic and Geologic Siting Criteria for Nuclear Power Plants*. Application of 10 CFR 100, Appendix A, criteria for nuclear power reactors will result in a higher level design earthquake but will not significantly reduce the level of public risk. Examination of the history of application of seismic design requirements to fuel storage facilities and the guidance provided in the NRC Regulatory Guide (RG) 3.44 (applicable to pool storage facilities) (NRC 1989a) and RG 3.48 (applicable to dry storage facilities) (NRC 1989b), suggests that selection of the design basis seismic event can include consideration of the potential consequences of seismically induced accidents. (See Section 2.2 and Appendix B of this report).

Due to the following: 1) the current CSB design meets both the DOE and NRC safety goals, and 2) overall seismic risk is lower than the risk associated with licensed nuclear power plants; the equivalency policy and underlying objectives can be met by use of DOE Order 5480.28 and associated standards for the seismic design of new SNFP facilities.

FACILITY SAFETY

Application of seismic design criteria based on DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, and its implementation standards ensures a level of safety protection against potential seismic events that could occur at Hanford's spent nuclear fuel facilities consistent with NRC and DOE safety goals..

Application of seismic Performance Criteria 3 (PC-3)¹ for new SNFP facilities results in seismic design criteria that supports the safety goals identified in DOE's *Nuclear Safety Policy*, SEN 35-91.² Use of the PC-3 seismic performance criteria for a fuel storage facility (e.g., the CSB) located in the Hanford 200 Area also results in seismic risks that are estimated to be about one order of magnitude (i.e., a factor ranging from 3 to 50) lower than the seismically induced risk from typical licensed nuclear power plants in the United States (See section 5.1 of this report). Potential consequences associated with seismically induced accidents from a fuel storage facility (e.g., the CSB) are estimated to be at least 2 orders of magnitude less severe than those from a power reactor facility. The probability of exceeding acceptable design performance in a seismic event is estimated to be about an order of magnitude higher for a PC-3 facility than for a nuclear reactor facility designed to NRC 10 CFR 100, Appendix A criteria. Total risk from a seismic event is defined as the

¹ Seismic performance categories are defined in DOE Order 5480.28 based on performance goals established in that Order and associated implementation standards. For facilities in the Hanford 200 Area East, a PC-3 seismic performance category results in an acceleration response spectra anchored at a peak horizontal value of about 0.2g (i.e., a 0.2g response spectra).

² DOE's and NRC's nuclear safety goals are essentially equivalent. The nuclear safety policies of both agencies require that the general public be protected such that no individual bears significant risk from the operation of the nuclear facility above the risk to which members of the general population are normally exposed. Both safety policies quantify the risk by requiring that the risk to an average individual in the vicinity of a facility should not exceed one-tenth of one percent (0.1%) of the risk (both prompt and latent) to which members of the population are normally exposed.

mathematical product of the probability of occurrence times the consequences; thus, total risk from seismically induced accidents is approximately a factor 10 times (i.e., about an order of magnitude) lower for a CSB like fuel storage facility in the Hanford 200 Area designed to PC-3 than for NRC licensed nuclear power stations. Although these figures represent an estimated range of risk and are not precise in nature, they demonstrate that design to the DOE criteria provides an acceptable level of nuclear safety and a degree of protection against seismic events that is equivalent or better than that provided for NRC licensed commercial nuclear power reactors.

Completion of the partially constructed Canister Storage Building (CSB) results in significant cost and schedule benefit for the SNF Project. The existing CSB was designed to a horizontal seismic spectra anchored at 0.35g in anticipation of the draft guidance on seismic design requirements at the time. The existing CSB seismic design is conservatively designed compared to the requirements for a PC-3 facility.³

EARTHQUAKE DAMAGE ASSESSMENT

An assessment of earthquake damage to the current CSB design was conducted for a seismic event with a response spectra anchored at 0.52g (1.5 times greater than the current 0.35g design basis response spectra and 2.6 times the 0.2g Performance Category 3 response spectra). This event is slightly larger than the estimated 10 CFR 100, Appendix A, response spectra (i.e., 0.49g response spectra) for the Hanford 200 East Area. The results of this assessment indicate a less than 10% probability of unacceptable performance of CSB structures, systems, and components for this larger earthquake. Based on this result, even if a much larger earthquake were to occur at the CSB site, significant accident consequences would be extremely unlikely.

COST EFFECTIVENESS

The impact to the SNFP of using the 10 CFR 100, Appendix A, nuclear reactor seismic design criteria for design of the CSB is estimated to cost an additional \$29 million and result in an approximate six month delay in the project schedule. Upgrading the CSB or other new SNFP facilities to the 10 CFR 100, Appendix A (0.49g) response spectra is not required to achieve an adequate level of safety and incremental seismic risk improvement is small. Thus redesign for improved seismic response capabilities and the associated construction upgrades are not cost effective, and do not support the urgent safety considerations requiring the expedited removal of the fuel from the K Basins.

³ The annual probability of exceeding an earthquake that would result in unacceptable design performance for a facility designed to the PC-3 response spectra (0.2g) is estimated to be 1×10^{-4} per year. If the NRC criteria of 10 CFR 100, Appendix A, is applied at the 200 Area CSB site— a 0.49g response spectra would result, with an exceedance probability of approximately 1×10^{-5} per year. If the current CSB design spectra (0.35g) is used the exceedance probability would be between these values at about 5×10^{-5} .

K BASIN RISK

The present storage of the spent fuel in the K Basins presents a significant safety and environmental risk (Bergsman 1995), including risks from seismic events as well as all other accident initiators. Once the fuel is removed from K basins into the CSB or a similar facility in the 200 Area: 1) it will no longer present a threat to the Columbia River, 2) the fuel will have been dried to prevent continued corrosion, which produces radioactive particulate that can potentially be spread following any release, and 3) it will be doubly contained to provide increased protection against release to the environment. Delaying removal of fuel from the K Basins by six months (which is the projected schedule delay required to upgrade the CSB design to accommodate a 0.49g response spectra) would unnecessarily extend risks associated with K Basins operation for a longer period of time and would tend to reduce the small risk benefit achieved by redesigning the CSB for larger earthquakes.

CONCLUSION

This paper demonstrates that by using the DOE Order 5480.28 criteria and its implementing standards, an adequate level of nuclear safety is ensured and the DOE's objectives associated with NRC equivalency are achieved.

SPENT NUCLEAR FUEL PROJECT SEISMIC DESIGN CRITERIA - NUCLEAR REGULATORY COMMISSION EQUIVALENCY EVALUATION REPORT

1.0 INTRODUCTION

The DOE has established a program to expeditiously move the spent nuclear fuel from the K Basins to a new storage facility located in the 200 East Area of the Hanford Site. The present storage of spent nuclear fuel in the K Basins, which are located near the Columbia River, presents significant environmental, worker, and public health risks (Bergsman 1995). The intent of the SNFP is to move the fuel into a new facility for temporary storage away from the Columbia River as soon as possible, rapidly reducing the environmental and safety risks. The new facility will provide longer-term safe storage of the spent nuclear fuel prior to final disposition of the fuel.

Recommendations for a series of aggressive projects to construct and operate systems and facilities to manage the safe removal of K Basins fuel was made in the *Hanford Spent Nuclear Fuel Recommended Path Forward*, (WHC 1994), and its subsequent update, *Hanford Spent Nuclear Fuel Project Integrated Process Strategy for K Basins Fuel*, (WHC 1995a; referred to as the Integrated Process Strategy). The recommendations call for the construction of a canister storage building (CSB) in the 200 area of the Hanford Site to serve as the interim storage location for K Basins fuel. Additionally, the Integrated Process Strategy recommends use of a two-step fuel drying and conditioning process to mitigate fuel degradation problems and increase the assurance of safe fuel storage. The two-step process consists of vacuum drying the fuel as it is removed from the basins, prior to its repackaging for transport to the 200 area; then, hot-vacuum conditioning the fuel in a facility near the CSB prior to its interim storage.

The DOE established a policy in *K Basins Spent Nuclear Fuel Project - Regulatory Policy* (DOE 1995) that new SNFP facilities achieve nuclear safety equivalence to comparable Nuclear Regulatory Commission (NRC) licensed facilities (hereafter referred to as the equivalency policy). The policy will be accomplished by applying technical requirements to SNFP facilities based on those applied by the NRC to comparable licensed facilities. This will be accomplished within the bounds of DOE objectives that facility requirements remain technically defensible and cost-effective.

This paper considers the seismic design criteria to be applied to the Spent Nuclear Fuel Project (SNFP) facilities with regard to DOE's equivalency policy. The SNFP is proposing the use of the DOE seismic design criteria established in DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*. In the following discussion, the CSB is used as an example case application of the DOE and NRC seismic design criteria to compare resulting designs, seismic risks, costs, and other considerations developed by these methods. The results demonstrate that the DOE criteria provides a design that is safe, cost effective, and consistent with the intent of DOE's equivalency policy.

2.0 DOE AND NRC SEISMIC DESIGN CRITERIA

This section describes the DOE and NRC methods for determining seismic design criteria for spent nuclear fuel storage facilities. Although the DOE and NRC seismic design criteria are developed differently, the methodologies share the same basic objective; to provide an adequate level of safety for protection against seismic events, consistent with safety goals and policies.

2.1 Safety Goals

Evaluation of the DOE's and the NRC's nuclear safety policies indicates that the two policies are essentially equivalent. Both safety policies require that the general public be protected such that no individual bears significant additional risk to health and safety from the operation of a nuclear facility above the risks to which members of the general population are normally exposed. Both safety policies quantify the risk by requiring that the risk to an average individual in the vicinity of a facility should not exceed one-tenth of one percent (0.1%) of the risks (both prompt and latent) to which members of the population are generally exposed.

2.2 NRC Seismic Design Criteria

The NRC requirements for licensing spent nuclear fuel storage facilities, including requirements for seismological siting criteria, are documented in 10 CFR 72, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste*. The regulations define an independent spent fuel storage installation (ISFSI) as a complex designed and constructed for the interim storage of spent nuclear fuel. Section 102 of 10 CFR 72 requires that ISFSIs sited "West of the Rocky Mountain Front (west of approximately 104° west longitude), and in other areas of known potential seismic activity, seismicity will be evaluated by the techniques of appendix A of part 100 of this chapter." This section also requires "For sites that have been evaluated under the criteria of Appendix A of 10 CFR part 100, the design earthquake must be equivalent to the safe shutdown earthquake for a nuclear power plant."

Appendix A of 10 CFR 100, *Seismic and Geologic Siting Criteria for Nuclear Power Plants*, establishes a deterministic approach to identify the maximum earthquake potential at a site considering the regional and local geology and seismology. This earthquake is designated the "Safe Shutdown Earthquake," or SSE, which is the earthquake that produces the maximum vibratory ground motion for which certain structures, systems, and components of a nuclear power plant are designed to remain functional. The SSE is equivalently designated the "Design Basis Earthquake."

The guidance provided in Regulatory Guide 3.44 (NRC 1989a), *Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation*

(*Water-Basin Type*), seems to be inconsistent with the current regulations established in 10 CFR 72. Regulatory Guide 3.44 provides for seismic design to be based upon an event that has “a predicted recurrence interval of about once in a thousand years.” This suggests that selection of the recurrence interval for the design basis seismic event can include consideration of the potential consequences of seismically induced accidents dependent upon the type of facility being considered.

Regulatory Guide 3.48 (NRC 1989b), *Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)*, relative to Regulatory Guide 3.44, uses a somewhat more conservative maximum earthquake for its Design Basis Earthquake. This may result from its anticipated larger radioactive inventory (100,000 tons a typical water- basin type facility or the 2000 tons of K Basins fuel).

It is clear that the NRC’s seismic design criteria, with respect to the storage of spent fuel, has been changing and that 10 CFR 100, Appendix A does not reflect the current risk-based regulatory thinking. The history of the NRC’s development of seismic design criteria is discussed further in Appendix B.

2.3 DOE Seismic Design Criteria

The DOE seismic design requirement for nuclear facilities is provided in DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*. The DOE Order, along with its implementing standards, uses a Probabilistic approach to determine the likelihood of an earthquake that results in the exceedance of acceptable design performance of a facility. Structures, systems, and components of a facility are assigned one of five performance categories (PCs) in accordance with the guidance provided in DOE-STD-1021-92, *Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems, and Components* (DOE 1992). Each performance category has been assigned a performance goal. The natural phenomena hazards (NPH) performance goals required for seismic events relative to defined performance categories are presented in Table A-3 (Appendix A). The performance categories provide a graded approach to application of seismic design criteria based on consideration of the relative probabilities and consequences of potential damage or failure of a facility. A graded approach to seismic design criteria, considering the relative hazards and consequences related to failure of a facility, is the primary difference between the DOE and NRC seismic design criteria as it is applied to spent nuclear fuel storage facilities.

2.4 Comparison of NRC Versus DOE Seismic Design Methodology

The structural design methodology that would be employed for a facility such as the CSB originates from the Lawrence Livermore National Laboratory UCRL-15910, *Design and Evaluation Guidelines for DOE Facilities Subjected to Natural Phenomena Hazards Design and Evaluation Criteria for DOE facilities* (UCRL 1990). This criteria ensures ductile design

by specifying the minimum ductility requirements. It then allows credit to be taken for higher damping values and an inelastic reduction factor. This type of design has been found to be very resilient to dynamic loading that occurs during seismic events.

The above approach to structural design is in contrast to that prescribed by the NRC Standard Review Plan (NRC 1989c), which requires structures to remain primarily elastic during design basis events. This methodology results in very strong, robust structures and is most appropriate for reactor containments because the worst case accident loading usually stems from over-pressure events rather than from seismic events.

3.0 APPLICATION OF SEISMIC DESIGN CRITERIA TO THE CSB

Application of DOE Order 5480.28 and its implementing standards provides a graded approach for developing a facility's seismic design requirements depending upon the performance category and performance goal that it is assigned. Thus, to compare designs developed under DOE and the NRC seismic design criteria, the type of facility and its hazards must be known. The CSB facility was selected as an example case application of the DOE and NRC seismic design criteria. Since the NRC criteria requires that seismic design requirements for the CSB be developed according to 10 CFR 100, Appendix A requirements for a nuclear power plant, the objective of this discussion will be to develop the rationale for selection of the DOE NPH performance category. The NPH performance category and 10 CFR 100, Appendix A criteria form the basis for determining the seismic design response spectra presented in Section 4.0.

3.1 Process and Design Description

Spent nuclear fuel from Hanford's plutonium production reactors is currently stored under water in two fuel storage basins in the 100 K area of the Hanford site. The fuel will be moved to interim dry storage in the CSB, located in the 200 East area of the site.

The CSB will be a concrete structure containing three below-grade storage vaults. The structure will be approximately 166-feet wide by 181-feet long and will be supported on a 5 $\frac{2}{3}$ -foot thick base mat. A five-foot thick operating deck will cover the storage vaults and the operating area will be covered by a 32-foot high steel structure.

Operations at the fuel storage basins in the 100 K area will remove the fuel elements from the canisters in which they are currently packaged. The fuel elements will be cleaned of sludge and debris and packed in baskets. The baskets will then be placed in a multi-canister overpack (MCO). Each MCO will hold approximately 5400 kg of fuel elements and large fuel pieces. A vacuum drying process will remove residual water, and the MCO atmosphere will be replaced with an inert cover gas before the MCOs are placed in casks for shipping to the CSB.

One of the CSB storage vaults will be used for the storage of the spent nuclear fuel. The CSB vault will contain 26-inch diameter steel tubes that extend from the floor to the operating deck. The MCOs will be stacked vertically in the tubes, two to a tube, and the storage tubes will be capped with concrete seal plugs.

3.2 Preliminary Safety Analyses

A Preliminary Safety Evaluation (PSE) (WHC 1995b) was performed to support the conceptual design of the CSB. The accidents scenarios considered credible include the following:

1. **An MCO over-pressurization during staging.** Over-pressurization of the MCO is assumed to occur as a result of hydrogen buildup, rupturing the MCO rupture disk.
2. **Dropping of an MCO into a storage tube.** Human error or equipment failure is assumed to result in an MCO being dropped into a storage tube where another MCO is being stored. Both MCOs are assumed to fail, releasing their contents.
3. **MCO failure during dry storage.** It is assumed that passivation has been imperfect, and that the fuel surface is available for oxidation. An unspecified event causes an opening to develop in the MCO canister that is large enough to allow air to pass between the inside and outside of the MCO with negligible friction losses, but small enough that the exchange of gases is dominated by the volume change in response to atmospheric pressure fluctuations in the tube.

The safety evaluation considered MCO inventories that included a five percent by weight loading of sludge. In the current process, the fuel material is vacuum dried and reracked before being packaged in the MCO canister. The accidents considered in the PSE were re-evaluated based on the current process.

Preliminary analyses indicate acceptable offsite consequences in terms of the maximum exposed individual (MEI) throughout the entire range of accident frequencies. The MEI is defined as the radiological dose consequences received by an individual at the site boundary in the direction of the maximum plume release. Exposures to the total population surrounding the site from the site boundary out to 80 kilometers, in terms of increased cancer incidents, are well below the DOE safety goal for all frequencies.

The results of the accident analysis are illustrated in Table 1.

Table 1. Accident Analyses Results

Accident	Total Fuel Material Released	Offsite MEI Consequences	Average Annual Population Exposure (Increased cancer incidents)
An MCO over-pressurization during staging	7.9 g	.02 rem	2×10^{-10}
Dropping of an MCO into a storage tube	14 g	.05 rem	4×10^{-10}
MCO failure during dry storage	0.037 mg	negligible	1×10^{-15}

In addition, a very conservative bounding accident was considered in the Hazard Category Analysis for the CSB (WHC 1995c). The postulated accident assumed the total collapse of the CSB structure, as well as failure of all 390 MCOs, releasing their contents. The assumptions used in this analysis included:

1. The remaining respirable particulate material (i.e., the material assumed to be at risk of release) in the MCO after treatment and before shipping was taken to be a maximum of 6.5 kg. This 6.5 kg value is conservatively assumed to be the average value present for long-term storage.
2. The isotopic content of the particulate is assumed to be the same as the fuel.
3. The release from the MCOs was a re-suspension over a 24-hour period of the fine particulate material.
4. It was also assumed that 1% of the MCOs (4) had not been adequately dried, or adequately vented, and contained hydrogen gas buildup from radiolysis and corrosion, resulting in a sudden venting of particulate material (resulting in a total of 13.0 kg of material at risk for each container).
5. The fuel elements and large fuel pieces are excluded from the inventory of material that may be released.
6. No mechanism could be identified that would result in a significant temperature increase — fuel pieces larger than 1 cm would not reach temperatures sufficient for self-sustained ignition.

The results of these analyses are shown in Table 2.

Table 2. Conservative Analyses Results

Accident	Total Fuel Material Released	Offsite MEI Consequences	Average Annual Population Exposure (Increased cancer incidents)
Bounding accident (complete facility failure)	2,460 g	1.7 rem	6×10^{-8}

Offsite MEI consequences greater than 0.5 rem require a Safety Class (SC) 1 confinement barrier to preclude the release of significant quantities of material per Westinghouse Hanford Company Safety Analysis Manual, Safety Class Criteria (WHC 1992), which is consistent with DOE Order 6430.1A, *General Design Criteria*.

Per NRC 10 CFR 72, the MCO performs a function that is important to safety — namely, the primary confinement against radioactive material releases. The SNFP position is to apply SC 1 design criteria to those structures, systems, and components that would be identified as important to safety by 10 CFR 72. Therefore, the MCO canister will be designed to SC 1 design requirements. The storage tube provides a secondary confinement boundary and will also be designed to SC 1 design requirements as a means of providing defense-in-depth.⁴

To provide further defense-in-depth and preclude common cause failure of the MCOs (assumed in the bounding accident), the concrete vault substructure and operating deck will also be designed to SC 1 design requirements. Designing these structures to SC 1 requirements will ensure that no scenario with consequences even approaching the bounding accident in the hazard categorization document will occur.

3.3 Safety Class and Performance Category Correlation

DOE Orders 5480.23, *Nuclear Facility Safety Analysis Reports*, and DOE 5480.22, *Technical Safety Requirements*, and their associated standards rely on the safety classification of structures, systems, and components to grade requirements. DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, and its standards use performance categories to provide NPH design requirements within the graded approach. The safety classification process also uses a graded approach. The consequence limits and other criteria used to classify structures, systems, and components are defined in the Westinghouse Hanford Company Safety Analysis Manual (WHC 1992), and include radiological and toxicological criteria. The correlation of NPH performance categories and safety classification leads to a unified graded approach.

Qualitative correlation of the NPH performance categories and safety classification is provided by matching the concepts and terminology of the NPH performance categories to the concepts and terminology used in the safety classification process (Webb 1994). Quantitative correlation is achieved by comparing safety classification limits to performance category numerical values.

Because of their importance to safety, the MCOs are a Safety Class 1 confinement barrier. Based on the safety analysis and principles of defense-in-depth, the storage tubes, operating deck, and vault substructure are also categorized as Safety Class 1. Using the WHC correlation between their safety classification process and performance categories (Webb 1994), the vault substructure, operating deck, MCOs, and storage tubes will be designed to NPH performance category PC-3 requirements.

⁴ Defense-in-depth is an approach to facility safety that builds in layers of defense against release of materials so that no one layer by itself, no matter how good, is completely relied upon (DOE 1994a).

4.0 200 EAST AREA CSB SITE SEISMIC RESPONSE

The CSB, MCOs, storage tubes, vault substructure and operating deck have been classified as NPH performance category PC-3 and will be designed to PC-3 requirements. The design response spectra for a PC-3 structure, system, or component are probabilistically based and defined at the 5×10^{-4} seismic hazard annual probability of exceedance (2000-year return period) ground motion (see Table A-3, Appendix A). For the CSB, located in the 200 East area, this is equivalent to a peak horizontal ground motion of approximately 0.2g. The 5% damped, equal-hazard, PC-3 horizontal and vertical design response spectra are shown in Figures 1 and 2, respectively. The vertical response spectrum was developed from the horizontal spectrum using draft American Society of Civil Engineers Standard Number 4, *Seismic Analysis of Safety Related Nuclear Structures* (ASCE 1995). Use of the attenuation relationship developed by Campbell (1989 and 1990) suggests that soil site vertical spectra should be equal to horizontal only for frequencies of 10 Hz and higher.

The PC-3 response spectra for the 200 East area CSB site are based on the seismic hazard assessment of the Hanford Site (Geomatrix 1994a and 1994b). Two review comments on this assessment are currently being addressed that may result in a small increase (less than 20%) in the PC-3 design response spectra.

Response spectra were also developed to meet the intent of a 10 CFR 100, Appendix A- type assessment. The seismic sources used in this assessment were the same as those used in NRC power reactor licensing on the Hanford Site. A more recent licensing practice than that used for the Hanford Site was followed in the response spectrum development (Geomatrix, 1995). The horizontal acceleration response spectrum is anchored to a peak ground acceleration of 0.49g (Figure 1). The vertical response spectrum is shown in Figure 2.

Figure 1. Horizontal Response Spectra for the 200 Area CSB Site.

Figure 2. Vertical Response Spectra for the 200 Area CSB Site.

5.0 SAFETY EQUIVALENCY DISCUSSION

The objective of this discussion is to demonstrate that application of the DOE 5480.28 seismic design criteria, using the CSB as an example case, provides an adequate level of safety for protection against potential seismic events. This is accomplished by demonstrating that the seismic safety risks of the CSB developed under the DOE criteria are equivalent to or less than seismically induced risks associated with NRC licensed facilities.

5.1 Seismic Safety Risks

Comparing seismic safety risks between DOE and NRC nuclear facilities requires that the probability and consequences of a seismic event that results in the exceedance of acceptable facility performance be determined. The total radionuclide inventory (radionuclides important to health) of the spent nuclear fuel to be stored in the CSB is much smaller than the comparable radionuclide inventory for a nuclear power plant (see Table A-1, Appendix A). Of particular importance for the CSB spent fuel is the reduced inventory of noble gases and short-lived fission products. The radiological dose consequences to the public from the potential release of radionuclides is directly proportional to the total radionuclide inventory at risk. Thus, the radiological dose consequences to the public from the potential release of radionuclides from a reactor facility would be approximately two orders of magnitude greater than the radiological dose consequences from the potential release of radionuclides from the spent nuclear fuel stored in the CSB.

Evaluating the energetics available to release the radionuclide content, it is evident that the energetics in a reactor facility are much larger than the energetics that are available to release the radionuclide content from the spent nuclear fuel stored in the CSB. Consequently, both the likelihood of a radionuclide release and the quantity of radionuclides available for release would be greater from a reactor facility than from the spent nuclear fuel stored in the CSB.

For nuclear power plants, the mean annual seismic core damage frequencies are presented in Table A-2 (Appendix A) from published probabilistic risk assessments (PRAs) for seven plants, based on utility hazard estimates. The annual probabilities of seismically induced core damage ranged from about 3×10^{-6} to 5×10^{-5} per year. Because the potential radiological dose consequences are two orders of magnitude larger for a nuclear power plant than for the CSB, a higher probability of a radiological release as a result of a seismic event would be acceptable for the CSB (that is, an annual seismic event exceedance probability of 5×10^{-3} per year or less).

Based on DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, a nuclear power plant would be assigned a performance category of PC-4,⁵ commensurate with the performance goal of an annual probability of seismic core damage of 1×10^{-5} per year. Using the same logic, the CSB could be assigned a performance category of PC-2 (an annual probability of exceeding acceptable performance for the CSB of 5×10^{-4} per year). A higher PC-3 performance category will be used for the MCOs, storage tubes, and the storage vault substructure as a means of providing defense-in-depth and added protection for the worker and the environment.

In summary, potential consequences from seismically induced CSB accidents are estimated to be at least two orders of magnitude less severe than those from a commercial nuclear power reactor facility. The CSB designed to PC-2 performance category would provide a level of risk from seismic events that is nearly the same order of magnitude of risk from NRC licensed nuclear power plants (Table A-2). The CSB designed to the PC-3 performance category provides a design that is approximately one order of magnitude lower (3 to 50 times lower) than the PC-2 performance category facility and that of typical nuclear power reactors. Although these figures represent an estimated range rather than precise calculations of risk, they demonstrate that the CSB designed to DOE seismic design criteria provides an acceptable level of nuclear safety and a level of seismic protection that is equivalent to or better than that for a nuclear power reactor. A comparison of NRC and DOE safety requirements supports the determination that the CSB, designed to the PC-3 performance category, meets or exceeds the applicable safety requirements. Table 3 provides a summary of the comparison of important NRC and DOE safety items.

Table 3. Comparison of Important Safety Items

Item	NRC (Reactor)	DOE (CSB) PC-3 Criteria
Nuclear Safety Policy	Equivalent	Equivalent
Radionuclide Source	$\sim 10^8$ Ci (see Table A-1)	$\sim 10^6$ Ci (see Table A-1)
Energetics; High pressure High temperature	Very energetic; Steam Pressure Temperature	Less energetic; No steam Low pressure Low temperature
Potential radiological dose consequences		$\sim 10^{-2}$ less
Annual probability of exceeding unacceptable performance from a seismic event	$\sim 10^{-5}$ per yr	~ 10 times larger for comparable risk ($\sim 10^{-4}$ per yr)
DOE NPH Performance Category	PC-4 ¹	Could be as low as PC-2 (will use PC-3)

¹ The PC-4 performance category only strictly applies to DOE Reactors.

⁵ The PC-4 performance category only strictly applies to DOE reactors.

5.2 Cost Considerations

Using the NRC seismic design criteria of 10 CFR 100, Appendix A, would require that the design of the CSB be upgraded from the PC-3 response spectra at approximately 0.2g to 0.49g response spectra. This would add significant unnecessary costs to develop an even more robust facility when the PC-3 requirement provides a more than adequate level of seismic protection. Thus, using the graded approach developed under the DOE seismic design criteria provides more cost effective designs for the SNFP.

5.3 Existing CSB Design

The SNFP has selected as a candidate for interim storage of the K Basins fuel the partially completed Canister Storage Building located in the 200 East area of the Hanford Site. The CSB was originally designed for the Hanford Waste Vitrification Project (HWVP). Construction of the base mat and part of the east and north walls were completed prior to termination of the HWVP in 1992. The option to use the CSB offers significant cost and schedule benefits for the project.

The existing CSB was designed to a horizontal seismic design spectra anchored at 0.35 g in anticipation of the draft guidance on seismic design requirements at the time. Correlating this design spectra from the Hazard Curve presented in Figure 3 results in the corresponding return period of 8000 years and a probability of exceedance of acceptable design performance at 5×10^{-5} . Calculating the total seismic risk for the CSB designed at 0.35g response spectra results in a design that is approximately two orders of magnitude lower risk as compared to an NRC licensed nuclear power plant and a CSB designed to the PC-3 performance category as discussed above.

The 5% damped, equal-hazard, horizontal and vertical design response spectra for the existing CSB designed to 0.35g compared with the PC-3 and NRC 10 CFR 100, Appendix A design response spectra are included in Figures C-1 and C-2 of Appendix C, respectively. The response spectra illustrate that the existing CSB design response is more conservative than that associated with the PC-3 response spectra.

Figure 3. Seismic Hazard Curve for the CSB.

5.4 Impact of Upgrade to the 10 CFR 100, Appendix A, Seismic Criteria

The impact to the SNFP of upgrading the existing CSB structure to withstand 10 CFR 100, Appendix A, level ground motions is estimated by the CSB designer to require a six-month slippage of the schedule beyond the December 1997 original start date for initiating fuel removal from the K Basins. A six-month schedule slippage would require the continued staffing of the K Basins and the SNFP, amounting to additional project costs of approximately \$21 million for the K Basins and \$4 million for the project staff. This, along with the \$3.5 million direct design and construction costs, brings the total impact of the upgrade to approximately \$29 million.

The spent fuel in the K Basins is stored under water in a facility designed and constructed in the early 1950s. The K Basins are perceived by the public to be an unacceptable storage facility, which does not provide sufficient protection from the hazards presented by the fuel. That facility has the same likelihood of experiencing a seismic event of a given ground motion as does the CSB. The CSB is designed to withstand ground motions from a seismic event that produces greater ground motion (0.35g) than any facility at the Hanford Site. Other DOE facilities, including K Basins, are designed to withstand 0.2g or even less. The likelihood of damage to the K Basins from an event generating ground motions as high as 0.35g is much greater than that of damage to the CSB.

The result of damage to the K Basins could be greater than similar damage to the CSB because of the defense-in-depth designed into the CSB fuel storage. Once the fuel has been moved into the CSB, it will have been: 1) moved away from the river to prevent the effects of contamination reaching the river or the water table; 2) dried to stop continuing corrosion that is producing radioactive particulates that can be spread following any release; 3) cleaned to remove the corrosion products from the past storage as much as possible; 4) conditioned to reduce the effect of air interaction with the fuel following an event; and 5) doubly contained (MCOs and storage tubes) to preclude air reaching and reacting with the fuel during an event.

The K Basins have none of these features that reduce the effects from an event. Moving the spent fuel away from the K Basins into the CSB will significantly reduce the risk related to the storage of the fuel. A comparison of the seismic safety risk assumed at the K Basins during the six month schedule delay to the risk reduction achieved by increasing the CSB seismic design criteria from 0.35 response spectra to 0.49 response spectra shows that the risks are of the same order of magnitude. Furthermore, the K Basins seismic risk represents only a portion of the total risk assumed during the six month delay. Consideration of risks based on other initiating factors would tend to increase the risk impact of delaying fuel removal from K Basins. Also, the consequences from design basis seismic events at the CSB are likely to be lower than at the K Basins, due to the defense-in-depth designed into the CSB. These factors tend to diminish any risk improvement that would be gained from the redesign of the CSB to the 0.49 response spectra.

5.5 Qualitative Effects from an NRC Design Earthquake

This section describes the effects of a 0.52g horizontal ground acceleration event, on a completed CSB that was designed for a 0.35g horizontal acceleration, which is a 50% greater loading than the design.

As noted in Section 2.4.3 of the DOE Standard, DOE-STD-1020-94 (DOE 1994b), the basic intention of the seismic evaluation and acceptance criteria for PC-3 is to achieve less than a 10% probability of unacceptable performance for a structure, system, or component subjected to a scaled ground motion equal to 1.5 times the Design Basis Earthquake (DBE) ground motion. Furthermore, Table C-2 of DOE-STD-1020-94 provides the following qualitative description of acceptable performance for the PC-3 category:

1. Concrete barriers can be cracked, but cracks should be small enough to maintain pressure differential with normal HVAC systems. Cracks should not be expected to exceed $\frac{1}{8}$ of an inch.
2. Metal liners and metal pressure-retaining components should remain leak-tight.
3. Components should remain anchored in place and be functional.
4. Visible local damage, but permanent distortion will not be immediately apparent to the naked eye.

The functions of the structure, including spent fuel cooling, should remain intact. Any structure, system, or component designed to the seismic evaluation and acceptance criteria for PC-3 in DOE-STD-1020-94 and for an acceleration response spectrum anchored at a peak horizontal acceleration of 0.35g, can be expected to have less than a 10% probability of suffering damage greater than that described above for a similar response spectra anchored at a 0.52g peak horizontal acceleration ground motion. Since this 0.52g response spectrum exceeds the estimated deterministic 10 CFR 100, Appendix A-type acceleration response spectrum anchored at 0.49g previously described, one would expect less than 10% likelihood of more severe damage than that described above if the CSB were subjected to ground motions described by the 10 CFR 100, Appendix A, spectra.

Considering the limited consequences of the bounding accident condition described in Section 3.2, a much more severe level of damage than the NRC DBE, the limited level of expected damage from a 10 CFR 100, Appendix A-type 0.49g peak ground acceleration response spectrum is considered acceptable.

6.0 CONCLUSION

The DOE Regulatory Policy (DOE 1995) for nuclear safety of K Basin SNFP new facilities is being applied to the design and construction of the CSB. This policy states “. . . that the K Basin Spent Nuclear Fuel Project will achieve nuclear safety equivalency to comparable Nuclear Regulatory Commission-licensed facilities.” The policy objectives are “to achieve in the design and construction of new SNFP facilities a level of nuclear safety comparable to that of NRC-licensed commercial nuclear facilities,” and “to achieve a set of requirements that are technically defensible and cost effective.” This paper has considered the application of the seismic design requirements applicable to the SNFP with regard to DOE’s equivalency policy. The DOE seismic design criteria established in DOE Order 5480.28, *Natural Phenomena Hazards Mitigation* for SNFP facilities results in designs that are safe, cost-effective, and consistent with the intent of DOE’s policy. The safety equivalence policy and the underlying objectives are met by the use of the DOE Order 5480.28 and the resulting PC-3 seismic response spectrum anchored at approximately 0.2g. The methods used to accomplish this policy are somewhat different than those that usually are applied by the NRC, but the results obtained provide nuclear safety equivalency.

Furthermore, it has been demonstrated that the current spent nuclear fuel seismic design criteria used for the existing CSB provides a level of safety that meets both DOE and NRC safety goals and provides greater safety than that provided by the use of a PC-3 response spectra for the Hanford Site.

7.0 REFERENCES

- AEC, 1974, Regulatory Guide 3.24, *Guidance on the License Application, Siting, Design, and Plant Protection for and Independent Spent Fuel Storage Installation*, Directorate of Regulatory Standards, U.S. Atomic Energy Commission, Washington, D.C.
- Bergsman, K. H., et al., 1995, *K Basins Environmental Impact Statement Technical Input*, WHC-SD-SNF-TI-013, Rev. A, Appendix A, July, Westinghouse Hanford Company, Richland, Washington.
- Campbell, K. W., 1989, "Empirical prediction of near-source ground motion for the Diablo Canyon Power Plant site," San Luis Obispo County, California: U.S. Geological Survey Open-File Report 89-484.
- Campbell, K. W., 1990, "Empirical prediction of near-source soil and soft rock ground motion for the Diablo Canyon Power Plant site," San Luis Obispo County, California, report prepared for Lawrence Livermore National Laboratory by Dames & Moore, September.
- DOE, 1992, *Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems, and Components*, DOE-STD-1021-92.
- DOE, 1994a, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009-94.
- DOE, 1994b, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, DOE-STD-1020-94.
- DOE, 1995, *K Basins Spent Nuclear Fuel Project - Regulatory Policy*, August, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.22, *Technical Safety Requirements*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.23, *Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C.
- DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, U.S. Department of Energy, Washington, D.C.
- DOE Order 6430.1A, *General Design Criteria*, U.S. Department of Energy, Washington, D.C.

7.0 REFERENCES (*Continued*)

- Geomatrix, 1994a, *Probabilistic Seismic Hazard Analysis*, DOE Hanford Site, Washington, WHC-SD-W236A-TI-002, report prepared by Geomatrix Consultants for Westinghouse Hanford Company, Richland, Washington.
- Geomatrix, 1994b, *Seismic Design Spectra 200 West and East Areas, DOE Hanford Site, Washington*, WHC-SD-W236A-TI-016, report prepared by Geomatrix Consultants for Westinghouse Hanford Company, Richland, Washington.
- Geomatrix, 1995, *NRC Equivalency Ground Motions for the Spent Nuclear Fuel Canister Storage Building*, a letter report by Geomatrix Consultants to Westinghouse Hanford Company, Richland, Washington.
- Nelson, T. A., Murray, R., Short, S. A. And Kennedy, R. P., 1992. *Seismic Design Strategy for New Production Reactors (NPR)*, UCRL-ID-110126, Lawrence Livermore National Laboratory, Livermore, California.
- NRC, 1989a, Regulatory Guide 3.44, *Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Water-Basin Type)*, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C.
- NRC, 1989b, Regulatory Guide 3.48, *Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)*, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C.
- SEN-35-91, *Nuclear Safety Policy*, September 9, 1991, U. S. Department of Energy, Washington, D.C.
- Webb, A. B. and Conrads, T. J., 1994. *Proposed Correlation of DOE Safety Classes, Performance Categories, and Design Requirements*, WHC-SD-GN-RD-30011, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1992, *Westinghouse Hanford Company Safety Analysis Manual*, WHC-CM-4-46, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1994, *Spent Nuclear Fuel Project Recommended Path Forward*, WHC-EP-0830, Rev. 0, Volumes I and II, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1995a, *Hanford Spent Nuclear Fuel Project Integrated Process Strategy for K Basins Fuel*, WHC-SD-SNF-SP-005, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

7.0 REFERENCES (*Continued*)

- WHC, 1995b, *Spent Nuclear Fuel Path Forward Preliminary Safety Evaluation*, WHC-SD-SNF-PSE-002, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WHC, 1995c, *Hazard Category Analysis for the Canister Storage Building*, WHC-SD-SNF-HC-007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- UCRL, 1990, *Design and Evaluation Guidelines for DOE Facilities Subjected to Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities*, UCRL-15910, Lawrence Livermore National Laboratory, Livermore, California.

APPENDIX A

**Table A-1. Comparison of a Reactor and Canister Storage Building
Total Radionuclide Inventories (Ci)**

Radionuclide	Reactor	CSB
Kr-83M	0.1428E+08	
Kr-85M	0.3129E+08	
Kr-85	0.5461E+07	5.73E+05
Kr-87	0.5893E+08	
Kr-88	0.8475E+08	
Sr-89	0.1121E+09	
Sr-90	0.1382E+09	9.34E+06
Y-90	0.1382E+09	9.35E+06
Sr-91	0.1400E+09	
Y-91	0.1437E+09	
Sr-92	0.1376E+09	
Y-92	0.1495E+09	
Zr-95	0.1777E+09	
Nb-95	0.1818E+09	
Mo-99	0.1844E+09	
I-131	0.9689E+08	
Te-132	0.1409E+09	
I-132	0.1426E+09	
I-133	0.1883E+09	
Xe-133M	0.4519E+07	
Xe-133	0.1882E+09	
Cs-134	0.3116E+07	
I-134	0.2321E+09	
I-135	0.1823E+09	
Xe-135M	0.2643E+08	
Xe-135	0.2789E+08	
Cs-136	0.1145E+07	
Cs-137	0.1658E+09	1.19E+07
Xe-138	0.1695E+09	
Ba-140	0.1610E+09	
La-140	0.1842E+09	
Ce-144	0.1473E+09	
Pr-144	0.1473E+09	
Pu-238		9.70E+04
Pu-239		2.16E+05
Pu-240		1.14E+05
Pu-241		5.79E+06
Am-241		2.93E+05
Cm-244		1.04E+04

Table A-2. Comparison of Mean Annual Seismic Induced Core Damage Frequencies From Past Reactor Probabilistic Risk Assessments

Power Reactor	Mean Annual Core Damage Frequency (1/yr)
Zion	5.7×10^{-6}
Indian Point 2	4.8×10^{-5}
Indian Point 3	3.1×10^{-6}
Limerick	5.8×10^{-6}
Millstone 3	8.9×10^{-6}
Seabrook	2.3×10^{-5}
Shoreham	2.6×10^{-6}

(Nelson 1992)

Table A-3. Comparison of Natural Phenomena Hazards Performance Goals and Performance Categories

Performance Category	P_H (1/year)	Return Period (yr)	Risk Reduction Factor ($R_R = P_H/P_P$)
PC-1	2×10^{-3}	500	2
PC-2	1×10^{-3}	1,000	2
PC-3	5×10^{-4}	2,000	5
PC-4	1×10^{-4}	10,000	10

P_P = Performance Goal = Annual probability of exceedance of acceptable behavior limits
 P_H = Seismic hazards exceedance probability;
 Return Period = $1/P_H$

(DOE Order 5480.28 and DOE 1994)

APPENDIX B

NRC Siting Requirements for Independent Spent Fuel Storage Installations

Independent Spent Fuel Storage Installations (ISFSIs) were licensed by the NRC under the general regulation for Domestic Licensing of Special Nuclear Material, 10 CFR 70, prior to November 1980. Early siting guidelines for wet pool storage of spent fuel recognized the fact that the radiological inventory at risk in an ISFSI is some four orders of magnitude less than that in a power reactor, and that there are few energy sources available to disperse the inventory during design basis accidents. Thus, NRC practice for development of siting requirements for these facilities were different from those for power reactors.

Siting guidelines for development of the Design Earthquake for an ISFSI were recommended in Regulatory Guide 3.24, *Guidance on the License Application, Siting, Design, and Plant Protection for an Independent Spent Fuel Storage Installation* (AEC 1974). The Regulatory Position in Section C.2.c. "Seismology" specified a site investigation methodology with a level of detail similar to that in 10 CFR 100, Appendix A. However, the suggested return period to be considered for the Design Earthquake was shorter. Section C.2.c.(5) "Selection of a Design Earthquake" suggested the following:

"In view of the limited consequences of seismic events in excess of those used as the basis for seismic design, it appears appropriate that the design earthquake developed from the above information should be such as to have a predicted recurrence interval of about once in a thousand years."

During the latter part of the 1970s, there was considerable effort being made at the NRC to develop regulations for the back end of the nuclear fuel cycle to allow final disposal of high-level nuclear waste. It was decided at that time to develop a new part of the regulations to specifically address the licensing requirements for storage of spent fuel in an independent spent fuel storage installation. The final rule, 10 CFR 72, *Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation*, was issued in November 1980 (46 FR 74693). This rule was subsequently revised in 1988 (53 FR 31651) to include requirements for a Monitored Retrievable Storage facility as part of the repository program and ISFSIs with dry storage.

Current NRC recommendations for development of the Design Earthquake for an ISFSI using water basins are presented in Regulatory Guide 3.44 (NRC 1989a), which addresses the standard format and content for the Safety Analysis Report for the facility.

The recommendation for development of the Design Earthquake is given in Section 2.6.2, "Vibratory Ground Motion," Subsection 2.6.2.3, "Earthquake Probabilities" as follows:

"Develop or determine a site-specific earthquake g value associated with a mean 500-year recurrence interval. As an alternative, this value may be developed by the deterministic methods developed for the siting of nuclear power plants as outlined in Section 2.6.2.4."

As noted in the earlier guidance, the site investigation is similar in level of detail to that of 10 CFR 100, Appendix A, with the use of a shorter return period.

Regulatory Guide 3.48 (NRC 1989b), the format and content guide for an ISFSI with dry storage, has criteria for development of the Design Earthquake that are based on a "maximum earthquake." These criteria are somewhat more conservative than those in RG 3.44 and have more in common with the deterministic procedure in 10 CFR 100, Appendix A. Additional conservatism in the seismic design earthquake may be due in part to the very large spent fuel inventory in a Monitored Retrievable Storage system, perhaps as much as 100,000 tons of heavy metal. For comparison purposes, the SNFP is dealing with about 2,000 tons of spent fuel.

There are indications in the records of discussion and comment leading to issuance of 10 CFR 100 that reaching a consensus on the use of a risk-based rationale to support a reduced level of seismic event for design of ISFSI was difficult. However, issuance of revised 10 CFR 100, Appendix A, for comment and development of Design Guide 1032 clearly indicates that the intent of NRC is to base selection of design basis earthquakes on probabilistic evaluations similar to DOE.

APPENDIX C

Horizontal and Vertical Response Spectra for Existing CSB Design

Figure C-1. Horizontal Seismic Response Spectra for the CSB

Figure C-2. Vertical Seismic Response Spectra for the CSB

vertical

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	Spent Nuclear Fuel Project	Date 11/06/95
Project Title/Work Order		EDT No. 612977
WHC-SD-SNF-DB-004, Revision 0 for SNF Project Seismic Design Criteria		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
F. W. Bradshaw	R3-85	X			
K. D. Daschke	R3-85	X			
J. C. Fulton	R3-11	X			
W. D. Gallo	R3-85	X			
L. J. Garvin	R3-85	X			
E. W. Gerber	R3-86	X			
L. H. Goldmann	R3-86	X			
A. T. Kee	R3-86	X			
M. K. Mahaffey	R3-85	X			
C. R. Miska	R3-86	X			
G. C. Mooers	R3-11	X			
J. M. Mortimer	S8-07	X			
D. A. Reny	R3-11	X			
J. C. Wiborg	R3-86	X			
M. E. Witherspoon	R3-85	X			
Central Files	A3-88	X			
SNF Project File	R3-11	X			
<i>A.R. Trueger</i>	<i>X3-85</i>	<i>X</i>			